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MINNESOTA ACADEMY

OF

NATURAL SCIENCES, Minneapolis

VOL. III -4

(1883—1891)

C. W. HALL, Editor

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OF THE

MINNESOTA ACADEMY OF NATURAL SCIENCES.

VOLUME III, BULLETIN I.

January 2, 1883.

Twenty-seven persons present.

The following persons were elected members:

J. W. Griffin. Geo. H. Miller, F. A. Dunsmoor, Robt. S. Innes, E. S. Kelley, J. M. Sullivan, Wm. W. Folwell, A. H. Pearson, J. M. Holzinger, W. J. Warren, J. C. Plant.

The subject of the coming of the American Association for the Advancement of Science was brought up by President Elliot. After some deliberation the Academy appointed a committee consisting of T. B. Walker, N. H. Winchell and A. F. iot to prepare a circular inviting citizens to a meeting in the Academy hall at such time as the committee deems best.

The Corresponding Secretary reported the following additions to the library received between March 1st, 1881 and December 31st. 1882.

1881 (from March 1st.)

THE UNITED STATES.

CONNECTICUT—*Middletown.*—Museum of Wesleyan University: Tenth Annual Report.

District of Columbia—*Washington.*—U. S. Geological Survey: Bulletin, Vol. vi., Nos. 1 and 2; Dep't of Interior; Second Report on Rocky Mt. Locust, 1878-9.

Massachusetts—*Salem.*—Am. Ass'n for the Advancement of Science: Proceedings, 1880.

New York—*Brooklyn.*—Long Island Historical Society: Recent Additions, etc.
Buffalo.—Society of Natural Sciences: Bulletin, Vol. iv., No. 1.
New York.—American Geographical Society: Bulletins, Nos. 2 to 6.

Ohio—*Cincinnati.*—Society of Natural History: Journal, Vol. iv., Nos. 1, 2, 3 and 4.

Rhode Island—*Providence.*—R. I. Historical Society: Proceedings, 1880-81.

FOREIGN.

Canada—*Toronto.*—Canadian Institute: Journal, Vol. i., Pt. 2.

Denmark—*Copenhagen.*—Library of the University: Ornamental Jewelry of North; His Majesty's Birth-day Feast; Church Reformation; Causes of Sterility; Studies of Milk; Embolism and Thrombus; Legal Essay; Gastrotomien; Pathology of Deaf and Dumb; Heart Diseases of Soldiers; State Paper, 1880; Foreign Bodies in Eyes; Ordinations of Clergy.

Germany—*Hamburg.*—Society of Natural Sciences: Transactions, 1880.
Kassel.—Natural History Society: Paper by O. Uhlwern.

India.—*Bombay.*—Royal Asiatic Society(Bombay Branch); Journal 1880, 1881.

New South Wales—*Sydney.*—Royal Society of N. S. W.: Proceedings, Vol. xiv., 1881.

Norway—*Christiana.*—Royal Frederick University: Tree Planting; Treatise on Crustacea and Fauna of Norway; Treatise on Mathematics; Insects of Norway.

1882.

THE UNITED STATES.

California—*San Francisco.*—Academy of Natural Sciences: Proceedings, Aug. 1882; Foot Found at State Prison.

Connecticut—*New Haven.*—Academy of Arts and Sciences: Transactions, Vol. iv., Vol. v., Pt. 2.

D. C.—*Washington.*—Patent Office: Official Gazette, Vol. 21-26, Pts.
Washington.—Smithsonian Institution: Report of Regents, 1880.
Annual Report of Bureau of Ethnology, 1879-80.
Washington.—U. S. Geological Survey (Dept. of Int.): Bulletin, No. 7; Bulletin, Vol. vi., No. 3.

Illinois—*Champaign.*—State Entomologist: 11th Annual Report, 1882.

Indiana—*Indianapolis.*—Geological Survey: 11th Report of Geologist.

Iowa—*Davenport.*—Academy of Natural Sciences: Proceedings, Vol. iii., Pt. ii.

Kentucky—*Louisville.*—Society for the Advancement of Science: Proceedings for 1881.

MASSACHUSETTS—*Boston.*—Horticultural Society: Transactions, 1882, Pt. I.
Cambridge.—Museum of Comparative Zoology; Bulletin, Vol. x., Nos. 1, 2, 3, 4, 5 and 6. Annual Report of Curator '81-2.

MISSOURI—*St. Louis.*—Academy of Science: Transactions, Vol. IV., No. 2.
St. Louis.—State Historical Society: Publications, Nos. 1, 2, 3, 4, 5 and 6.

NEW YORK—*Buffalo.*—Society of Natural Sciences: Bulletin, Vol. IV., No. 3.
Buffalo.—Historical Society: Bulletin, Vol. IV. No. 2; Semi-centennial Celebration of city of Buffalo.
New York.—American Geographical Society: Journal, 1880. Bulletins 1881, Nos. 1 and 5.
New York.—American Museum of Natural History: Bulletin, Nos. 1, 2, 3 and 4, 1881. Bulletin, Vol. I., No. 3. Annual Reports 1st to 13th.

OHIO—*Cincinnati.*—Society of Natural History: Journal, Vol. V., Nos. 1, 2, 3, and 4.

PENNSYLVANIA—*Philadelphia.*—Zoological Society: 10th Annual Report.

RHODE ISLAND—*Providence.*—R. I. Historical Society: Proceedings, 1881-82.

WISCONSIN—*Madison.*—Academy of Sciences, Arts and Letters: Transactions, 1879 to 81.
Madison.—Wis. Natural History Society: Proceedings, 1881-82.

FOREIGN.

CANADA—*Ottawa.*—Geological and Natural History Survey: Report of Progress, 1879-80; Maps.
Toronto.—Canadian Institute: Proceedings, Vol. I. Fasc. 3.

NEW SOUTH WALES—*Sydney.*—Department of Mines: Report, 1881.

NETHERLANDS—*Harlem.*—Teyler Institution: Archives, Ser. II.

NORWAY—*Christiana.*—Royal Frederick University: Silurian Age; Movement of atmospheres.

SCOTLAND—*Glasgow.*—Geological society: Transactions, vol. VI. Pt. 2.

After the reports of the retiring officers had been made the following officers were elected for the coming year:

President, - - - - - - - - A. F. Elliot.
Vice-president, - - - - - W. E. Leonard.
Recording Secretary, - - - C. W. Hall.
Treasurer, - - - - - - - - N. H. Hemiup.
Corresponding Secretary, - - W. H. Leonard.
Trustees for three years, - { J. McGolrick, N. H. Winchell.

February 6, 1883.

Thirty-seven persons present.

Mr. John B. Leiberg, of Mankato and Dr. H. W. Brazie of Minneapolis were elected members.

Professor J. A. Dodge, introduced the following resolution:

Whereas, the Water Commissioners of the city of Minneapolis are about to improve the water works of the city on a large scale,

And whereas, it is of vital importance to the city that the supply of water be pure and healthful:

Resolved, that a committee of this Academy be appointed by the chair to investigate this matter and report at a subsequent meeting with a view if possible to secure the purest water to supply the city.

The resolution was unanimously carried and the following members were appointed to constitute this committee: Professors J. A. Dodge and C. W. Hall, Dr. A. E. Johnson, S. C. Gale and C. L. Herrick.

N. H. Hemiup, read the paper of the evening, "a memoir on Charles Darwin" in response to an invitation of the Academy of May 2d, 1882.

A vote of thanks was extended to Mr. Hemiup for his able and interesting paper.

March 6, 1883.

Twenty-four persons present.

Clinton Morrison, R. F. Jones, S. W. Farnham, E. V. White, Geo. W. Hael, Geo. H. Eastman, Dr. Adolph Blitz, C. C. Schmidt, A. W. Rankin and Geo. B. Aiton were elected members.

The following presentations were received:

From Geo. H. Eastman, a complete set of the reports of the survey of the fortieth parallel, 7 volumes with atlas.

From President Elliot, crystallized salt from Great Salt Lake; section of the stem of the century plant from the Sierra Madre mountains, California.

From Rev. E. M. Williams, one years subscription to the *Siderial Messenger.*

C. L. Herrick, chairman, presented a statement of the work of the section of Biology for the past year.

Warren Upham enumerated various botanical works published during the year and stated what had been done to further our knowledge of the botany of Minnesota.

Dr. W. E. Leonard read a paper, "some early Philadelphia botanists," mentioning with biographical and scientific notes, Schweinitz, Nuttall, Rafinesque and Darlington. [See paper A.]

Franklin Benner, then gave an account of the founding and work of the Torrey botanical club of New York.

John B. Leiberg presented a paper "on some plants occurring in Blue Earth and Pipestone counties but rare in the state." [See paper B.]

Professor J. A. Dodge, for the committee on the city water supply appointed at the last meeting presented the report. [See paper C.]

April 3, 1883.

Eight persons present.

A communication was read from Hon. W. D. Washburn, M. C. presenting certain public documents.*

Dr. A. H. Salisbury, Dr. C. M. Skinner, Hon. J. M. Shaw, C. W. Johnson, A. B. Nettleton and Mrs. N. F. Griswold were elected members.

Professor Dodge read a paper entitled, "some results of recent analyses of the water of the Mississippi river from different points in this state." [See paper D.]

May 8, 1883.

Twenty-nine persons present.

Trustee T. B. Walker, presented a series of 196 models from the U. S. Patent office selected by himself for the Academy.

W. A. Noyes, Ph. D., read a paper on "the oxidation of the brom-toluenes," being a continuation of the December paper† on the oxidation of toluene derivatives with potassium ferricyanide and caustic potash. [This paper has appeared in full in the American Chemical Journal, vol. v, No. 2, p. 1.]

Warren Upham, discussed "changes in the currents of the ice of the last glacial epoch in eastern Minnesota." [See paper E.] Also: "The topography and altitude of Minnesota. [See paper F.]

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*The titles of these documents will appear in the library lists.

†Vol. II. p. 417 these Bulletins.

Secretary Hall read a paper by Mr. J. C. Arthur, on "some algae of Minnesota supposed to be poisonous with which also were presented descriptions of Iowa Uromyces."

[This paper by Mr. Arthur was printed by the Academy, May 31, 1883, as an appendix to Bulletin 4, vol. II, and was distributed with that Bulletin. By an unfortunate oversight no references to the paper appear in the index to vol II.

It is hoped that this note will direct the attention of botanists to Mr. Arthur's work.

June 5, 1883.

Eleven persons present.

Dr. R. F. Lynch, of Princeton was elected a member.

Mr. C. L. Herrick read a paper, sketching some recent discoveries and new books in zoology and botany.

August 7, 1883.

A special meeting of the Academy.

Chas. H. Woods was elected a member.

The following committee was appointed to cooperate with other local sub-committees in the entertainment of the American association for the advancement of science which is to meet in this city this month:

President Elliot, Warren Upham, Thos. F. Roberts, Dr. W. E. Leonard, Dr. W. A. Noyes and Rev. Jas. McGolrick.

October 2, 1883.

Thirteen persons present.

The following presentations were made to the Academy:

By Professor J. A. Dodge, silver ore, Black Hawk Mine, Silver City, S. W. New Mexico.

By W. H. Mitchell, two samples of pressed brick made by Forest View pressed brick company, Minto, Dak.

By President Elliot, Pipe made from burnt flour from the mill explosion, May, 1878; gold ore from the Winnipeg consolidated mine Lake of the Woods, 3 samples; gold ore from Hog Island, 1 sample; gold ore from Pine Island, 1 sample; tin ore, San Jacinto, Cal.; Organ pipe coral, Island Java.

Mrs. A. M. Elliot, a tail of a dolphin from Caroline Island; a mammoth starfish from California; eggs of a shark; eggs of a dolphin.

The thanks of the Academy were heartily tendered Professor

F. W. Putnam for a set of the proceedings of the American association for the advancement of science presented by him in August.

A paper was read by secretary Hall, from A. F. Bechdolt, of Mankato, entitled "notes on the local geology of Mankato." [See paper G.]

Warren Upham. then read a review of the recent book by Baron Nordenskjorld. The voyage of the Vega.

November 8, 1883.

Fifty-two persons present.

Andrew Rinker, of Minneapolis and W. J. McGee of the U. S. Geological Survey Washington were elected members.

The following additions to the museum were received:

From Geo. H. Miller, a specimen of native copper weighing 75 lbs. It was taken from the glacial draft at Taylors Falls in 1882.

From President Elliot, silver and gold ores near Helena, Montana, 5 specimens.

From Dr. C. M. Skinner, a nautilus sp? in sections, Yellow Stone river valley.

The evening was devoted to the discussion by the section of Sanitary science of the question: "What aid has science given for the prevention and control of infectious diseases?" An unusually large number of members of the section took part in the discussion and the meeting proved to be one of unusual practical every day interest.

December 4, 1883.

Thirteen persons present.

Presentations: Nathan Butler, some pieces of resin or amber from the coal beds near Dickinson, Mont.

President Elliot, some pieces of ore from mine in Colo.

Professor W. A. Pike gave a description of the methods pursued in testing the strength of materials in engineering schools.

N. H. Hemiup read a paper on "Cosmic dust."

R. J. Mendenhall mentioned a meteoric shower at and around Minneapolis in which a black powdery substance fell on the snow to the depth of from one-sixth to one-fourth of an inch in the winter of 1860-61. The shower was of considerable extent.

January 8, 1884.

Seventeen persons present.

George R. Stuntz of Duluth and H. L. Gordon of Minneapolis were elected members.

The reports of the retiring officers were then listened to.

The Corresponding Secretary, Dr. W. H. Leonard, presented the following list of publications received during the year 1883:

THE UNITED STATES.

CONNECTICUT—*Bridgeport.*—Scientific Society: Annual President's Address, 1882.

Middleton.—Museum of Weslayan University: 11th Annual Report.

DISTRICT OF COLUMBIA—*Washington.*—Bureau of Education. (Dept. of Int.) National Pedagogical Congress of Spain. Circulars Nos. 3, 4, 5. High Schools of Sweden.

Washington.—Patent Office: Official Gazette, Vol's 22 (26 No's) 23 (26 No's) 24 (13 No's) and 25 (12 No's) Annual Report. List of Inventions 1883.

Washington.—Smithsonian Institution: Report of Regents–1881.

Washington.—U. S. Geological Survey: Tertiary History of Grand Canon District. Report of Sec'y of Interior Vol. 3, Geol. Survey, 1881. Report on Wyoming and Idaho, 1878. Geol. Survey by Williams. Geol. Survey, 2nd Annual Report. 1880-81. Bulletin No. 1. Report of Sec'y of Interior, 1882.

Washington.—Signal Service (War Dep't): Report of Chief Officer, 1880. Messages and Documents, Weather proverbs.

GEORGIA—*Savannah.*—Historical Society: By-Laws and Constitution.

ILLINOIS—*Champaign.*—Laboratory of Natural History: Bulletins 5 and 6.

INDIANA—*Indianapolis.*—Geological Survey: 11th Report, 1881.

KENTUCKY—*Louisville.*—Society for the Advancement of Science: Pennsylvania Terminal Moraine.

MASSACHUSETTS—*Cambridge.*—Museum of Comparative Zoology: Annual Report of Curator. Bulletins, Vol. XI, 9 Nos.

Salem.—American Association for the Advancement of Science: Proceedings 1882.

NEW YORK—*New York.*—American Geographical Society: Bulletins, Nos. to 5, 1882; Bulletins Nos. 1 and 2.

New York—*New York.*—American Museum of Natural History: Bulletin, Vol. I, No. 4; Annual Report 1883.
—Linnaean Society: Transactions, 1882; Vol. I.
—Torrey Botanical Club: Bulletin, Vol. X, Nos. 1 to 5.
Poughkeepsie.—Vassar Brothers' Institute: Transactions, Vol. I.
Ohio—*Cincinnati.*—Society of Natural History: Journal, Vol. VI, Nos. 1–2.
Pennsylvania—*Philadelphia.*—Zoological Society: 11th Annual Report.
Rhode Island—*Providence.*—R. I. Historical Society: Proceedings, 1882–3; Memoirs of Z. Allen.
Wisconsin—*Madison.*—State Historical Society: Collections, Vol. IX.

1883.

FOREIGN.

Belgium—*Brussels.*—Royal Museum of Natural History: Extract of Bulletins, 1882.
—Malacological Society: Proceedings, Vol. XII, 1883.
Canada—*Toronto.*—Canadian Institute: Proceedings, Vol. XI, Fasc. 4–5.
—Natural History Society: Check L st of Insects; Label List of Insects.
England—*Liverpool.*—Geological Society: Proceedings, 22nd Ser., 1880–81; Proceedings, Vol. IV., Pt. 4.
Germany—*Hamburg.*—Society of Natural Sciences: Transactions, 1883.
—*Munster.*—Society of Sciences and Arts: Proceedings, 1882.
India—*Bombay.*—Royal Asiatic Society: Journal, 1882.
(Bombay Branch:) Journal, 1882–3.
New South Wales—*Sydney.*—Department of Mines: Mines and Mineral Statistics; Minerals of N. S. W.
—Royal Society of N. S. W.: Journal and Proceedings, 1881; N. S. W. in 1881.
Netherlands—*Harlem.*—Teyler Institution: Archives, Ser. II, 1882.

As the next order the following officers were elected for the ensuing year:

President, - -	A.F. Elliot.
Vice-President, - -	W. E. Leonard.
Recording Secretary, -	C. W. Hall.
Treasurer, - -	N. H. Hemiup.
Corresponding Secretary,	W. H. Leonard.
Trustees for three years,	N. Butler. C. W. Hall.

The thanks of the Academy were extended to President Elliot for the practical suggestions contained in his retiring address.

February 5th, 1884.

Eleven persons present.

A vote of thanks was extended to Mr. Warren Upham for 2,500 museum labels which he presented to the Academy.

The president announced the list of chairmen for the several sections of the Academy, as follows:

Anthropology, - - - - -	A. E. Johnson.
Astronomy, - - - -	N. H. Hemiup.
Biology, - - - - -	C. L. Herrick.
Botany, - - - -	Warren Upham.
Chemistry, - - - -	J. A. Dodge.
Geology, - - - -	C. W. Hall.
Invertebrate Zoology, - - - -	R. J. Mendenhall.
Mineralogy, - - - -	N. H. Winchell.
Microscopy, - - -	J. McGolrick.
Mechanical Philosophy, - - -	W. A. Pike.
Physics, - - - -	M. A. Morey.
Sanitary Science, - - -	Chas. N. Hewitt.
Vertebrate, Zoology, - - -	P. L. Hatch.

The finance committee was announced, consisting of Warren Upham, Professor Dodge and Franklin Benner.

Rev. J. C. Byrne and Rev. J. J. Hand were elected members.

A paper was read by N. H. Hemiup from the Section of Astronomy, entitled: "Asteroids: are they of meteoric or cometic origin?"

The paper was discussed by Rev. J. McGolrick and Mr. M. A. Morey.

The second paper of the evening was on "Storms and Tornadoes" by Warren Upham.

(Mr. Upham first gave some general remarks on circular storms and their geographical distribution, and named several investigators who have made the subject one of protracted investigation; and then extracted the theory of Mr. W. O. Davis from his series of articles in the current numbers of *Science*.)

March 4, 1884.

Twenty-three persons present.

An exchange of specimens was desired by Mr. A. T. Free, of Independence, Iowa. C. W. Hall and C. L. Herrick were appointed by the chair to select from the material of the Academy an equivalent for the specimens sent by Mr. Free and to forward him the same.

The following presentations were made:

By President Elliot: catlinite, Pipestone City, 3 specimens; prehistoric pottery, north of La Crosse, Wis.; 6 pieces Infusorial earth, Bennett Co., Wis.; collection of 11 California plants.

Professor L. W. Chaney, Jr., of Carlton College, Northfield, was elected a member.

C. L. Herrick, from the section of biology, read a paper which dealt particularly with *Monospilus*, a genus of Cladoceran Crustacea, new to America, and peculiar among its relatives in the absence of the compound eye, the larval organ being persistent through life, a fact supposed to be due to retrograde development.

Warren Upham, in introducing the programme of the section of botany for the evening, spoke of the progress made in cataloguing the flowering plants and ferns of Minnesota and expressed the hope that the geological and natural history survey would issue such a catalogue in the course of the coming year.

Dr. W. E. Leonard then read a paper on the condition of the Academy's herbarium, and outlined plans already set on foot for making it as complete as possible for the whole state. Miss Manning, of Lake City, and a clergyman of Saint Paul, among others, had been secured to make collections.

Mr. John B. Leiberg contributed "Notes on the flora of Montana and Dakota." This paper was read by Mr. Upham.

[See paper H.]

Mr. Upham also contributed some interesting facts touching "The Common Weeds of Minnesota." One thing stated was that only about one-half as many introduced plants were growing in Minnesota as in New England, owing no doubt to the more recent settlement of the former section.

April 8, 1884.

Thirteen persons present.

The following presentations were made:

By President Elliot: Leaf impressions, Little Missouri, several; baked earth with tufa, same locality; fossil fern leaves, Morris Co, Ill.; 5 specimens; crystals of antimony sulphide (Stibnite,) Prince William, N. B.; and the three following from Iron Butte, Mont.: *inoceramus problematicus*, *ammonites sp?: baculites*, probably *Ovatus*. Several other specimens not named, were received from Col. J. B. Clough, localities in Dakota and Montana.

The paper of the evening was read by Professor J. A. Dodge, entitled "An Analysis of Filtered Water."

[See paper I]

In the discussion which followed, C. W. Hall called attention to some of the physical features of the upper Mississippi valley. He said:

The area of the Mississippi river valley above the mouth of the Minnesota river at Fort Snelling is, according to a careful computation, 16,596 square miles, and its altitude will average over 1300 feet above the Gulf of Mexico. There are in all this area no prominent ridges of high land, and, consequently, no rapid streams. This area is almost wholly forest covered, and a large portion of the pine forests of the state are included here.

The entire surface is drift covered, the material for this mantle, which is often 250 or more feet thick, coming from the pre-Cambrian area of the central and northwestern portions of the state, and from these same rocks and the Cretaceous beds which once undoubtedly covered the western and north-western portions of Minnesota. Swamps are numerous and extensive; the brooks and creeks draining them are sluggish; the annual rainfall is about 27 inches per annum. Thus the water which comes from this territory to Minneapolis would naturally contain a diversity of mineral constituents and much organic matter.

May 6, 1884.

Twelve persons present.

Rev. Dr. H. C. Hovey was elected a member.

C. W. Hall, chairman of the section of geology, in introducing the programme of the evening gave a brief sketch of the geological work of the different members of the section during the past year.

"An Account of chains of Glacial Lakes in Martin County, Minnesota," was given by Warren Upham. These Lakes, the speaker maintained, show suggestive features to our seeking a key to the position of the moraines in that part of the state, and to the removal of the superabundant waters which must have been present at the melting away of the lobes of ice reaching towards central Iowa from Minnesota and Dakota.

Mr. Upham then discussed "the Glacial Moraines of Minnesota."

The speaker arranged these moraines into the following lines of hills and knolls, each line representing a moraine, and each moraine named after the locality where it is especially prominent:

a Altamont;
b Gary;
c Antelope hills;
d Kiester;
e Elysian;
f Waconia, Carver County;
g Dovre;
h Fergus Falls;
i Leaf Hills;
j Itasca;
k Mesabi.

He now holds that there are no medial or interlobate moraines in the state; all are *lateral.*

C. F. Sidener laid before the Academy a brief account of the method of preparing the Chamberlain patent illuminating gas, with a description of the apparatus used. In the informal discussion which followed, participated in by Dr. S. H. Chute and Secretary Hall, the speaker considered the manner of condensation of the gas and its cost to consumers.

June 3, 1884.

Fifteen persons present.

C. L. Herrick presented some notes on a few infusoria which had been observed by himself and the class in zoology in the University of Minnesota.

Secretary Hall read a letter from Rev. Louis J. Hauge to the Academy, mentioning the occurrence of fossil wood in the drift at various depths and at various localities in Minnesota and Dakota, and giving an account of the occurrence of stumps and other vestiges of a forest among the "foot hills" of Dakota and Montana, with the possible relation of these to the religious rites of the early Indians of the region.

[See paper J.]

Rev. H. C. Hovey related some interesting observations about the ant-lion, specimens of which he kept constantly in his library.

October 7, 1884.

Fifteen persons present.

Dr. A. A. Camp, of Minneapolis, was elected a member.

Presentation was made by Professor J. A. Dodge, of three specimens of pyrolusite from Nova Scotia: They represented a deposit of this mineral worth about one hundred dollars per ton.

Secretary Hall presented a series of hand specimens, eight pieces, representing the lithology of the Trenton and Cambrian rocks at Minneapolis.

Mr. O. W. Oestlund offered some remarks on insects injurious to the cabbage, as noticed this season on the Experimental Farm of the State University. Nine different species were mentioned as living on the cabbage. Those noticed as especially destructive were and *Plutella cruciferarum*, Zell.
Pieris rapæ, Schr; *Pleusia brasiccæ*, Riley; *Ceramica picta*, Harris;

The laeva of Pieris rapæ has this year been subjected to a sickness that has carried off a great number of them and undoubtedly done much towards the saving of the cabbage crop. Attention was also called to the occurrence of the harlequin cabbage bug, Murgantia histrionica, Hahn, in the state. This is a southern insect that has been extending its range northward, something as the Colorado potato-beetle has eastward, and if it prove as destructive here as further south the cabbage growers of this state will have a new pest to contend with not inferior to the larva of the imported cabbage butterfly.

Secretary Hall gave a brief description of the geological features of the Minnesota river valley where the United States geological survey had been prosecuting field work during the season under his charge.

Warren Upham called attention to some of the features of United States geologist Chamberlain's classification of the glacial moraines of the northwest.

A report from the section of botany was received through chairman Upham.

Among the things mentioned in this report was the collection of plants recently received from Miss Sara Manning of Lake City, consisting of the following:

Minnesota plants, - -	157	species.
Wisconsin plants, - -	49	"
New Jersy plants, - -	15	"
Total, - .	221	"

Of the 157 Minnesota species 37 were already in the herbarium of the Academy, leaving 120 new species thus added. Nearly all the specimens of species are numerous enough to leave several for exchanges.

The thanks of the Academy were heartily voted to Miss Manning for this excellent collection of plants.

November 11, 1884.

Sixty persons present.

Secretary Hall being absent, Professor J. A. Dodge was elected secretary *pro-tem.*

Mr. A. F. Bechdolt, of Mankato, sent a paper to the Academy on the discovery of "an inter-glacial bed of peat near Mankato." The peat occurred between two layers of glacial drift consisting principally of clay, and it possesses some of the characters of lignite. The bed was about two feet thick. Samples of the material were presented the Academy illustrative of the paper.

A communication was offered by Judge N. H. Hemiup having reference to the question of a public building to be built for uniting the places of meeting of this Academy and the Athenaeum library. Mr. Hemiup moved that a committee of three, of whom President Elliot should be one, be appointed to consider the matter in conference with the trustees of the Athenaeum, with a view to solicitation of funds from the public.

The motion prevailed as did an additional resolution bearing on the same subject, offered by Professor N. H. Winchell, as follows:

Resolved: That it is the sense of The Minnesota Academy of Natural Sciences that there should be erected a joint building for the accommodation of the Academy, the Athenaeum and the Minneapolis Society of Fine Arts, and that this Academy will gladly co-operate with any parties who may inaugurate a general movement to secure this event.

President Elliot selected as his associates on the committee to consider the project, T. B. Walker and S. C. Gale.

The report of the section of sanitary science was next taken up.

Chairman C. N. Hewitt, in introducing this report made some reference in the first place to the work of investigators in different departments by the newer methods, as those of Pasteur, etc. The speaker thought too much time had been taken up by these scientific discussions, to the neglect of simple, well known and effectual modes of prevention and repression of contagious diseases. The doctor proposed to point out, *first*, some of the methods and means of preventing disease; and *second*, some of the results really obtained. He gave a brief general statement of the relations of hygiene and family life.

The first special paper was on "The Relations of Contagious Diseases to Filth, as found in this city;" by the health officer of Minneapolis, Dr. T. F. Quinby. The speaker proposed to discard technicality. He spoke of the now universally accepted theory of infection by bacteria or bacilli. The ratio between accumulated filth and disease of some sort is a direct one. If these sources of filth do not produce the germs themselves they favor their development. For examples the speaker referred to the ill effects of sewer gas; also to the danger from old privies, whether open or filled with earth. Some precautions were deemed advisable in view of the prospects of the passage of cholera to this country next year.

1. Clean up privies and cess-pools.
2. The river water should be examined. The building of the new Union depot on its bank, it is said, will be likely to contaminate the water.
3. Wells should not be used in the thickly settled portions of the city.

A diagram of the vicinity of Bassett's creek was shown with dots indicating where diphtheria and scarlet fever has recently occurred. This was in the third ward. A similar diagram of the fifth ward was shown with dots indicating scarlet fever cases. The doctor thought these latter cases were explained by drive wells and privies. In the seventh ward a cemetery was referred to as a cause of much disease, especially diphtheria. More legislation was recommended; also the co-operation of all citizens to remove filth accumulations and to prevent them in future.

The next paper was by Mr. Van Duzee, sanitary engineer of Minneapolis. Mr. Van Duzee exhibited a plan of the sewage system of the city which he explained, pointing out the locality, direction, etc., of the principal sewers in different districts. The general plan was said to be to deposit all sewage below the falls if possible. A diagram of a so-called well connecting with the sewer was shown and explained; also the connection of the well with a tunnel. Reference was made to a method of permitting the "storm water" to be run off without passing through the sewer tunnels. In reply to a question by Dr. Hewitt whether it was possible to convey the sewage to some place south of the city and deposit it on the land instead of passing it into the river, the engineer thought it was possible to utilize land between the Chicago, Milwaukee & St. Paul railway bridge and Minnehaha creek for this purpose. He stated further that only about one-tenth of the people who could avail themselves of sewer privileges had as yet done so.

Dr. C. H. Hunter then presented a paper on "Specific Bacteria." He began with an aphorism—"Nature abhors death"—referring in this to the extraordinary rapidity and universality of the development of infusoria and bacteria in filth. Among those forms generally recognized as germs, the doctor discussed that which is so often introduced into wounds and cause pyæmia; that which is the cause of typhoid fever; that of consumption, discovered by Koch; that erysipelas; that of pneumonia.

Professor Dodge discussed "the filtration of water." Several results of analyses of unfiltered and of filtered water from the Mississippi river were given. The unfiltered water gave about five times as much ammonia as the filtered, and so far as this is a criterion of purity the filtered water is by far to be preferred. The permanganate test gave substantially similar results. Some discussion followed bearing on the different forms of filtering apparatus, and the different kinds of filtering media.

The chairman, Dr. Hewitt, recommended Tobin's ventilation for cesspools; Waring's system of cess-pool arrrangement was also recommended, and the well water of the city was condemned in the strongest terms. The chairman concluded by alluding to the hygienic errors in the home life of the people which were not connected with infectious diseases and to the general carelessness of people about health questions.

December 2, 1884.

Thirteen persons present.

A paper by Geo. R. Stuntz, of Duluth, was read by the Secretary, entitled: "Early Man in Northwestern Minnesota."

[See paper K.]

The paper provoked some discussion which led the Academy to direct the secretary to solicit from Mr. Stuntz another paper which should describe somewhat in detail the method of improving navigation adopted by the early navigators of the streams of northeastern Minnesota.

N. H. Hemiup then read a paper on "The Characters of the Marsupialia."

January 6, 1885.

Twenty-three persons present.

The secretary read a paper from Mr. Geo. R. Stuntz, of Duluth, entitled "The Mound Builders in Northeastern Minnesota: Their Occupations and Routes of Travel."

[See paper L.]

N. H. Hemiup brought up the question of aiding the pupils of the public schools to organize a Natural History society. S. C. Gale spoke strongly in favor of the policy of encouraging pupils of every grade of advancement to an interest in scientific subjects.

So far as it pertained to opening the hall of the Academy the matter was placed in charge of Judge Hemiup.

The reports of the retiring officers were listened to. Among them was the following from the Corresponding Secretary, Dr. W. H. Leonard, of publications received during the year 1884:

THE UNITED STATES.

California—*San Francisco.*—Academy of Natural Sciences: Bulletin No. 1, 1884.

Connecticut—*New Haven.*—Academy of Arts and Sciences: Transactions, Vol. vi, Pt. 1.

D. C.—*Washington.*—Congressional Library: Report of Tariff Commission; Report of Yorktown Commission; Proceedings of Congress on Presentation of Jefferson's Desk.

—Patent Office: List of Inventions; Official Gazette; Vols. 26 (13 Nos.,) 27 (13 Nos.,) 28 (14 Nos.) and 29 (13 Nos.)

—Smithsonian Institution: Report of Regents, 1882; Annual Report of Bureau of Ethnology, 1880–1.

—U. S. Fish Commission: Report for 1880.

—U. S. Geological Survey: Geological Survey, Vol. iii; Map; Mineral Resources, 1883.

Indiana—*Indianapolis.*—Geological Survey; Geological and Natural History Report, 1883.

Iowa.—State Board of Health: 1st and 2nd Biennial Reports; Typhoid Fever: nature, causes, etc.; Preventitive Medicine.

Massachusetts—*Boston.*—Society of Natural History: Proceedings, Vol. 22, Pts. 1, 2, 3 and 4.

—*Cambridge.*—Museum of Comparative Zoology: Vols. i, ii, iii, v, vi, vii, viii, ix, x, xi and xii; 25th Annual Report of Curator, 1884–85.

—*Salem.*—American Association for the Advancement of Science: Proceedings, 1883.

—Essex Institute: North American Reptiles.

MICHIGAN—*Ann Arbor.*—University Library: Philosophy of Ralph Cudworth.
Grand Rapids.—Horticultural Society: Annual Reports, 1881-2-3; Pomological Report 1872-5-6-9 and 80.

MINNESOTA—Horticultural Society: Reports 1866 to 1884.
—State Board of Health: 9th Report of Board.
—*Minneapolis.*—Geological and Natural History Survey: Geological Survey, Final Report, Vol. I.
—University of Minnesota: Catalogue of Flora of Minnesota, Upham.

MISSOURI—*St. Louis.*—Academy of Science: Transactions, Vol. IV, No. 3.

NEW YORK—*Buffalo.*—Society of Natural Sciences: Bulletin, Vol. IV, No. 4.
—Historical Society: Publication, Vol. II.
—*New York.*—American Geographical Society: Bulletins Nos. 3 to 6, 1883; Bulletins Nos. 1 and 2, 1884.
—American Museum of Natural History: Bulletin Vol. I, No. 5; Annual Report, 1884.
—Linnæan Society: Transactions, 1884; Vol. II.
—*Poughkeepsie.*—Vassar Brothers' Institute: Transactions, Vol. II, Pt. 1.

OHIO—*Cincinnati*—Society of Natural History: Journal, Vol. VII, Nos. 1, 2, 3 and 4.

PENNSYLVANIA—*Philadelphia.*—Academy of Natural Sciences: Proceedings, 1883, Pts. I, II and III; Proceedings, 1884, Pts. I and II.
—Zoological Society: 12th Annual Report.

RHODE ISLAND—*Providence.*—R. I. Historical Society: Proceedings, 1883-4; Catalogue of Library.

WISCONSIN—*Madison.*—Wisconsin Natural History Society: Proceedings, 1880-81.

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ARGENTINE REPUBLIC—*Cordoba.*—National Academy of Sciences: Bulletin, Vol. VI, Nos. 1, 2 and 3.

CANADA—*Ottawa.*—Geological and Natural History Survey: Report of Progress, 1880-81-82; Maps.
Toronto.—Canadian Institute: Proceedings, Vol. II, Fasc. 1.

ENGLAND—*Liverpool.*—Geological Society: Proceedings, Vol. IV, Pt. 5.
London.—Alexander Ramasy, F. G. S.: The Scientific Roll, Pt. I, Nos. 1, 2, 3, 4 and 5; Pt. II, Nos. 7, 8, 9, 10 and 11.

INDIA—*Bombay.*—Royal Asiatic Society, (Bombay Branch:) Journal, Vol. XVI, No. 42.

NETHERLANDS—*Harlem.*—Teyler Institute: Archives, Ser. II, Pt. 4.

NOVA SCOTIA—*Halifax.*—Institute of Natural Sciences: Proceedings, Vol. VI, Pt. 1.

After the reports of the retiring officers were listened to, the following board of officers for the year was elected:

President, - - -	A. F. Elliot.
Vice-President, - -	J. A. Dodge.
Recording Secretary, -	C. W. Hall.
Treasurer, - - -	N. H. Hemiup.
Corresponding Secretary,	W. H. Leonard.
Trustees for three years,	T. B. Walker, R. E. Grimshaw.

February 3, 1885.

Six persons present.

President Elliot presented a stone hammer found near Otsego, Wright County, in 1881.

H. L. Gordon presented a stone hammer used in making pemmican by the Indians living near Fort Abercrombie. It was picked up by the donor near that place in 1871. Weight 12 pounds.

N. H. Hemiup, chairman of the section of Astronomy, read two short papers:

1. "Encke's Comet."
2. "Biela's Lost Comet."

The president announced two changes had occurred in the chairmanships of sections, as follows:

Section Invertebrate Zoology, L. W. Chaney, Jr., chairman, in place of R. J. Mendenhall.

Section Microscopy, P. L. Hatch in place of J. McGolrick.

There were also two or three vacancies which would soon be filled; otherwise the heads of the sections remain unchanged*.

March 3, 1885.

Twenty persons present.

Secretary Hall read some notes on the progress of Mineralogy during the year 1884, giving some of the results reached in this field of research and the names of the investigators who were most diligent in the work in this country and in Europe.

President Elliot spoke for a few minutes of his visit to New Orleans. What he said related particularly to the location of the city; its system of sewage and its sanitary conditions.

The president presented several geological reports.

Warren Upham introduced the report of the section of botany by brief outline of what were deemed to be the most marked triumphs of botanists throughout the world during the year 1884. Mr. Upham further occupied some minutes in giving the Academy

*See list for 1884, p. 10.

a few impressions received during a visit to New Orleans in December last. They were chiefly botanical impressions, and introduced some observations relating to the geographical distribution of plants.

W. E. Leonard then read before the Academy a review of Professor Sargent's monograph "The Forest Trees of the United States," being vol. IX of the Tenth Census Reports. The maps accompanying the mongraph served to illustrate the statements and quotations made.

A paper by John Leiberg was read by Mr. Upham, entitled, "The Forest Trees of Idaho."

[See paper M.]

Some discussion of the paper followed the reading. participated in by members Hemiup, Hovey and Upham.

April 7, 1885.

Twenty-four persons present.

Nathan Butler presented a skinning knife from Ellsworth, Me., found one and one-half feet below the surface.

Professor J. A. Dodge, presented a paper from the Section of Chemistry entitled: "Some Analyses of Coals and Lignites from the Northern Pacific territory." [See paper N.]

May 5, 1885.

Twenty-six persons present.

C. W. Hall, in introducing the program prepared for the evening by the Section of Geology reported the work engaged in during the year past by the several members of the section following with an outline of his own observations on the Geology of the Southern portion of the State and closing with a summary of Irving's researches in the great Keweenawan trough of Lake Superior as recently published in his Monograph.*

Rev. H. C. Hovey, read a paper on the Geology of some portions of Australia closing with a resume of the structure of the continent.

Following that paper Dr. Hovey gave a description of the newly discovered and interesting caves of the Fish river valley. Fifteen stereopticon views illustrated this description.

Warren Upham, recounted some of the results of recent re-

*R. D. Irving. The Copper bearing rocks of Lake Superior. Monograph V, U. S. Geol. Survey, Washington, 1883.

searches in the Glacial Geology of Minnesota. The paper was based largely on Mr. Upham's own labors and observations and reflected his most mature views on the subject.

June 2, 1885.

Eighteen persons present.

Professor L. W. Chaney, Jr., of Carleton College presented a paper on the Anatomy of the Crayfish, with some observations on its embryology.

O. W. Oestlund read "Notes on the numbers of insects already known and probably to be found within the State."

Secretary Hall read a paper by Mr. J. C. Arthur on "Some Algae of Minnesota, supposed to be poisonous." This was a second paper on the subject by Mr. Arthur, the first having been already published by this Academy.*

[See paper O.]

October 6, 1885.

Eighteen persons present.

The Northern Pacific Coal Company, through Mr. C. F. Sidener, presented a series of coal and lignite specimens. These specimens represent the same coals and lignites analyzed by Professor Dodge and Mr. Sidener and reported by the former at the April meeting last.

Secretary Hall read a paper from N. H. Winchell entitled "The Lingulae and Paradoxides of the Catlinite of Southwestern Minnesota." [See paper P.]

Warren Upham read a paper on "Red Lake and the Ojb. ways" with geological and botanical observations on Northwestern Minnesota.

C. W. Hall read "a brief history of Copper-mining in Minnesota." [See paper Q.]

Also a paper on "the lithological characters of the Trenton limestone of Minneapolis and St.Paul," with a note on the borings of the West Hotel artesian well. [See paper R.]†

November 3, 1885.

Thirty-three persons present.

President Elliot called the attention of the members present

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*Vol II, Bul. IV, Appendix.

†The paper as published is an abstract of what was given at this time, and that presented one year ago when a series of samples of the Trenton and Cambrian rocks at Minneapolis was presented to the Academy. See page 13, C. W. H,

to a communication from Anna M. Briggs of Briggs Lake, Minnesota, offering for sale a collection of mounted birds.

Professor L. W. Chaney, Jr., exhibited and described the sledge microtome manufactured by the Bansch and Lomb Optical Co.

Dr. Charles N. Hewitt read a paper for the section of Sanitary Science on "the water of Artesian wells; its quality and the possibility of its becoming a source of Supply in Minnesota."

Secretary Hall followed with a paper on "the geological conditions which control Artesian well boring in Minnesota." A series of sections was shown illustrating the depth of the leading Artesian wells of Minnesota and the position of the several water-bearing strata of the Southeastern portion of the State.

[See paper S.]

December 8, 1885.

Thirteen persons present.

F. L. Washburn was elected a member.

Professor H. F. Nachtrieb of the University of Minnesota gave an interesting account of life at a seaside laboratory.

The account was base l on incidents of personal experience at the Chesapeake biological laboratory located at Beaufort, N. C. The speaker outlined some of the methods pursued in collecting and preserving material for study, stating points not disputed but universally accepted by workers touching the possession of the same, and detailing the various ways of working up the supplies of material constantly on hand.

Rev. Dr. Hovey and F. L. Washburn followed with pleasant reminiscences of laboratory life.

January 5, 1886.

Eight persons present.

As this was the annual meeting of the Academy the reports of the retiring officers was the first order of business.

The following is the report of the corresponding secretary:

1885.

THE UNITED STATES.

CALIFORNIA—*San Di go.*—Society of Natural History: West American Scientist, October, 1885.

San Francisco.—Academy of Natural Sciences: Bulletins Nos. 2 and 3.

COLORADO—*Denver.*—Colorado Scientific Society. Proceedings, Vol. I, 83-84.

CONNECTICUT—*Hartford.*—Historical Society. Collections, Vol. I and II.

Meriden—Scientific Association. Transactions, Vol. I, 1884.

New Haven.—Academy of Arts and Sciences. Transactions, Vol. VI, Pt. 2.

DIST. COLUMBIA—*Washington.*—Census Office. (Dept. of Int.) 10th Census Vol. XI, Pt. 1 v. 10th Census, Vol. —.

—National Academy of Sciences. Report for 1883.

—Patent Office. Official Gazette Vols. 3031, 32 and 33, with Index and Lists. Report of Commissioner of Patents 1884.

—Smithsonian Institution. 2nd Annual Report of Bureau of Ethnology 1880-81. Annual Report for 1883. 3rd Annual Report, Bureau of Ethnology 1881-2.

—U. S. Fish Commission. Osteology of Arnia Calva.

—U. S. Geological Survey. Bulletin Nos. 2 to 6. Coleoptology of N. A., Pt. I. Internal Commerce 1882. Commerce and Navigation, 1880. Foreign Relations 1883. Comstock Lode, 3rd Annual Report 1882-3.

—U. S. Geological Survey, Vol. VIII. Monographs, Nos. IV, V, VI, VII and VIII. 4th Annual Report 1882-3. Bulletins Nos. 7, 8, 9, 10, 11, 12, 13 and 14.

—Signal Service. (War Dept.) Report for 1884. Report of International Expl. to Alaska.

GEORGIA—*Savannah.*—Historical Society. Origin of the Plan of Savannah.

ILLINOIS—*Champaign.*—State Entomologist. 12th and 13th Annual Reports.

—Laboratory of Natural History; Bulletin, Vol. II, Arts. I and III, 1884.

Chicago.—Dearborn Observatory. Annual Reports for 1880-81-82-83 and 84.

INDIANA—*Brookville.*—Society of Natural History. Bulletin No. 1.

IOWA—*Iowa City.*—State Historical Society. Iowa Historical Record, Vol. I, Nos. 1, 2, 3 and 4. 15th Biennial Report 1883.

—Academy of Science. Bulletin, Vol. I, No. 1.

KANSAS—*Topeka.*—Academy of Sciences. Transactions, Vol. IX, 83-4.

Washburn College. Bulletins, Vol. I, Nos. 1, 2, 3 and 4.

Labratory of Natural History; Brown's Catalogue of Birds.

MAINE—*Portland.*—Society of Natural History. Proceedings, Vol. I, Pts. 1 and 2, for 1862-69. Proceedings for 1880-81-82. Journal, Vol. I, No. 1, 1864, Catalogue of Plants 1868.

MARYLAND—*Baltimore.*—John Hopkins University. Circulars, Vol. IV, Nos. 36 to 45, 1885.

MASSACHUSETTS—*Boston.*—American Academy of Arts and Scienes. Proceedings, Vol. XX.

—Society of Natural History. Proceedings, Vol. 23, Pt. 1.

MASSACHUSETTS—*Cambridge.*—Museum of Comp. Zool. Bulletin, Vol. XII, No. 2. 25th Annual Report of Curator.

Boston.—Horticultural Society. Transactions, 1884, Pts 1 and 2, 1885, Pt. I.

Salem.—Amer. Ass'n. for the Advancement of Science. Archæan Palæozoic Contact near Philadelphia.

Worcester.—American Antiquarian Society. Index to Proceedings. Catalogue of Library.

MICHIGAN—*Agricultural College.*—State Board of Agriculture. Bulletins, Nos. 5, 6, 7, 8 and 9. 23rd Annual Report, 1884.

MINNESOTA—*St. Paul.*—Fish Commissioners. Annuals Reports, 1881-2 and 3.
—Historical Society; Collections, Vol. V.

MISSOURI—*St. Louis.*—State Historical Society. Publications, No. 7 and 8.

Sedalia.—Natural History Society. Bulletin No. 1, 1885.

NEW JERSEY—*New Brunswick.*—State Geological Survey. Report of Clay Deposits of N. J., 1878. Catalogue of N. J. Plants, 1881. Annual Report of Geologist for 1882-83 and 84. Atlas Sheets Nos. 2, 3, 4, 6, 7 and 16.

NEW YORK—*Buffalo.*—Historical Society. Annual report, 1885. Transactions, Vol. III.

New York.—American Geographical Society. Bulletin No. 4, 1884. Bulletin No. 1, 1885.
—American Museum of Natural History. Bulletin Vol. I, No. 6. Annual Report, 1884-5.
—Microscopical Society. Journal, Vol. I, Nos. 2, 3, 4, 6 and 7.

OHIO—*Cincinnati.*—Society of Natural History. Journal, Vol. VIII, Nos. 1, 2 and 3.
—Historical and Philosophical Society. Diary of Zeisberger, 1781-98, Vols. I and II.

Columbus.—Geological Survey. Report Vol. III, Pt. I, Geology, 1878. Report Vol. IV, Pt. I, Zoology. 1882.
—State Board of Agriculture. Reports for 1878-79-80-81-82 83. Crop Reports, July, August and September, 1885.

PENNSYLVANIA—*Philadelphia.*—Academy of Natural Sciences. Proceedings, 1885, Pt. 2, Marginal Kames.
—American Entomological Society. List of Coleoptera of America north of Mexico, 1885.
—American Philosophical Society. A great Trap Dyke across S. E. Penn. H. C. Lewis.
—Zoological Society. 13th Annual Report.

RHODE ISLAND—*Providence.*—R. I. Historical Society. Proceedings, 1884-5; Some New England Almanacs.

SOUTH CAROLINA—*Charleston.*—Elliott Society of Science and Art. Proceedings, vol. 1859-60. Swainson's Warbler, 1885.

South Carolina—*Columbia.*—Department of Agriculture. South Carolina, its resources, population, etc.

Tennessee—*Nashville.*—Geological Survey. Vanderbilt University. Report for 1885. Report of Experimental Work in Agricultural Department. Proceedings Southern Immigration Association, 1884. Handbook of Tennessee.

Virginia—*Richmond.*—Historical Society. Collections, Vol. I, II, III, and IV. Proceedings, February, 1882. Map of Virginia.

Wisconsin—*Madison.*—State Historical Society. Catalogue of Library Vols. I, II, III, IV, V and VI. 2nd and 3rd Annual Reports, 1855-6. 29th, 30th and 31st Annual Reports.

—Wisconsin Natural History Society. Proceedings, March, 1885.

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FOREIGN.

Argentine Republic—*Cordoba.*—National Academy of Sciences. Bulletin, Vol. VI, No. 4. Records, Vol. V, Nos. 1 and 2.

Belgium—*Brussels.*—Belgic Microscopical Society. Microscopical Representations of Diatoms.

—Malacological Society. Proceedings, Vol. XIV, 1885.

Canada—*Montreal.*—Natural History Society. The Canadian Record Vol. I, Nos. 1, 2, 3 and 4.

Ottawa.—Geological and Natural History Survey. Comparative Vocabularies of Indian Tribes. Sketch of Phys. Geog. and Geol. of Canada, Maps. Report of Progress, 1882-84. Maps. Catalogue of Canadian Plants Pt II.

Toronto.—Canadian Institute. Proceedings, Vol, III, Fasc. 2.

England—*Liverpool.*—Geological Society. Proceedings, Vol. IV, Pt. VI. Proceedings, Vol. V, Pt. 1.

Bath.—Postal Microscopical Society. Journal of Microscopical and Natural Science, Vol. IV, Pts. 13, 14 and 15.

France—*Lyon.*—Society of Scientific Studies. Bulletin, Vol. 3, Nos. 1 and 2. Bulletin, Vol. 2, No. 2. Bulletin, Vol. 4, No. 1.

Linnœan Society. Annals, Vol. 30, 1883. Dr. St. Lager's Researches about Plants.

Germany—*Munster.* Society of Sciences and Arts. 12th and 13th Annual Reports.

India—*Bombay.*—Royal Asiatic Society (Bombay Branch.) Journal Vol. XVI, No. 44.

Italy—*Milan.*—Ulrico Hœpli, Bookseller. Catalogue of Ancient Library.

Manitoba—*Winnipeg.*—Historical and Scientific Society. Transactions, Nos. 2, 3, 4, 5, 12, 13, 14 and 15. Our Northern Waters.

New Brunswick—*St. Johns.*—Natural History Society. Bulletin No. IV, 1884. Bulletin No. IV, 1884-5.

New South Wales—*Sydney.*—Royal Society of N. S. W. Journal and Proceedings Vol. XVII. Journal and Proceedings Vol. XVIII.

NETHERLANDS—*Harlem.*—Teyler Institution. Archives, Ser. II, Vol. II, 1885.
NOVA SCOTIA—*Halifax.*—Institute of Natural Sciences. Proceedings and Transactions, Vol. VI, Pt. II.
PORTUGAL—*Lisbon.*—Royal Academy of Sciences. Memoirs, Vol. V, Pts. 1 and 2. History, Vols. VII, VIII and IX. Journal of Mathematics, 5 Nos. Journal of Botany. Journal of Zoology. Journal of Physics. Journal of Flora. Journal of Public Sessions.
RUSSIA—*Moscow.*—Imperial Society of Naturalists. Bulletin, Vol. 60, No. 3, 1884.
SCOTLAND—*Glasgow.*—Geological Society. Transactions, Vol. VII, Pt. II.
TURKEY—*Constantinople.*—Hellenic Philological Society. Periodical Compilations, Vol. 15, Pt. 1. Archelogical Supplement 1880-81.

Officers elected for 1886.

President, - - - - - - - -	A. F. Elliot.
Vice-president, - - - - - - -	J. A. Dodge.
Recording Secretary, - - - -	C. W. Hall.
Treasurer, - - - - - - - -	N. H. Hemiup.
Corresponding Secretary, - -	W. H. Leonard.
Trustees for three years,	J. McGolrick, N. H. Winchell.

February 2, 1886.

Three persons present. No quorum.

March 2, 1886.

Eight persons present.

Mr. O. W. Oestlund described "the renewal or reproduction of lost or mutilated limbs by insects."

The reader in illustration showed an insect which had by accident lost the use of one wing; the wing in its mutilated condition still remained, but another, a fifth, had been grown for service in flying. [See paper T.]

Secretary Hall gave an abstract of Bulletin 23 U. S. Geological Survey, Irving and Chamberlin.

This Bulletin is an important contribution by the authors to the discussion of the question of the relative stratigraphy and age of the Cupirferous Series--the Keweenaw group of Irving—and the so-called Eastern, horizontal, sandstones of the Lake Superior valley. The Keweenaw series is of a distinctly bedded nature; even the so-called eruptive rocks of the region came under this condition. There is a persistent uniformity and steadiness of dip, and this dip involves beds of enormous thickness, certainly 35,000 feet, while the Eastern sandstone is horizontal and aggregates a far less thickness. Again the Eastern sandstone is made up in the main of quartz grains while the

Keweenaw series is made up of silicate sands. A marked distortion of strata occurs along the line of junction between the two formations; the beds are bent up usually, exceptionally down, along this junction and there is a line of *junction debris* partly trappean and partly of detrital material, with contact faces, slickensides and foliated structure.

From these and other specification, the conclusion is reached by the authors "that the Keweenaw series is much older than the Eastern (Potsdam) sandstone; that it was upturned, faulted along the escarpment and much eroded before the deposition of the Eastern sandstone; that the latter was laid down unconformably against and upon the former and that subsequently minor faulting along the old line ensued, disturbing the contact edge of the sandstone." [Page 106.] The Trenton limestone and possibly other formations were subsequently laid down to be removed again at a still more recent date.

April 6, 1886.

Three persons present.

The evening after the city elections and no quorum.

May 4, 1886.

Sixteen persons present.

F. L. Washburn read a paper prepared by Mr. N. Kolkin for the Academy entitled, "the effect of an electric current on the oscillation of suspended bodies.

The secretary read for Mr. John Leiberg, "some notes on the most recent fossil flora of North Dakota and an inquiry into the causes that have led to the development of the treeless area of the Northwest." [See paper U.]

A paper by Warren Upham was read giving "a description for a set of maps showing the climate, geography and geology of Minnesota." [See paper V.]

The Secretary C. W. Hall gave the Academy an account of the tornado which visited St. Cloud in April last. [See paper W.]

June 8, 1886.

Seventeen persons present.

Miss Gertrude J. Leonard was elected a member.

Professor L. W. Chaney, Jr., from the section of invertebrate zoology discussed "the anatomy and embryology of *Unio*," embodying the professor's laboratory notes and studies so far as he had been able to pursue them in a single season.

Mr. F. L. Washburn gave an account of the method employed on the U. S. Fish Commission's Steamer Albatross in securing marine invertebrates, with incidental mention of the character and outfit of the vessel.

Mr. Washburn was on board the Albatross as one of the U. S. naturalists during the winter cruise to Nassau, Key West and other points along the coast of the United States in the season of 1885-6.

October 5, 1886.

Nine persons present.

Herbert W. Smith of St. Paul was elected a member.

President Elliot presented some silver ores, (part of them also gold-bearing) from the following localities in Montana; the Corinth mine; the Athens mine; the Lafayette mine; the Hennepin mine; the Arabi mine; the McQuinn mine and the Mt. King mine. The same donor presented a piece of Obsidian from Obsidian mountain, Yellow Stone Park.

Dr. E. S. Kelley presented a potato which exhibited a curious anomaly of vegetable growth; in that from an old potato remaining in the dark during the summer, a vine had developed and a single tuber had formed about three-fourths the size of the old one and 8 inches from it on the vine. This was an illustration apparently of growth by simple metastasis without the process of assimilation taking any preceptible part.

Secretary Hall presented some pyrite concretions from an artesian well at Aberdeen, Dak. and gave some geological facts bearing on the water supply of the eastern half of Dakota.

November 2, 1886.

Thirteen persons present.

S. P. Channell was elected a member.

A discussion on certain psychical phenomena and the work of the American and English societies for psychical research took place led by M. A. Morey.

Adjourned to meet the 16th inst. for the report of the section of sanitary science.

November 16, 1886.

Corresponding Secretary W. H. Leonard presided.

Dr. Charles N. Hewitt of Red Wing read a paper from the section of sanitary science of which the following is a syllabus:

The science and art of public health; their works; their future; and their claims to personal and public use and assistance. Recent advances in the leading departments of the subject were reviewed e. g. bacteriology, illustrated by a number of slides under microscopes; air and water as related to health and disease; their microsceopy and chemistry; preventive work against specific diseases e. g. rabies, variola, ague, etc., in man and lung plague and other diseases in cattle. The mutual relations of infectious diseases of animals and of man and the methods of preventing and controlling both. Organization as against causes of ill-health, sickness and premature death was urged. The interest of the individual; the family; society; and the state in the subject, and the obligations which it occasions were set forth.

Dr. Smart of Washington who was present gave some interesting points on the subject of the sanitary analysis of drinking waters and a brief history of the development of chemical analysis as a phase of the work.

December 7, 1886.

Thirteen persons present.

Corresponding Secretary W. H. Leonard presided.

N. H. Hemiup read a paper entitled "Some notes on the inhabitants of Terra del fuego; the lowest type of the human family.

The paper was followed by a discussion participated in by several members.

N. Kolkin and Geo. Davis each occupied a few minutes time in stating to the Academy some views which they deemed of importance.

[*Paper A.*]

SOME EARLY PHILADELPHIA BOTANISTS; SCHWEINITZ, NUTTALL, RAFINESQUE AND DARLINGTON.—*W. E. Leonard.*

SCHWEINITZ.

The Rev. Lewis David von Schweinitz, whose name is identified with some 200 species of plants, and 1,200 species of fungi, was practically a Philadelphian, although a resident of Bethlehem, Pa.

He was born at the latter place, February 13th, 1780, and died in the same, February 8th, 1834, lacking but five days of completing his fiftyfourth year.

At 18 years of age he went to Germany for his education, and returned when 34 years old (in 1812) as a Moravian minister to Salem, N. C., and nine years later to his native town of Bethlehem.

Of his life I am not able to learn many particulars,but the results of his incessant labor are left for us to contemplate.

As mentioned above he added 1,400 entirely new species to Botany, 1,200 being North American fungi. His printed works are as follows:—Conspectus Fungorum Lusatiae—Leipsic, 1805 Synopsis Fungorum Carolinae Superioris—Leipsic, 1818, edited by Dr. Schwargricken—Specimen Florae Americae Septentionalis, Cryptogamicae—1821, Monograph of the Linuaeau Genus Viola —Silliman's Journal, 1821. Catalogue of Plants Collected in the N. W. Territory, by Thos. Say, Phila., 1821. Synoposis Fungorum iu America Boreali Media Ingentium. Monograph upon the American Species of the Genus Carex (the Sedges) New York, 1825, and Synopsis Fungorum in America Boreali Media Ingentium, Philadelphia, 1832.

On his death in 1834, Schweinitz bequeathed to the Academy of Natural Sciences, Phila., his great collection, made during a period of forty years.

This herbarium contained, besides the Cryptogamous plants, 23,000 species. It remains at this day, almost fifty years later, the largest personal collection among the 90,000 species represented in what Dr. Darlington termed "one of the richest and most valuable herbaria in the United States."

Schweinitz laid all his scientific friends under tribute to gather together this magnificent collection. Most of the American species were collected by himself; but many were supplied by Dr. Torrey,M. LeConte, Rev. Mr. Dencke, Mr. J. Elliot, Mr. H. Steinaur, and other correspondents. The European species were supplied by Mr. Van Welden,Dr. Hooker, Mr. Bentham, Dr. Schwargrichen, Dr. Stendel, Dr. Zeyher and Mr. Bronguiart. The Siberian plants were furnished by Mr. Ledebour, and those of India by Dr. Wallich and Mr. H. Steinhaur. The Chinese collection was made by Mr. Jas. Read. The plants of the polar region were collected by Captain Parry and presented by Dr. Hooker; an interesting collection from Labrador was added by Mr. Kohlmeister, a Moravian missionary of that country. The South American species were obtained chiefly through M. Von Martius, Dr. Huffel and Dr. Constantine Hering. Dr. Baldwin contributed 3,000 species of plants collected by himself in Buenos Ayres, Florida and other parts of North America.

NUTTALL.

Dr. Thomas Nuttall, an ardent and distinguished American botanist, whose collections also remain to us in the Phila. Academy of Sciences, was born in Yorkshire, England in 1786.and died in St. Helens, Lancashire, September 10th, 1859, being 73 years of age. His trade was that of a printer, but early in life he came to the U. S. as a student of natural history, and especially of botany and geology.

While still a young man he travelled extensively in this country. He explored the Great Lakes, and the upper branches of the Mississippi; in 1810 he ascended the Missouri as far as the Mandan villages.

In 1819 he explored the Arkansas river and neighboring regions, and published a "Journal of Travels into Arkansas Territory" in Phila., 1821.

He also travelled on the Pacific Coast, and published several papers on the shells and plants of that region. From 1822 to 1824 he was Prof. of Natural History at Harvard College and Curator of the botanical gardens. He subsequently returned to England and lived on an estate at Nutgrove Lancashire, bequeathed to him on condition that he should reside there during the remainder of his life.

His principal works are:

"A Manual of the Orinthology of the United States and Canada," 2 Vols., 12 mo. Boston, 1834, and "The North American Sylva," 3 Vols., 8 mo., Phila., 1842-9, contemporaneous with Micheax' great work on the forest trees of North America.

In the Academy Museum at Phila. are *3,000* species of North American plants presented by Dr. Nuttall, besides his entire exotic herbarium, embracing among others 1,500 Cape plants collected by Marson, a large number of New Holland plants, and many interesting species from New Zealand and the islands of the Pacific, collected by Foster, Labillardier and others.

Subsequently Nuttall presented to this museum a complete suite of specimens collected by him in his arduous journey across the Rocky mountains to the mouth of the Columbia River, different parts of California, and the Sandwich Islands.

Dr. Nuttall did much work before taking up his residence in England in classifying and arranging the large botanical collection of the Philadelphia Academy.

He also contributed largely to the Academy collections in Conchology and Mineralogy.

RAFINESQUE.

Another botanist of merit whose chief home was in Philadelphia was Constantine S. Rafinesque. His life almost entirely given up to science, but a mistaken ambition greatly obscured his work. He was born in 1784, at Galeta, a suburb of Constantinople inhabited by Christian merchants and traders, his father being a

French merchant of Marsailles. For any notes concerning his early career, I am at a loss since his autobiography, entitled "A Life of Travel and Research," is not accessible. However, from a "notice of the Botanical Writings of the late C. S. Rafinesque" written for the American Journal of Science in 1841, by Prof. Asa Gray, and quoted in the Botanical Gazette for January, 1883—for which I am chiefly indebted for the material of this sketch—we learn that Rafinesque came to this country in 1802. Here he remained three years, which time was occupied in exploring our Atlantic coast and in travelling on foot over much of the territory between Northern Pennsylvania and Virginia. At the time of his coming the botanical field was all his own for no one made any pretentions to the knowledge he possessed. With an ample fortune at his command his opportunities for original work were unequalled. But in 1805 he returned to Sicily where he published three scientific works in French. He did not again see America until 1815, when he was shipwrecked off the coast of Long Island and lost his collection of plants and the balance of his fortune. Here he became a teacher and remained until his death in 1840. On this his second coming he found such botanists as Pursh, Nuttall, Elliott, Bigelow, etc., at work. It may be a gratuitous supposition, but I suspect that the knowledge that the workers just mentioned had accomplished much that he might have done made him rather too caustic in his criticisms of them, and these his criticisms led later critics to omit some honor that was really his due. Yet to his credit be it said, he often praised those he had criticised, and, if unwise in his discourtesy, was not embittered by malice.

During the twenty-five years of his life in the United States, he explored most indefatigably from Vermont to Virginia and westward to the Wabash river. In 1819 he was appointed Professor of Natural Sciences in the University of Lexington, Kentucky, where he remained for seven years. In this time he claims to have explored the state thoroughly and made excursions into the neighboring states north and south.

He finally settled in Philadelphia, and in 1832, when 48 years of age, established the "Atlantic Journal and Friend of Knowledge" of which eight numbers appeared.

His chief published books are as follows:—

Annals of Kentucky, 8 vo., Frankfort, 1824. Medical Flora of U. S., 2 vols. 12 mo. Phila., 1836, and A Life of Travel and Research, 1836. Besides these Prof. Gray enumerates some 27 titles, principally magazine articles and pamphlets.

The writings of C. S. Rafinesque on Recent and Fossil Conchology have been edited by W. G. Binney and G. W. Tyron, Jr., 8 vo. Phila., 1864. During his last years Rafinesque was engaged chiefly in exploring South New Jersey and the pine barrens.

That Rafinesque was an active worker in the field no one will doubt from the above brief account of his travels. Many amateur botanists will appreciate his daily trials as thus quaintly portrayed in an introduction to his "New Flora of North America:"—

"Mosquitoes and fleas will often annoy you or suck your blood if you stop or leave a hurried step. Gnats dance before the eyes and often fall in unless you shut them; insects creep on you and into your ears. Ants crawl on you whenever you rest on the ground, wasps will assail you like furies if you touch their nests. But ticks, the worst of all, are unavoidable whenever you go among bushes, and stick to you in crowds, filling your skin with pimples and sores. Spiders, gallineps, horse-flies and other obnoxious insects, will often beset you, or sorely hurt you."

Evidently Rafinesque had no taste for entomology! Yet he knew the opposite side of this picture, for he well describes the pleasant excitement of finding "new things."

Rafinesque is sorely criticised and justly too, it would seem, by Prof. Gray, for being too ambitious to establish new genera, without regard to previous authorities, and having solely in view the slighest deviation in leaves or floral organs. He insisted that new species and genera are being constantly produced by the deviation of existing forms. This view was certainly in advance of his age and does great credit to his powers of observation. But he absurdly gave estimates as to the time in which these changes were made, stating that from thirty to one hundred years was the average time required for the production of a new species, and five hundred to a thousand years the time required for a new genus.

Hence he thought that the business of establishing new genera and species would be endless, and set himself manfully to work in his "Flora Telluriana" to establish 1,000 totally new genera. He had the pernicious habit of forming genera and species upon very imperfect descriptions by unreliable observers of forms which he had never seen. Futhermore, by dissecting the works of such men as Pursh, Nuttall, Elliott, Torrey, etc., he converted their doubtful forms into new species. Thus out of Dr. Torrey's account of the plants collected by Dr. James in Long's expedition, Rafinesque constructed *30* new genera. He furnishes probably the only instance of a botanist persistently desiring to dedicate a genus to himself. The genus proposed just as persistently refused to stand, and in despair he provides half a dozen Rafinesquias from which botanists may take their choice. None of these are to be found in the last edition of Gray's Manual.

Of the 3,000 new genera which this botanist boasts of having established only a paltry 13 have stood the fire of criticism in the region covered by Gray's Manual, viz:—

Adlumia—Climbing Fumitory (Fumariácae.)
Polanisia—Polanisia (Caper Family.)
Cladrastis—Yellow Wood (Leguminosae.)
Osmorrhiza—Sweet Cicely (Umbelliferae.)
Lepachys— (Compositae.)
Erechthites—Fireweed "
Ilysanthes— (Scrophulariaceae)
Blephilia—Blephilia—(Labiatae.)
Peltandra—Arrow Arum—(Araceae.)
Clintonia—Clintonia—(Liliaceae.)
Diarrhena—Diarrhena—(Gramineae.)
Eatonia— "
Pachystima

And of all these Bentham and Hooker have slain some. [Of these genera, nine, viz., Polanisia Osmorrhiza, Erecthites, Lepachys, Diarrhena, Eatonia, Ilysanthes, Blephilia, Clintonia are found in the catalogue of the plants of Minnesota now being brought up to date by Mr. Warren Upham.]

While deserving credit for being an excellent and indefatigable observer, Rafinesque should undoubtedly be held up before the young botanist of today as the type of a species maker whose tendency was to so magnify every slightest deviation from the type that to him it meant a new genus or species.

The results of Rafinesque's labors remaining to us today are to be found in the botanical museum of the Academy of Natural Sciences of Phila., being that portion of his herbarium containing the specimens from which descriptions in his Medical Flora have been made; presented by Mr. Wm. Hembel.

In spite of all that is unfavorable concerning the labors of Rafinesque, Mr. Thos. Meehan, the well known botanist of Germantown, in the Botanical Gazette above referred to (Feb. 1883.) would have us a little more charitable with the memory of an able worker so long since passed away. He would have us remember that other botanists have also manufactured species, that other men have been and are still egotistical, and that Rafinesque endured rarely paralleled misfortunes, and sacrificed a large fortune for the sake of science.

Truly we may well be saddened and made forgetful of his faults when we read, on the authority of Mr. Meehan, who remembers the contemporaries of Rafinesque, that the eccentric botanist lived, in his latter days, in a dingy garret, with scarcely a loaf of bread to eat, working for science as he understood it, to the very last. On September 18, 1842, he died on a cot, with scarcely a rag to cover him, and without a solitary friend to stand by him in his last hours. Bringhurst, a kind-hearted undertaker, committed his body to the earth, and for years a pine board with C. S. R. was all that marked his last resting place.

Mr. Meehan concludes his brief defense, as follows: "Let us meet in spirit around his unhonored grave in old Ronaldson cemetery, remembering his sacrifices, grateful for what he did and tried to do, and not forgetting that we too are human as was he."

DARLINGTON.

Wm. Darlington, M. D., the noted botanist of West Chester, Pa., was born in Birmingham, Pa., April 28, 1782, and died in West Chester April 23rd, 1863.

At 22 years he received the degree of M. D. from the University of Penna. For two years thereafter he studied languages and botany, and in 1816 went as ship's surgeon to Calcutta. His first literary attempt grew out of this voyage in the shape of Letters from Calcutta, published in the Analectic Magazine.

On returning the Dr. settled down to practice in his adopted town, West Chester. Incidentally to his career as a botanist ought to be mentioned the fact that in 1812 he became a major of a volunteer regiment, and that he served as a member of Congress in 1815-17 and 1819 to '23.

In 1812 Dr. Darlington founded at West Chester an Academy, an Athenæum, and a prosperous Society of Natural History, of which he was the first president. A year later the Doctor's botanical tastes first displayed themselves by his beginning a descriptive catalogue of the plants growing about West Chester. This was published in 1826, under the title Florula Cestrica enlarged in 1837 as Flora Cestrica and again in 1853 made complete for the entire county of Chester.

This book is a standard local authority, so compiled as to suit both amateur and scientist. (I once had the pleasure of consulting a copy in the Merchantile library of Philadelphia.)

Dr. Darlington had made many friends in his favorite science, for in 1853, a rare and curious genus of pitcher plant was called for him—Darlingtonia Californica.

His botanical works are:—

Agricultural Botany—or strictly American Weeds and Useful Plants,—published first in 1847, Agricultural Chemistry, (1846) and (his last works) Notae Cestrienses, the latter being a series of observations on the flora and natural history of Chester Co.

Besides these, a treatise on the Mutual Influence of Habits and Disease and several memoirs of personal friends—Baldwin, Bartram and Marshall, all men interested in the Phila. Academy of Sciences—came from his pen.

Let me read from the Dr.'s American Weeds, etc., two paragraphs to show how broad a field Botany embraced in his mind and how all persons should be more or less instructed therein.

"It is a great mistake, in my opinion, to suppose that the significant language of our science must necessarily be merged in the vernacular idiom or degraded into the local *patois*, in order to adapt it to the capacities of intelligent practicical men * * * Instead of *writing down* to the level of boorish comprehension, I would rather see agricultural works gradually written up to the scientific standard.

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"The study of botany, in its widest sense—comprising as it does, the entire vegetable creation—will ever have its select votaries in those who appreciate its manifold charms, and find their reward in the pleasures incident to the present. But when regarded in a more limited and practical point of view, it may fairly challenge the attention even of the most inveterate utilitarians. There are three aspects, or relations of the science in which its importance will scarcely be denied by the most penurious calculator of economical values—namely: 1, agricultural botany; 2, medical botany; and 3, artistical botany; or the history of those plants which are employed, or afford material in the process of the arts of manufacturers. The medical branch has been treated of with something like system; the other two divisions with less frequency and less method. * * * The botany of the arts, whenever undertaken, will afford a highly interesting theme for some future laborer in this elegant department of natural history".

Preface to the first edition—pp. *II. or XI.*

[*Paper B.*]

NOTES ON SOME OF THE RARER PLANTS FOUND IN BLUE EARTH AND PIPESTONE COUNTIES, MINNESOTA, DURING THE SUMMER OF 1882. —*John Leiberg.*

Among the many rare and interesting plants found during the summer of '82 in Blue Earth and Pipestone counties, a few deserve especial mention from the fact that no other observer has as yet recorded their occurrence in Minnesota.

The first and possibly the most interesting is the Buffalo grass, Buchloe dactyloides, Engelm. This grass was found in abundance upon the rocky ledges that come to the surface near Pipestone City. Associated with this grass were two species of cacti, opuntia missouriensis and fragilis. To the occurrence of these two species of cacti is no doubt to be attributed the survival of the buffalo grass at this place, which, but for the protecting power of the long and sharp spines with which these cacti are armed, would long since have been stamped out by cattle. It is very remarkable that this grass should occur so far to the northeast, and it is a question if this station be not the farthest northeast point reached by it. It is hardly possible that it is a native of this place, more probable would be the supposition that to the Indians from the western plains who have come here to quarry the pipestone its introduction is due. Here and there growing in the hollows and fissures of the ledge we find Beckmannia eruccaeformis,Host. A curious grass with the general appearance of a paspalum, also a native of the plains. Growing very sparingly on the dryest and rockiest spots we find another rather rare grass, lepturus paniculatus. This grass is generally associated with salines and its occurrence here is rather remarkable. So many plants peculiar to the great plains give this place a remarkable aspect, more so as the vegetation surrounding the ledge on all sides is the ordinary prairie flora. In the shallow stream, called Pipestone creek, large masses of the interesting liverwort Riccia fluitans, Z. were found, but none that were fertile.

Among the rare plants from Blue Earth Co., may be mentioned wolffia columbiana, Kasten. This plant occurs in a small pond near South Bend. The pond is a part of an old, abandoned channel of the Blue Earth river and is hemmed in on all sides by high bluffs. Here the wolffia occurs in great abundance, forming a stratum on the surface of the pond from one to two inches in thickness during the hot summer months. It has not yet been found in flower in this locality, and is doubtless an immigrant from localities further south, though it must have existed in this particular pond for many years, judging from the great masses of decomposed wolffias that have accumulated around the borders of the pond.

Blue Earth Co. is very rich in different forms of characeae. Five species were met with though no special search was made for them. They were as follows:

Nitella flexilis.
Chara foetida.
C. fragilis.
C. contraria.
C. ?

This latter has not yet been determined and may prove to be an undescribed species. The attention of our botanical collectors is called to this interesting group of plants. There are doubtless very many species of these plants within the borders of the state and a systematic search cannot but be rewarded with the discovery of many as yet, unknown species.

March 6, 1883.

[*Paper C.*]

Minneapolis, Minn., March 6, 1883.

MR. CHAIRMAN:—

The committee appointed at the last meeting of this Academy, to investigate and report on the subject of the water supply of the City of Minneapolis, now offer their report.

The committee interpreted their commission as including an investigation of the quality of the water of the river at present supplied, the quality of the water shortly to be supplied through the change in the location of the in-take, and the quality of the water from any other point or points from which the taking of water for the city supply seemed advisable or practicable. Questions connected with these, such as the location of sources of contamination of the water and the nature and amount of such contamination were also understood as lying within the province of your Committee.

The investigation of the quality of the water includes two branches: a *chemical examination* or analysis, and a *biological examination.* We will state the results of these separately. For purposes of a chemical examination, on the 12th of February a sample of water was obtained from the point at which the new in-take is located, a "crib" on the line of the boom lying along the "mill-pond," nearly opposite the bridge by which First street south crosses the railway. On the same day a sample was obtained from a point about a mile and a half farther up the river, opposite Twenty-fourth avenue north-west and in the middle of the river, where an open space in the ice permitted the taking of the water. These samples were taken to the Chemical Laboratory of the University and analyzed, by the tests commonly applied in an analysis of water for sanitary purposes. The results of the analysis of these two samples of water are given in the following table.

Results of Sanitary Analysis of the water of the Mississippi at two points in Minneapolis:

1. The test for *ammonia* (Wanklyn's process):—

a. Water above City opposite 24th Ave. N. W., showed free ammonia $\frac{11}{100}$ parts per million, albuminoid ammonia $\frac{23}{100}$ parts per million.

b. Water at new in-take pipe showed free ammonia $\frac{11\frac{1}{2}}{100}$ parts per million, albuminoid ammonia $\frac{23}{100}$ parts. (The difference is slight, but to the advantage of the water above City.)

2. The test for *Chlorine*:—

a. Water above City contained $1\frac{9}{100}$ parts per million.

b. Water at new in-take contained $1\frac{12}{100}$ parts per million. (To the advantage of the water above.)

3. The test for *nitrates and nitrites*:—

a. Water above City contained nitrogen as present in nitrates and nitrites $\frac{13}{100}$ parts per million.

b. Water at new in-take contained nitrogen as present in nitrates and nitrites $\frac{16}{100}$ parts per million. (To the advantage of the water above.

4. The test for organic matter with *permanganate solution.* (Tidy's process):—

a. Water above City required for oxidation of the organic matter $1\frac{75}{100}$ parts oxygen per million.

b. Water at new in-take required for oxidation of the organic matter $2\frac{3}{100}$ parts oxygen per million. (To the advantage of the water above.)

5. Determination of the *total solid residue* from evaporation:—

a. Water above City yielded 205 parts per million.

b. Water at new in-take yielded 205 parts per million. (No appreciable difference in this respect.)

These results of chemical analysis do not show any very considerable difference in the two samples of water. But what difference there is in the figures is, in case of each test, to the advantage of the water taken above the City. The water opposite Twenty-fourth avenue north is conclusively shown to be better than that at the new in-take, on the 12th of February. If at this point the question be raised as to the absolute goodness of the waters in question, apart from their relative qualities, it is to be said that, *so far as chemical tests go*, neither of these samples would be classed among bad waters. Neither of them betrays to the tests of the chemist, a dangerous or even a very objectionable character. The chemical examination of water alone is not sufficient to settle its absolute character. Other modes of examination and other considerations of various kinds must have their place. But before passing on to these, we will first make reference to another question which we have settled at the Chemical Laboratory. On the 2d of March two samples of the river water were procured, one at the point where the water is at present taken into the pump-house to be supplied to the mains, the other at the new in-take pipe at the crib above mentioned. These two samples have been analyzed like the others. The several tests have shown a difference between the two samples to the advantage of the new in-take, although the difference is not very considerable. The water at the new in-take was conclusively shown to be better than that taken into the pump-house at present. But even the water now taken and supplied to the city does not reveal *to chemical tests* a decidedly bad character.

To pass on to the biological part of the investigation, it should be said in the first place that the winter season is an unfavorable one for the purpose. The result of an investigation of the animal life found in the waters about Minneapolis in winter can have, at best, but a negative value. Water taken in February from near the location of the new in-take pipe of the city water-works was found to contain very few organic impurities visible by means of the microscope. A few orthopterous larvae, *Thysanurae*, occur. Water taken from a hydrant near the corner of Sixth street and Nicollet avenue in June last, however, exhibited considerable quantities of animal and vegetable impurities. Among the latter were algae of the genera *Closterium Staurastrum*, *Nostoc*, *Spirogyra*, etc., together with diatoms and the like. Among the former were several species of entomostraca, as *Bosmina*, *Ceriodaphnia* and several Lynceids, rotifers and infusoria, and an *unusually large proportion of parasitic worms.* A study of the waters of our larger lakes in winter shows that those forms of life which may be regarded as danger signals are absent or few in number, in other words the conditions are not favorable for such animals as inhabit by preference putrid waters. In larger lakes fed by springs are found minute crustaceans, such as *Daphnia pulex* and species of *Diaptomus*, *Cyclops fluviatilis* and others; while in the smaller lakes the common pond *Cyclops* species, with the associated *Canthocampus* are almost the only entomostraca. To this fact is due the survival of fish in the larger lakes, which perish in others even if sufficiently ventilated. That portion of the Mississippi which lies immediately about the mouth of Bassett's creek is subject during the summer to constant contamination from the numerous marshes, slums and ditches which border that creek and fester and rot in the sun. The figures given below show how enormous a number of animal forms are supported by the filth in the pool known as Oak Lake. In a quart of water dipped from Oak Lake the following were counted:—

Ceriodaphnia,	1,400.	Amphipods,	120.
Daphnia,	9.	Infusoria,	35.
Simocephalus,	56.	Mollusks,	22.
Cypris,	50.	Diptera(larvae)	100.
Cyclops,	28.	Hemiptera,	9.

These were all visible to the unassisted eye.

It is obvious that the present in-take at the city water-works must be subject to contamination from this source. The microscopic examination of hydrant water is sufficient proof that the water-supply is actually thus contaminated.

It must be repeated that the past month has not been a favorable time for showing fully the character and quality of the water supply of the city. The river and the banks have been covered with ice and snow, and the inflow of impurities has been greatly reduced below what it must be in the warm season. In the course of the spring and summer, individual members of your committee will probably make some further investigations from time to time in connection with this subject. To sum up the principal points of this communication thus far; the chemical analyses have shown that the water of the river as it is now supplied by the water-works is inferior to that which will be obtained through the new in-take pipe, and that this latter again is inferior to the water of the river a mile and a half above; the results of biological examination now and at a different season of the year have shown considerable animal and vegetable life both in the water that we are now supplied with and in the river at the point from which we are soon to be supplied; and it is the presence of this animal and vegetable life which affords decided proof of contamination from foul sources.

But this is not all of the investigation. The examiners of a water supply are not to confine themselves to what they may be able to find in a quart or two of the water bottled up and taken to the laboratory. There are other ways of reaching just conclusions as to the quality of a water besides those involving the use of the microscope or the application of chemical tests. Attention must be given to the nature and condition of the surroundings of the stretch of water from which the supply is derived.

Your committee have given some attention to the matters here referred to; and to any who may not be acquainted with the ground in question, they would recommend the following walk. Starting from the Market building, pass up on the right hand side of First street north. We note that the slope of the ground is towards the river, and we observe that this ground, in the back yards of dwelling houses and around stables, etc., is in a very unclean state. We cannot doubt that in wet weather, the surface drainage will carry a large amount of impure matter into the river. Keep on across the railway and come to the point where Bassett's creek is crossed by the road. We observe here the houses,—and the out-houses,—on the sides of the banks. Pass around through an avenue to a corresponding point of observation on Second street. Here among other things we find a general dumping place for mixed refuse. Now pass around to Washington avenue, and look at the surroundings of the creek on both sides of the road. In short, it will be apparent to any one that the water of Bassett's creek in that neighborhood must be of the foulest character. This being admitted, two practical questions present themselves: First, will the water of Bassett's creek,or any of it, find its way into the new in-take of the city water-works? Second, will any harm result from such contamination of our water supply? To the first of these questions your committee feel constrained to give an answer in the affirmative. The configuration of the west bank of the river from the mouth of Bassett's creek downward is such that the water flowing out of the creek cannot be expected to confine itself to the immediate neighborhood of the bank as it passes along. If we stand on the Suspension bridge and look along the stream above and below, observing the position of the new in-take, etc., or if we place before us a map of the city, the conclusion becomes inevitable that the in-take pipe will receive its share of the foul water coming from that creek. Nevertheless we believe that we shall, after the completion of the work now being done by the water board, have a supply in some degree better than the old one. The surface drainage from the unclean premises along the steep bank on High street, below the Suspension bridge, will certainly not enter the new pipes to the extent that it has entered the old. But as we attend to points higher up stream, the smaller will be the difference in the effect of contamination derived from these sources upon the water at the two places,—the old and the new in-take. The dwelling houses and stables along First street, the mills and iron works, the railway structures, the three bridges crossing the river, will all contribute their portion of dirt, of which the water pipe at the crib will draw in its share. The second question in this connection was, whether any harm will result from the contamination of the water to which we have referred. This is not a question of mere uncleanliness. It is undoubtedly repulsive to all of us to think of the impure matters of whose presence in the river we have ample evidence. Contact with dirt we are all destined to have, in some degree; but we generally seek to make that contact as small as possible. This is a question of positive danger to health and life. The matters in drinking water for which the chemist tests are in themselves comparatively or wholly harmless. The living creatures which are shown in the water by the microscope are to a great extent, also harmless. But the obtaining of these tests and observations is important as showing the contamination of the water by refuse animal substances. It is now everywhere held by medical and other scientific men that the presence in water of even very small quantities of excrementitious matter from diseased persons makes that water highly dangerous. The subtle germs of infection are in it, though they as yet defy the tests of chemistry and even the powers of the microscope. They are revealed by their effects. You may dilute the impure matters. The Mississippi does dilute the impurities of Bassett's creek to a very high degree. But the dilution only diminishes the chances that any one of us using the water may be infected. One other point in this connection. The question as to the rapidity and the degree of the oxidation and destruction of sewage matters, when these have found their way into a river, is as yet not settled. The evidence thus far is considered to show that it is a slow process. and the most objectionable parts of the impure matters possess the greatest vitality. It must at least be said that the distance of about three quarters of a mile between our water pipe and Bassett's creek is too short to admit of any considerable destruction of the impurities by natural causes.

Your committee have endeavored to ascertain and present to you the facts of this matter, as they are learned by the various lines of investigation. In conclusion, they need hardly state, after what has been read,that they deem it desirable that the water supplied to the city should, at the earliest practicable time, be taken from a point sufficiently far up stream to avoid the sources of contamination to which reference has here been made.

The chemical analyses were made by J. A. Dodge. The statement of the results of biological work are by C. L. Herrick. Dr. A. E. Johnson has found results quite analagous with these.

Signed by the Committee,

JAMES A. DODGE,
C. L. HERRICK,
C. W. HALL.

[*Paper D.*]

Written for the regular meeting of April 3d, 1883.

Mr. Chairman and Members of the Academy:

By way of contributing something in the nature of a report of the section of Chemistry at the present meeting, as appointed for that section, I have thought it proper to present some results of recent analyses of the water of the Mississippi river from different points in this State. It should be premised however, that the winter or early spring season cannot be regarded as a very satisfactory time for making analyses of the water of the river, with a view to comparison of the purity, or impurity, of the water at different points. The river has been closed over, for the most part, by a thick covering of ice, excluding to a considerable extent the action of the air; while the frozen and snow-covered condition of the banks has prevented the inflow of surface drainage and thus greatly diminished the amount of contamination derived from these sources. Actual sewers have continued to send down their impurities into the river during the cold weather, very much as at other seasons.

The plan of the investigation was to secure samples of water from a number of points along the course of the river, and submit these waters to analysis. The results of the analyses were thought likely to have an interest as bearing on the question of the self purification of river waters by processes in the regular course of nature. It is now a commonly known and generally accepted proposition that flowing water,—and water otherwise moving—purifies itself from organic matters of a foul or objectionable nature, chiefly through the action of the oxygen of the air, the movement of the water being regarded as promoting this action by increasing the admixture of the air with the water and thus giving greater opportunity for the contact of the oxygen with the organic matters. This I have mentioned as a generally accepted proposition. And it rests upon abundant proof. The only points of difference in connection with the subject are in regard to the extent or completeness of the process of self-purification. It has appeared from occasional paragraphs and communications which I have noticed in the daily papers, that people express quite commonly a belief in the *complete*, or almost complete, removal of the foul matters in question, and that within a very limited distance from the point of influx of these matters. On the other hand, eminent authorities on the subject hold that when the foul matters have been introduced into the water of a river, though a part of them is oxidized and destroyed during the onward flow of the stream, yet the process of self-purification is never so complete as to render the dietetic use of the water free from risk.

In starting upon the analysis of a number of samples of water from properly chosen points along the stream, I had an expectation of finding the above mentioned proposition confirmed more or less decidedly. To proceed at once to a statement of my results, I will present the accompanying table.

	Water from above Minneapolis. Parts per Million.	Water from below St. Paul. Parts per Million.	Water from above Hastings. Parts per Million.	Water from above Winona. Parts per Million.
Free Ammonia.	.110	.165	.090	.070
Albuminoid Ammonia.	.230	.405	.250	.140
Chlorine....	1.09	1.87	1.82	1.69
Nitrogen as Nitrates and Nitrites	.130	.140	.109	.090
Permanganate Test....	1.75 oxygen	2.05 oxygen	1.69 oxygen	1.67 oxygen
Total Residue.........	205.	207.	203.	190.

In order that the comparison of a series of water analyses should be perfectly just, it is of course necessary that they be made throughout under the same conditions. In collecting the samples from the river, they should be taken simultaneously. It was impossible to conform strictly to this condition; but the samples whose analyses are presented were taken during a period of two weeks at the latter part of February and the early part of March. Those from Hastings and Winona were kindly procured for me by Professor C. W. Hall. In all other respects the samples of water were examined under the same conditions.

It seemed to me, considering the purpose in view,—namely the purpose of ascertaining if the results of my analyses would support the proposition that the river purifies itself as it flows onward, that the stretch of river between St. Paul and Hastings offered a favorable example. For, between St. Paul and Hastings there are no considerable streams flowing into the Mississippi and thereby complicating the question; there are on the other hand no towns or settlements of importance along that distance and hence no influx of impurity on the way. The distance is one of about thirty miles, a sufficiently long one to offer a fair test of the point in question. If the change in the character of the water by oxidation or other natural causes within the distance of thirty miles be not enough to shew itself through the ordinary methods of water analysis, then it would be rather too unimportant to be referred to in connection with sanitary matters. Now, on referring to the table, we observe in the case of each test that the water from the river above Hastings (it was in fact taken *just above* that town) shows itself better than the water from just below St. Paul. Setting aside the determinations of chlorine and of the total residue from evaporation, as from the nature of the case of little concern here, since there are evidently no special causes for their diminution, we observe that the water from above Hastings gives us lower figures than the water below St. Paul. The free ammonia has suffered a very considerable diminution. The albuminoid matters from which the "albuminoid ammonia" is derived by the method of Wanklyn, are also much less in amount. The explanation of their diminution is to be found mainly in a process of actual oxidation. The amount of nitrogen present in nitrates and nitrites is also less in the Hastings water. I had hardly expected much difference between the two in this respect, as I supposed the oxidation of nitrogenous matter represented by the ammonia would keep up the amount of nitrates and nitrites, so that the nitrogen would remain in the water in another combination. The explanation of the lower figures for nitrogen is, probably, that the nitrates and nitrites which were in the water at St. Paul, mixing with other organic matter also introduced at St. Paul, were reduced by this other organic matter and the nitrogen was set free in the elementary state. The same change must have happened to such nitrates and nitrites as were produced by the above mentioned oxidation of ammonia. Looking at the figures giving the results of the permanganate test (Forschammer's and Tidy's process,) we again find a considerable difference to the advantage of the Hastings water. That is, the amount of oxygen required for performing a work of destruction on organic matter, carbonaceous and nitrogenous, in the Hastings water was much less than in the water at St. Paul. This very convenient and, in the main, satisfactory test (by permanganate) shows at once to the eye that there has been oxidation of organic matter in the water while on the way from St. Paul to Hastings. I will say at this point that, in fact, the difference between, the two samples of water here referred to, as shown by these tests, proved itself greater than I had anticipated. For, seeing that the river was at the time, and for months previously, clothed with a comparatively close covering of ice, it seemed that the mount of air finding access to the water and consequently the degree of oxidation of organic matter therein would be small. Still there have been openings in the ice, made in various ways, through which the air has found entrance

The last column in the table shows the results for the water taken from the river just above Winona. In the case of this water, there are circumstances making conclusions rather less easy. This case is complicated on the one hand by the entrance of the St. Croix river and some other streams into the Mississippi between Hastings and Winona, and on the other hand by the fact that there are several towns along the way which contribute more or less sewage to the river. The inflowing of those streams would undoubtedly make the results of our tests lower, because they would bring a water somewhat purer than that of the Mississippi. The presence of the settlements along the bank will of course raise the results.

Hence, as said, our conclusions must be somewhat uncertain, in regard to the extent of the self-purification of the water in thi case. In fact, on considering the results of the determinations of chlorine and of solid residue, we see that the lower figures all through the column of results for the Winona water are probably due partly to dilution by purer water, namely that of the St. Croix, Chippewa and other streams; still the results under "free" and "albuminoid" ammonia are so considerably different from those of the waters higher up the river that we are disposed to take them as good evidence of the oxidizing process.

It will be noticed that I have a column of figures for the water taken from the river just above Minneapolis also. These are the results which have been already communicated to the Academy in a recent report of a committee. They have very little bearing on the present investigation, but are placed beside the others merely for incidental reference. The real purpose of the analyses outside of Minneapolis was to ascertain if the tests which we can conveniently and without great expenditure of time or complication of apparatus apply to a sanitary examination of water, would show a verification of the theory of self-purification of river waters. The result seems to me fairly satisfactory. It is the result of but one trial at the present time. A repetition of these comparative tests carried through the several seasons of the year, would be more completely satisfactory.

I wish now to make some further reference to that other question connected with this subject which was mentioned at the beginning, the question as to the *completeness* of this process of oxidation and destruction of organic matter which we see going on in our rivers. If we were to place an unqualified reliance upon the results of our chemical tests for the sanitary character of water, we should be obliged to say that the water taken from the river at Winona is purer than that taken at any point above, in our series of analyses; and this, in spite of the fact that the river has received on the way the sewage of Minneapolis and St. Paul. Even within the short distance between Minneapolis and Hastings, the self-purification of the water appears to be such that the water at Hastings is scarcely more contaminated and in some respects less contaminated, than that above Minneapolis, although the river at St. Paul shows itself highly impure by our tests. Shall we then say that the water at Hastings would be as wholesome and safe for drinking as that above Minneapolis? Is the water at Winona better than that above Minneapolis? In seeking to give an answer to these questions, I can hardly do better than quote a few paragraphs from Professor Frankland of London, one of the leading chemists of the world, and one who has given a great deal of special attention to the sanitary analysis of waters. In speaking of the contamination of water by sewage matters, Professor Frankland says: "The excrementitious matters which exist in sewage are sometimes possessed of intensely infectious properties; and sewage mixing with water, even in the minutest proportion, is likely by such properties to spread epidemic diseases among populations which drink the water. Thus is explained the peculiar power which impure waters have been shown to exercise on many occasions, in promoting epidemics of typhoid fever and cholera. The existence of an infectious property in water *cannot be proved by chemical analysis*, and is only learned, too late, from the effects which the water produces on man. But though chemistry cannot prove any existing infectious property, it can prove, if existing, certain degrees of sewage contamination. And every sewage contamination which chemistry can trace ought, *prima facie*, to be held to include the possibility of infectious properties. * * * There is always a risk lest some portion (not detectable by chemical or microscopical analysis) of the noxious constituents of the original animal matters should have escaped that decomposition which has resolved the remainder into innocuous compounds. * * * In the case of river water there is great probability that the morbific matter sometimes present in animal excreta will be carried rapidly down the stream, escape decomposition and produce disease in those persons who drink the water, as the organic matter of sewage undergoes decomposition very slowly when it is present in running water. The researches of Chauveau, Burdon, Sanderson, Klein and others leave no room for doubt that the specific poisons of the so-called zymotic diseases consist of organized and living organic matter; and it is now certain that water is the medium through which some at least of these diseases are propagated. It is evident, therefore that an amount of exposure to oxidizing influences which may resolve the *dead* organic matter present in water into innocuous mineral compounds, may, and probably will, fail to affect those constituents which are endowed with life." Again, in speaking of the possibility of rendering polluted waters again wholesome, the same authority says: "When the sewage of towns or other polluting organic matter is discharged into running water, the suspended matters may be more or less perfectly removed by subsidence and by filtration, but the foul organic matters in solution are very persistent. They oxidize very slowly, and they are removed only to a slight extent by sand filtration. * * The most efficient artificial filtration leaves in water much invisible matter in suspension (as well as in solution) and constitutes no effective safe-guard against the propagation of epidemic diseases by polluted water. Boiling the water for half an hour is a probable means of destroying its power of communicating these diseases." Since this last paragraph was published, more reliance, I will say, has come to be placed on filtration and especially filtration through spongy iron, that is metallic iron reduced from a porous oxide of iron, as a means of purifying water. An application of the filtering process through layers of spongy iron and sand has recently been made on a large scale at the public water-works of Antwerp in Belgium, whereby a badly contaminated river water is said to be made thoroughly wholesome. It is asserted that living germs as well as dead organic and inorganic matter are destroyed and removed from the water. Perhaps the people of Minneapolis, and other populations along the Mississippi, may in time avail themselves of such filtering processes. Scientific authority tells us that we run great risk in drinking water which has at any time been contaminated with animal excreta unless we apply to that water the most thorough methods of destroying organized microscopic impurities. The people of Winona, for example, and the people of Hastings, would run great risk of infection from impurities that enter the river at Minneapolis and St. Paul, although chemical tests as at present known and applied give the water at Winona and Hastings such comparatively good credit for purity. The best known methods of purification may not remove all this risk. But it would be the part of prudence to apply them when practicable.

JAMES A. DODGE.

[*Paper E.*]

CHANGES IN THE CURRENTS OF THE ICE OF THE LAST GLACIAL EPOCH IN EASTERN MINNESOTA.—*Warren Upham.*

Read before the Minnesota Academy of Natural Sciences, May 8, 1883.

When the ice of the last glacial epoch attained its maximum extent, it appears that the ice-current moving southwestward from lake Superior across the northeast part of Minnesota, spreading a reddish till containing boulders and pebbles peculiar to the region from which it came, had its limit at a line reaching from lake St. Croix southwesterly across the Mississippi and through the north part of Dakota county, thence bending to a northwest direction and continuing by lake Minnetonka and through Wright and Stearns counties. At the same time another portion of the ice-sheet was pushed from the region of lake Winnipeg and the Red river valley toward the south and southeast, meeting and opposing the ice-current from lake Superior along a line from Stearns county southeast by lake Minnetonka to Crystal lake in Dakota county: beyond which its eastern limit farther south was at the outer or eastern belt of the terminal moraine as traced in Rice, Steele and Freeborn counties, and onward to central Iowa. The angle formed by the margins of these portions of the ice-sheet, moving respectively from the northeast and the northwest. was at Crystal lake and Buck hill in Burnsville. Dakota county; from which point northwesterly, along an extent of a hundred miles or more, these ice-currents were pushed obliquely against each other.

At a late date in this last glacial epoch, after the ice-border had for the most part retreated considerably from its farthest limit, it is known to have halted in its recession (and it even probably re-advanced), forming a second belt of morainic accumulations. usually from five to fifteen miles back or inside from its former line of drift-hills. This second morainic belt is well exhibited from Rice county south to central Iowa. and at the west side of this lobe of the ice-sheet upon the Coteau des Prairies. At this time the ice-sheet that was pushed southwestward from lake Superior and northern Wisconsin probably terminated only a few miles back from its earlier limit east of lake St. Croix, and in Washington, Dàkota and Ramsey counties, and in the east edge of Hennepin county at Minneapolis. But farther northward the presence of bluish till, weathered next to the surface to a yellowish color. containing boulders and pebbles of limestone and of Cretaceous shale and other material brought from the northwest overlying the red till with rock fragments from the region of lake Superior, proves that the ice-current from the northwest was stronger and extended farther, the ice on this side of the great western lobe of the ice-sheet being therefore even deeper, at least in comparison with the eastern ice flowing southwestward from lake Superior, than in the former part of this glacial epoch when these ice-fields covered their greatest area. In that earlier part of this epoch the ice-currents from the northwest and northeast had met along a line drawn from Crystal lake and lake Minnetonka northwestward, but now, when elsewhere the border of the ice-fields had somewhat retreated and formed the second and inner terminal moraine, the ice flowing from the west extended eastward across Wright and Hennepin, Sherburne and Anoka counties, to the St. Croix river at the east side of Chisago county, and into the adjoining edge of Wisconsin, pushing back the ice-current that came from lake Superior and covering the red till brought by that ice with the characteristic blue till brought by the ice from the northwest and west.

The cause of this changed course of the line at which the currents of the west and east portions of the ice-sheet met, is to be found in the changed meteorological conditions of this time. During the increased ice-melting attendant upon the recession of the ice-fields from the outer to the inner terminal moraine, the prevailing westerly winds sweeping over the western side of the ice-sheet upon the Coteau des Prairies and eastward became more laden with moisture than in the earlier part of this epoch, when there was comparatively little melting upon the surface of the ice; and the increased temperature enabled these winds to carry their moisture farther than when the ice had its greatest extent. Then the precipitation of rain and snow took place more upon the western side of the ice; but at this later time the precipitation, by reason of the causes here mentioned, probably became much greater than before upon the east part of the lobe of the ice-sheet that extended southeastward from the Red river valley to central Iowa. Before this, lake Minnetonka and central Wright county had been the limit where this ice-flow was stopped by the opposing ice-current from lake Superior; but now, because of the relatively, and perhaps absolutely, greater thickness of this part of the ice flowing from the northwest, due, as shown, to climatic changes, its current pushed back that opposed to it on the east, covering the red till brought by that ice with blue till containing plentiful limestone boulders and other material from the west and northwest. The limit where these ice-fields, moving from the west and from the northeast, now met, lies in the south edge of Mille Lacs, Kanabec, and Pine counties, and even beyond the St. Croix river at the east side of Chisago county, fully seventy-five miles east of the line where these ice-currents formerly met; but it scarcely reaches into Washington and Ramsey counties, which remained covered with ice that came from the northeast. This persistence of the ice-flow from the northeast near the margin of the ice-covered area, and also in Stearns and Morrison counties north of the changed portion of the line of confluence of these ice-fields, proved by the character of the drift upon these counties, seems yet quite consistent with this explanation, by meteorological causes, of the change in source of the ice covering the intervening district, from Wright and Hennepin counties eastward to the St. Croix river and the edge of Wisconsin.

Details of sections in the drift, showing the blue (or next to the surface, yellow) till overlying the red till in this district, and more complete discussion of the glacial period, its ice-sheets, and their various drift deposits in this state, have been partially presented in the fifth, sixth, eighth and ninth annual reports of the Geological and Natural History Survey of Minnesota, and will be fully exhibited in the final reports of this survey.

In the later part of the last glacial epoch, the ice flowing from the northeast formed a terminal moraine of very roughly, knolly and hilly till, which is intersected twice by the Mississippi river on the northern border of Dakota county, once seven to ten miles below St. Paul, and again between St. Paul and Fort Snelling. This moraine is crossed by the river-road below St. Paul in sections 11, 14 and 22, Inver Grove. Thence it extends to the west a few miles, and soon (at the east side of Wescott station) curves to the north, forming the belt of irregularly broken highland, composed at the surface of till with many boulders, which occupies the northwest part of Inver Grove and the west half of West St. Paul, varying from two to three miles in width, and elevated about 300 feet above the Mississippi, or approximately 1,000 feet above the sea. The heights of the separate hills or ridges of this belt are from 40 to 75 feet above the hollows. In Mendota another belt of morainic drift-hills, also accumulated by the ice-current from the northeast, probably at nearly the same date with the preceding, lies one to three miles farther west, forming prominent hills and ridges in sections 35, 34, 26, and the southeast part of 23, about 250 feet above the Mississippi, and 50 to 75 feet above the belt of smooth prairie a mile wide between this and the parallel line of hills in West St. Paul. The most conspicuous hill of this moraine in Mendota is Pilot knob, in the northwest quarter of section 34, only about a mile southeast from Fort Snelling. Its height is 260 feet, approximately, above the Minnesota and Mississippi rivers. The continuation of this moraine to the north lies east of the Mississippi, reaching from the high hills in Reserve township two or three miles northeast of Fort Snelling, to the belt of hills, composed at the surface of very knolly drift, chiefly till, but partly gravel and sand, that lies about one mile east and northeast of the borders of Minneapolis, having a height 75 to 150 feet, and a few miles farther north fully 200 feet, above the plain of modified drift on which this city is built.

At this time the ice-current from the west appears to have pushed against that from the northeast along this line of morainic deposits in Inver Grove, Mendota and Reserve, and at the east border of Minneapolis. The junction of the margins of the ice-fields moving from the northeast and from the west was in Inver Grove, close east of Westcott station; and the waters produced by the melting of the ice were now conveyed to this point by the converging slopes of its surface, just as they had before been principally discharged at the angle formed in the ice-margin at Crystal lake in Burnsville, when the ice of this epoch had its maximum extent. From these two points of its terminal moraine, namely, Crystal lake and Inver Grove, very remarkable channels are found extending southeastward, which evidently once carried an immense volume of water but which are now dry.

The first of these channels is crossed by the road that leads southwest from Rosemount, in sections 2 and 3, Lakeville. The bed of this channel is a level plain of sand and fine gravel at least 25 to 30 feet deep, as shown by wells, and extending here a mile and a half in width, this expanse being commonly known as the "low prairie." On its northeast side it is bounded by a steep terrace-like escarpment of gravel and sand, 30 or 40 feet high, from the top of which a similarly flat plain, called in this vicinity the "high prairie," composed of the same modified drift, stretches eastward through Lebanon, Rosemount, and the north part of Empire and Vermillion, to the Vermillion river, and beyond that stream through Marshan and Ravenna to the Mississippi. This belt of modified drift, three to five miles wide and more than twenty miles in length from west to east, forming a flat plain with a slope descending about 100 feet toward the east in this distance, is the sediment deposited by the floods from the glacial melting, chiefly discharged from the ice-covered area in Inver Grove, at Crystal lake and at Lakeville lake.

After the floods that spread this extensive plain of gravel and sand had been so diminished that they could no longer cover all its surface and add to its thickness by further deposition, the volume of water still poured from the dissolving ice-sheet was sufficient to cut in this plain the broad channel called the "low prairie." This has a width of about one mile at the east end of Crystal lake, and it widens to one and a half miles, as stated, in the northeast part of Lakeville. It continues with nearly the same features southeastward to the Vermillion river close east of

Farmington, being bounded on its northeast side along this extent of eight miles by the plain of modified drift, 30 to 50 feet higher, on which the village of Rosemount is built.

Southwest of this channel, the road to Fairfield in its next three miles crosses massive swells or hills of till, 75 to 100 feet higher, and nearly as much above another plain of modified drift, which lies in the south part of Lakeville and northeastern Eureka, extending east to Farmington, and merging with the great expanse of this formation before described as reaching from west to east through the center of Dakota county. Farmington and Fairfield are situated on this belt of modified drift. It narrows in its west extremity from an average width of two miles to only about a quarter of a mile at the southeast end of Lakeville lake, which like Crystal lake, seems to mark the point in the terminal moraine where the waters of glacial melting had a principal outlet.

The channel which seems to have been formed by the waters discharged from the margin of the ice-sheet at the junction of its opposing currents, when the second or inner terminal moraine of the last glacial epoch was being accumulated, is well known under the name "Rich Valley." This is from one quarter to three quarters of a mile wide, with a bottom consisting, like the "low prairie," of stratified gravel and sand. It is bounded on each side, for the most part, by moderate slopes of the same materials or of till, rising 25 to 50 feet higher. Beginning within the hilly belt of the terminal moraine in the southwest quarter of section 20, Inver Grove, this valley extends with a course a little to the east of south four miles, to Rich Valley postoffice in the northeast corner of section 26, Rosemount. At the north side of this and and the adjoining section 25, Rich Valley is turned east by a swell of till, a mile and a half long from west to east and about a third of a mile wide, which rises some 75 feet above this valley and 40 feet above the adjacent Rosemount plain. Thence the course of the valley is east-southeastward, passing through sections 30, 29 and 28, in the east part of Rosemount.

A great glacial river appears to have flowed to the head of Rich Valley in Inver Grove, passing through the terminal moraine in the northeast part of Eagan, where the railroad now runs on a belt of undulating modified drift, from a quarter of a mile to one and a half miles wide, in some portions enclosing numerous hollows and lakelets 25 to 75 feet below the general level, to which depth, at least, this deposit of gravel and sand extends.

[*Paper F.*]

THE TOPOGRAPHY AND ALTITUDE OF MINNESOTA.—*Warren Upham.*

[ABSTRACT.]

The topographic features of Minnesota may be briefly summed up for its western three-quarters, being a moderately undulating, sometimes nearly flat, but occasionally hilly expanse, gradually descending from the Coteau des Prairies and the leaf hills, respectively about 2,000 and 1,700 feet above the sea to half that height. or from 1,000 to 800 feet, in the long flat basin of the Red river valley, and to the same height along the valley of the Mississippi from St. Cloud to Minneapolis.

The only exceptions to this moderately undulating or rolling and rarely hilly contour, are the southeast part of the state where the Mississippi river and its tributaries are enclosed by bluffs from 200 to 600 feet high; and the northwest shore of Lake Superior, and the part of the state lying north of this lake and east of Vermillion lake. A very bold rocky highland rises 400 to 800 feet above lake Superior, within from one to five miles back from its shore-line, all along the distance of 150 miles from Duluth to Pigeon point, the most eastern extremity of Minnesota; while farther north are many hill-ranges, 200 to 500 feet higher, mostly trending from northeast to southwest or from east to west. The most jagged of these lines of rugged peaks and ridges of rock, near the shore of lake Superior from Temperance river to Grand Marais, is called the Sawteeth mountains: and a second range of hills, rising from the more elevated region half-way between the lake and the north boundary, is called the Mesabi range. The height of lake Superior is 602 feet above the sea: and of the higher of the Sawteeth mountains 1,300 to 1,600, Carlton's peak being 1,529 feet above the sea, or 927 above lake Superior, about one and a half miles distant. The Mesabi range, south of Vermillion lake and eastward, is found by Prof. Winchell to be from 1,800 to 2,200 feet above the sea, being the highest land in Minnesota.

A few more altitudes in various parts of the state are as follows: Low water of the Mississippi river at the southeast corner of Minnesota, 620 feet above the sea-level: same of Lake Pepin, 662; same at St. Paul, 683; top of the falls of St. Anthony, 800; Mississippi river at St. Cloud railroad bridge, 966; at Brainerd, 1,152; head of Pokegama falls, 1,266; lake Winnibigoshish, 1,290; Leech lake, 1,292; Cass lake, 1,300; Itasca lake, about 1,500; high-

est points of the Leaf hills, 1,600 to about 1,750; of the Coteau des Prairies, 1,800 to about 1,960; lake Traverse, 970, and Big Stone lake 962; lake Benton, 1,754; lake Shetek about 1,475; Heron lake, 1,403; Mille Lacs, 1,251, and lake Minnetonka, 928.

The average elevation of the whole state cannot be less than 1,200 feet, which is 370 feet above the plain of modified drift on which Minneapolis is built; and it may be found, when carefully estimated throughout, even as high as a quarter of a mile, 1,320 feet above the sea. This is about half the average altitude of the whole United States, which is approximately 2,600 feet above the sea; but probably no state east of the Mississippi river has a greater mean altitude than Minnesota. Humboldt estimated the mean height of all North America to be 1,500 feet, and of Europe, 1,340 feet.

[*Paper G.*]

NOTES ON THE LOCAL GEOLOGY OF MANKATO. A PRE-GLACIAL RIVER CHANNEL.—*A. F. Bechdolt.*

What is locally known as Van Brunt's Slough lies in the western part of the city of Mankato, opens on the flood plain of the Minnesota river, and has a devious course in a direction slightly west of south.

The sides of the Slough resemble the banks of a river rather than those of a lake. In all their windings the opposite shores remain parallel.

This feature holds true for the entire length of the Slough except at one point where the concave side is not concentric with the opposite bank but makes a noticeable bay. This want of uniformity will be explained a little farther on. South of the point referred to lies Indian lake, an oblong pond, gradually filling up with silt. The depression of the Slough, above the head of the lake, turns to the west, along a small affluent of the lake, which is usually dry in mid-summer, to its source in a swamp. From this swamp another small stream flows west along the depression emptying into the Le Sueur river, not over one-fourth mile above the railroad bridge. Chalk run, as this stream is called, at its source, the highest place in the Slough depression, is probably not over twenty feet above low water in the Le Sueur. The outlet of Indian lake runs north along the slough, loses itself in the swamp.

to become a stream again near the city limits and flows into the Minnesota river at Mankato. Drift material is spread upon the sides of this valley and at several places terraces are clearly marked. This therefore must be regarded as a valley made in preglacial times and re-opened at the close of the Ice age. No terraces can be seen along the Le Sueur below the point where this depression opens into the valley of this river or along the Blue Earth river north of their union. From above the dam at the Red Jacket Mill to the river, just below the mill, the water falls eleven feet, and there is a marked fall in the Le Sueur below this point to where the Le Sueur and Blue Earth rivers join. I deem it therefore safe to estimate the fall in the Le Sueur from Chalk run to its mouth at fifteen feet. Where the Slough and the Blue Earth valley make the closest approach there is a ridge of sand and gravel, modified drift in fact. This ridge is lower than those on either side which are underlaid by the Shakopee and Jordan formations. Man has taken advantage of this low sandy ridge to carry the wagon and railroad from the Slough valley over to that of the Le Sueur river. From the facts here stated we conclude that the Slough valley marks a former channel of the Le Sueur and Blue Earth rivers; that these rivers united north of Indian Lake; that the Blue Earth river changed its course because of the ridge of modified drift extending across it near the junction, and by uniting more recently with the Le Sueur river at Red Jacket Mills left the valley of the Slough dry throughout its length, except where the retiring water left a pool, at Indian Lake, to mark the deepest places in the channel. An inspection of the locality will show even better than a chart, that at a time when the Le Sueur yet held its course along the Slough, the Blue Earth wound in a sharp curve round by Red Jacket Mill, leaving the knoll near the mill, now surrounded by meadows, as a bench or terrace on its northern bank. The two rivers were then separated by a narrow ridge underlaid by friable Jordan sandstone, tangent to the wearing side of the channel of both rivers. A gully, such as exists on the south bank today and is used by the railroad, may have materially lessened the distance. Sometime when the Le Sueur was gorged with ice it broke down the wall and left its old and tortuous course by the slough for a channel more direct and steeper.

A similar change has come about in the Blue Earth river near its mouth. From the middle of the south line of section 23, a low valley stretches to the middle of the north line of section 22 in the village of South Bend and there connects with the flood plain of the Minnesota river. This valley is closed in on either side by ridges of Shakopee and Jordan sandstone. There are several ponds in this valley with their longest measure along the line of the valley. Wells sunk in the valley, have found no water and have been dug in black sandy loam for their entire depth. At the time when the Blue Earth river flowed along this course the Minnesota flowed along the north shore of its flood plain, swept southeast to where the wagon bridge crosses the Blue Earth river at Mankato, and then turned northeast; thus establishing the same conditions as existed before between the Blue Earth and Le Sueur rivers, and the same result followed, the old channel was forsaken and a new one, across the ridge tangent to the two curves, was taken. In my own thoughts, I have been in the habit of regarding an ice gorge as the occasion for the first break in the channel. Recent observations on the immense amount of sand carried by the waters of the Le Sueur and Blue Earth, the way in which this sand is heaped up into sand banks, the current changed and the eroding effect of such current on the banks against which it impinges directly, while it is powerless to move the sand bank, incline me to the view that this heaping up of sand in the channel may have been a cause, if not the cause, for the changes of channel in these rivers. Why the Minnesota and Blue Earth cut through and formed the terrace like knolls, situated one on either side of the Blue Earth at its mouth, and parted them from the Nicollet county bank of the river is to me a puzzle for which I can not offer any satisfactory solution.

THE GEOLOGIC AGE OF SOME CLAYS FOUND ABOUT MANKATO.

At the Kunz quarry, four miles northeast of Mankato, in the C. St. P. M. & O. R. R. cuts at West Mankato and South Bend, above the wagon road behind the brewery at the Blue Earth river, in the quarries at the cement works, at the "Mound" on the west bank of the Blue Earth river near the mouth and along the banks of the Le Sueur river are found banks of clay, generally white in color, filling fissures on the Shakopee limestone and upon which is found the material of the drift, as yellow clay, boulders of granite and limestone and now and then masses of ferruginous sand, forming at places a conglomerate with here and there lumps of a fair limonite ore.

These clays have been called cretaceous by Professor N. H. Winchell, State Geologist, in a paper read before this body and published in the *Bulletins*. This fact first made these clays a source of interest to me and has led to a somewhat fragmentary study of their age and origin.

The recent laying bare of a large surface of the Shakopee formation at the cement works gave me an unusually good opportunity to concentrate and crystalize all that I had observed as peculiar to them. From what I have seen I am led to regard these deposits, not as cretaceous but as belonging to Silurian time.

The position of these clays:—They lie in fissures of varying width along joints in the Shakopee limestone. These fissures have their sides rounded, polished and moulded as by trickling water. The surface of the Shakopee limestone, where it has been recently laid bare, at the cement works, is embossed and rounded, suggesting *roches moutonnees* and indicating extensive denudation, the clays are not spread out upon the upper surface of the Shakopee, but extend down, within these fissures, at times through the Shakopee and are spread out upon the planes of bedding of the Shakopee and underlying Jordan sandstone.

In several fissures at the cement works, the beds of clay are spread out comformably to, and upon, the Jordan and under the Shakopee for more than one hundred feet on either side of the fissures. The sides of many of these fissures are lined with a layer of iron rust or bog manganese of varying thickness. Upon the clays and mixed with true glacial material are found, more especially along the Le Sueur river, the deposits of limonite to which reference has already been made.

The structure of the fissures:—The rounded sides of these fissures indicate the action of trickling water. They are not potholes as a cross section of any one of them shows, the clay is filled into these fissures with the angle or convex side toward the upper surface showing the action of a trickling stream, as a spring carrying the clay as an impurity. In no case is the bedding of the clays concentric with the sides of the inclosing cavity as would be the case had they been deposited from still waters filling the cavity and holding the clays in suspension.

In many places the clay has been filled in upon the Jordan just as fast as this was removed because the overlying strata have not been disturbed.

Character of the clays:—I have not been able, after repeated search, to detect the slightest trace of any fossil, animal or vegetable, large or minute, in these clays. Regarding them as cretaceous, this was a surprise to me, even the miscroscope would reveal no fragment of vegetable or animal organism.

These clays are not uniform in color, while the prevailing tint is white, bands of a pink, and a drab color are found; there is no uniformity of arrangement.

They are not uniform in composition, while most of the clays do not effervesce with chloric hydrate, (a surprise to me and in this respect not agreeing with a sample of cretaceous clay from Dakota) other layers may effervesce. Calcic carbonate as well as ferric oxide are therefore to be regarded as accidental impurities. Some of the layers are very free from grit, smooth and soapy to the touch, others are gritty and this grit varies from an impalpable powder, only distinguishable under the teeth or with a microscope, to rounded grains of white siliceous sand. As a rule the clay along the sides is finest and the most grit is in the centre of the fissure and in the lower layers. In some of the larger fissures, throughout the length of the fissure and in the direction of the former flow of the trickling water are found angular fragments of white sandstone, resembling the Jordan sandstone as seen here or the St. Peter as exposed in the bluffs at St. Paul. These angular fragments of white sandstone are also found in crevices in the Shakopee above Mr. Beatty's quarry, northeast of the city.

These are the facts that make it seem more than likely to me, that these clay deposits were formed from material taken up by water precolating through the St. Peter sandstone, while it was yet in position over the Shakopee, carrying away the clay, fine sand, etc., in suspension to deposit it in the lower and slower part of the underground course, just as a stream does. I have had no opportunity to examine the St. Peter sandstone, but presume that like the Jordan it contains throughout its mass lumps of clay, the source of these deposits. The origin and character of the rock makes this almost necessary. During the Drift period the St. Peter and at places nearly all of the Shakopee were ground up, dissolved, and swept away. They left behind broken fragments, sand, iron rust and wad. The incrustation along the sides of the fissures is iron and manganese from the surrounding rock, which were held in solution by the water and dropped along the line of the flow; this, since the clay has filled the fissures, has been along the sides, between the clay and limestone.

I do not doubt the existence of cretaceous deposits in this part of the state. On the sand banks near the mouth of the Blue Earth river are found bits of lignite that must come from somewhere along either the Blue Earth or Minnesota river. Also fragments of cretaceous corals and teeth of fish in the stream drift show the presence of beds of material belonging to this period not far away, but certainly these beds of white clay must be counted out.

[*Paper II.*]

NOTES ON THE FLORA OF WESTERN DAKOTA AND EASTERN MONTANA ADJACENT TO THE NORTHERN PACIFIC RAILROAD—*By John B. Leiberg.*

[Read before the Minnesota Academy of Natural Sciences, March 4th, 1884.]

While in the service of the Northern Pacific railroad company during the past year in the interest of tree culture, I had abundant opportunity to examine the interesting and to some extent peculiar flora of western Dakota, and to a limited degree the eastern portion also, and the eastern part of Montana as far west as the Yellowstone river at Glendive, and to make large and full collections of the same. Copious and interesting notes were made respecting the botanical features of the region, and a few of the more prominent are presented for the consideration of the Academy.

The climate of eastern Dakota, in both rain-fall and temperature, does not appear to present any great varation from that of the prairie region of western Minnesota, except perhaps a somewhat longer winter. The climate of the western portion is very different. The summer is very dry; showers are of rare occurance; and the temperature varies excessively. Thus in the month of July the mercury rose to 115° Fahrenheit, and fell to 32.° Such great variations cannot fail to modify plant life to a very great extent. The hot, scorching winds that generally accompany the high temperatures quickly dry up all vegetation, except along the water-courses. The extreme dryness of these hot winds is remarkable. During the great heat which prevailed in the early part of July, I saw the grass on the prairie, which was green and fresh as prairie grass usually is, completely dried up and converted into hay within a period of two hours. As a consequence of this dry weather, we find no annuals in summer. They only appear during the spring, while the ground is still moist. The perennials all have long root-stocks, which penetrate deeply into the ground and enable them to withstand the drouth effectually.

The surface of the country west of the Red river valley is more rolling than in Minnesota, and is found still more so as the Missouri river is approached. Numerous stony knolls and long ranges of rocky, pointed hills mark the ancient glacial moraines. The flora here shows plain indications of the proximity of the dry, treeless plains west of the Missouri: though at the same time the climate is humid enough to permit species of plants to grow and flourish, whose principal habitat is much farther eastward. Here and there alkaline pools appear with their peculiar plants, adding largely to the variety of the flora of this region. Many species are found whose home in the Southwest is at a high elevation, proving that as we go north the increase in latitude compensates for a decrease in elevation.

Scattered over the drift hills in great abundance, and the first flower to appear in spring is *Anemone patens*, L., var. *Nuttaliana*, Gray, attaining a luxuriance of growth never met with in Minnesota. After crossing the Missouri and the western boundary of the glacial drift, this plant wholly disappears. In the moist places of the prairies is found *Ranunculus glaberrimus*, Hook., and around alkaline ponds *R. Cymbalaria*, Pursh, the latter being very abundant west of the Missouri river. Another representative of this genus resembles *R. rhomboideus*, Goldie, but differs from that in its more errect and taller growth and much smaller flowers. It appears to be some undescribed species.

A *Draba*, probably *D. nemorosa*, L., is quite plentiful. Early in the spring, and flowering until late in the summer, we find *Vesicaria Ludoviciana*, DC. *Erysimum asperum*, DC., is abundant as we proceed westward, becoming a very conspicuous plant. Around the alkaline ponds grows a *Nasturtium* near N. *sinuatum*, Nutt. It may prove to be only a variety of this species.

Cleome integrifolia, Torr. & Gr., which is found here and there in Minnesota as an introduced plant, is first met with in its indigenous state in Pyramid Park near the Little Missouri river. There also, and nowhere else in the territory under consideration, *Cleome lutea*, Hook., was observed. *Polanisia graveolens*, Raf., was frequently noticed along the water-courses, differing somewhat from its character in Minnesota, in having a more clammy pubescence and longer and more turgid pods.

Viola Nuttallii, Pursh, was met with abundantly, but does not extend to any great distance west of the Missouri river, and was not observed east of Jamestown. *Viola cucullata*, Ait., was not rare in the region covered by the drift, but was confined to the borders of the numerous small ponds.

A Cerastium and two species of *Arenaria*, not determined, were very common. One of the Arenarias was met with only on the top of the buttes west of the Missouri, forming dense tufts, the short stems closely covered with small rigid leaves giving it a spiny appearance.

A rather common and showy plant was *Malvastrum coccineum*, Gray, the only one of the *Malvaceæ* seen.

Two species of *Linum*, *L. rigidum*, Pursh and *L. perenne*, L., were found. The latter grows very rank, with showy blue flowers, often more than an inch in diameter. The seed-vessels were observed later in the season, and were found to be nearly as large as in the cultivated flax (*L. usitatissimum, L.*) with seeds about half as large, of a shining dark brown color, and apparently containing a considerable proportion of oil. The question arises, whether this wild flax could be improved by cultivation so as to equal in fiber, if not in oil, the *L. usitatissimum.* It is well worth experiment to determine these points, more especially as it is a perennial, while the cultivated flax is an annual.

Polygala verticilliata, L., and another species of which no published description could be found, were frequently collected west of the Missouri, extending into Montana.

As might be expected, the *Leguminosæ* were well represented, but a lack of authorities and published descriptions prevented full and complete determinations of the many interesting species collected. Fourteen species of *Astragalus* were observed, among them *A. simplicifolius*, Gray, and *A. triflorus*, Gray. The former was observed only in Montana, on the hills between McClennan and Hodges stations on the Northern Pacific railroad. *Psoralea* *argophylla*, Pursh, P. *esculenta*, Pursh, and P. *lanceolata*, Pursh, were noted. The latter possesses the peculiarity of forming at maturity a perfect joint on the stem near the ground. A light wind will then cause the plant to break off and go rolling along in the same manner as happens with *Amarantus albus*, L. (commonly called "tumble-weed") on the prairies of Minnesota. *Psoralea argophylla* and *esculenta* also break off near the ground, but do not appear to form a distinct joint. The separation in these species is effected by means of a constriction on the stem, which cuts off, as it were, the nourishment from the root, and causes the stalk to shrivel at that point, when the least touch or gust of wind releases the plant. On the hills near Mandan, and in no other place along the route, *Petalostemon macrostachyus*, Torr., was collected. Here also *P. Villosus*, Nutt., was quite abundant. *Amorpha fruticosa*, L., and *A. canescens*, Nutt., were both well represented, but a little farther westward they were largely replaced by *A. microphylla*, Pursh. *Oxytropis*, *Desmodium*, *Vicia*, *Lathyrus* and *Hosackia* were found in abundance throughout the territory. *Lupinus perennis*, L., was met with in the valley of the Green river; also an apparently undescribed species of this genus was collected.

Eleven species of *Potentilla* were collected among them *P. Pennsylvanica*, L., and *P. fruticosa*, L., the latter nowhere except in Pyramid Park. Only one species of *Prunus* was seen west of the Missouri river, namely, *P. pumila*. L. Growing abundantly on the rocky buttes was *Chamærhodos erecta*, Bunge. So far as I know, this plant has not before been referred to this region. Our most common species of strawberry (*Fragaria Virginiana*, Duchesne) abounds east of the Missouri, but is very infrequent farther west. The hot dry weather prevailing during June and July doubtless proves unsuitable for its growth.

A gooseberry (*Ribes*) near *R. Cynosbati*, L., of a low bushy form, thickly armed with long stout prickles, grows on the summit of the dry baked clay hills of western Dakota and eastern Montana. Although growing in these extremely dry localities, it was heavily loaded in the month of July with large ripe juicy fruit, possessing a sweet and agreeable taste. Aside from scattered patches of *Shepherdia*, this was the only native edible wild fruit that was observed along the route after crossing the Missouri.

Hippuris vulgaris, L., rare in Minnesota, is plentiful in every little stream west of the Missouri, provided it is not alkaline and contains water sufficient to prevent complete evaporation during the dry season.

Of the *Onagraceæ*, *Epilobium palustre*, L.,and *E. molle*, Torr., were sparingly found; more common were *Œnothera cæspitosa*, Nutt., and *Œ. albicaulis*, Nutt., the latter extending as far as to Muskoda station east of the Red river. Much more rare was *Œ. Missouriensis*, Sims. *Gaura coccinea*, Nutt., was very abundant.

Three species of *Cactaceæ*,*Mamillaria vivipara*, Haw.,*Opuntia Missouriensis*, DC., and *O. Rafinesquii*, Engelm., were plentiful. *O. Missouriensis* was first observed, in going westward, on the hills around Mandan.

The *Umbelliferæ* were mostly represented by species of *Peucedanum*, *Cymopterus* and *Museneum*. Of these only one, *Peucedanum nudicaule*, Nutt., extends as far east as Minnesota.

The *Compositæ*, as might be expected, were numerously represented. Species of *Liatris*, *Solidago* and *Bigelovia* were abundant. Asters were rather rare. *Helianthus lenticularis*, Dougl., (more correctly known as *H. annuus*, L., since it has been shown to be the original of the common cultivated sunflower,) was the only species of this extensive genus occurring at all plentifully west of the Missouri. *Lepachys pinnata*, Torr. & Gr., was wholly replaced by *L. columnaris*, Torr & Gr., and its variety *pulcherrima*,Torr. & Gr. It is curious to notice the gradual transition to *L. pinnata*, as the Red river valley is approached. A number of species of *Artemisia* were noticed; among others *A. tridentata*, Nutt. (sage-brush), but not extending eastward much beyond Pyramid Park. *Senecio lugens*, Rich., var. *Hookeri*, Eaton, was common everywhere. Species of *Hieracium* peculiar to the far west were found; also *Grindelia squarrosa*, Dunal., which extends east into the edge of Minnesota. *Troximon cuspidatum*, Pursh, common in Minnesota, was replaced by *T. glaucum*, Nutt.; and *Iva xanthiifolia*, Nutt.; by *I. axillaris*, Pursh. Two species of *Gaillardia*, *G. aristata*, Pursh, and an undetermined one were collected. *Antennaria* was represented by *A. dioica*, Gærtn., a rather pretty little plant.

Aphyllon fasciculatum, Gray, of the order *Orobanchaceæ*, was very common on the dry hill-sides, parasitic on the roots of various species of *Artemisia*.

Numerous species of *Pentstemon* and *Castilleia* made up the bulk of the *Scrophulariaceæ*.

Only one of the order *Labiatæ* was collected west of the Missouri; this was a species of *Hedeoma.*

Three species of *Echinospermum*, one *Mertensia*, and three species of *Eritrichium*, were noted as representing the *Borraginaceæ.*

Phlox cæspitosa, Nutt., is first found in going westward near the Missouri river, but only on the summit of the highest and stoniest hills; farther west it covers the ground nearly everywhere.

Asclepias Cornuti, Decaisne, was supplanted by *A. speciosa*, Torr., a closely allied species, rather more handsome though not so tall and robust.

Among the rarer *Chenopodiaceæ*, I collected *Monolepis chenopodioides*, Moq., *Eurotia lanata*, Moq., *Sarcobatus vermiculatus*, Torr. (this only in Pyramid Park), *Salicornia herbacea*, *L.*, and three or four species of *Obione.*

Among the *Polygonaceæ*, *Rumex venosus*, Pursh, and several species of *Eriogonum* were of frequent occurrence.

Shepherdia argentea, Nutt., and *S. Canadensis*, Nutt., commonly called "buffalo-berries," and *Elæagnus argentea*, Pursh, the silver-berry, abounded along the streams.

A low trailing *Juniperus* was exceedingly common west of the Missouri, growing everywhere upon the sides of the dry rocky buttes.

Allium reticulatum, Fraser, two species of *Zygadenus*, *Smilacina stellata*, Desf., and *Calochortus Gunnisoni*, Watson, this last not extending east of Pyramid Park, and *Yucca angustifolia*, Pursh, make up the list of *Liliaceæ* noted in Western Dakota.

Scirpus maritimus, L., was common around alkaline ponds, together with several undetermined species of *Eleocharis.* Numerous *Carices* were observed, mostly differing from Minnesota species.

The *Gramineæ* were much more sparingly represented than one would suppose to be the case. West of the Missouri fully half of the grass consisted of a single species, *Kæleria cristata*, Pers. The remaining half was divided between a dozen other species, such as *Aristida purpurea*, Nutt., an undetermined *Calamagrostis* near *C. stricta*, Trin., *Stipa Mongolica*, Turcz., and *S. viridula*. Trin., *Spartina gracilis*, Trin., *Brizopyrum spicatum*, Hook., *Bouteloua hirsuta*, Lagasca, and *B. oligostachya*, Torr., which two last commonly pass by the name of "buffalo grass," *Munroa squarrosa*, Torr., and *Buchloe dactyloides*, Engelm., the true buffalo grass, the last only occurring in scattered patches here and there. Several species of *Poa*, *Beckmannia erucæformis*, Host., *Schedonnardus Texanus*, Steud., *Eriocoma cuspidata*, Nutt., and several species of *Triticum*, complete the list of grasses collected.

Only two species of ferns were observed,a *Woodsia* and *Pellæa atropurpurea*, Link., the latter growing in the crevices of the rocky ledges on the summit of the buttes. A few mosses were seen, and two species of lichens.

The arboreal vegetation was, as might be supposed, very scanty. Aside from the timber on the Missouri river bottoms, only a few stunted willows, cotton-wood, box-elder and June berry were found scattered at intervals along the streams.

A curious feature of the country west of the Missouri, beyond the limit of the drift, was the great number of fossil tree stumps, protruding through the sod. Hundreds could be counted in many places, and in some localities, especially in Pyramid Park, the fossil trunks were found where they had fallen, almost whole and but little the worse for the ravages of time. There is no doubt that during the Cretaceous and Tertiary periods extensive forests flourished in this region; and to judge from the size of the stumps remaining, some of the trees must have been of immense size. Many stumps were seen ten feet or more in diameter, and I heard of others still larger.

This region will yet prove a mine of wealth to the botanist studying our fossil flora. Fossil leaves in great abundance occur everywhere in the Tertiary sandstones and soft Cretaceous clays. In some places the clay beds were originally underlain by seams of lignite, which have been burned, baking the clay above into a kind of brown, red, or yellow brick, which shows perfectly the forms and venation of these fossil leaves. The region is well worth the time and attention of working botanists, both in recent and fossil botany; and will doubtless ere long receive its due share of exploration and study, since it has become so easy of access.

[*Paper I.*]

AN ANALYSIS OF FILTERED WATER.—*James A. Dodge.*

The question of the ways and means of obtaining sufficiently pure water for drinking purposes and domestic use in this city, is one that has been several times discussed before the Academy and elsewhere. We must all admit that it is a question of importance.

We have been repeatedly informed by sanitary authorities what the consequences of drinking impure water may be—what they undoubtedly have been in some localities in this country and in Europe, and what they *may* be here. Whatever our source of supply, river water, lake water, well water, cistern water, we know that they are all liable to contamination with impurities of various kinds, and that certain of these impurities, especially human excreta, introduce into the water an element of *danger* and throw upon those who partake of it a positive risk of contracting disease. Now here in Minneapolis the greater number of us are personally concerned with the character of the water of the river as supplied by the city water works. We are for the most part willing to admit that there are worse waters used than the river water; but at the same time we are aware that the river water is not up to the standard of purity which an intelligent and cleanly community desires. Considering however, that it is the water with which we are likely to be supplied for some time to come, we are interested in any method by which this water can be made better, by the destruction or removal of its impurities. I have been giving some attention of late to the subject of the improvement of water by filtration, and more particularly by domestic filtration. At my residence we have been using for about a year a filtering apparatus which we have applied to the purification of water supplied by the city works, and, as I think, with satisfactory results.

(The construction of the apparatus was represented in a figure on the blackboard.)

The apparatus is of stone ware. A space holding about two gallons is the receptacle into which is poured the water to be filtered. The filtering medium is granulated animal charcoal or boneblack. A lower space holds the water after filtration delivering it from a faucet. At one point is a sponge stuffed into a cavity as represented. The upper space is emptied and cleaned from time to time, together with the sponge. It might surprise one not acquainted with the subject to see the amount of dirt which deposits itself in this space and in the sponge after a short time of use.

In order to obtain some definite knowledge of the efficiency of this filter, I drew a quantity of the filtered water into a well cleaned bottle and took it to the laboratory for analysis. We did not make a complete analysis, as I judged that unnecessary for my purpose. But I submitted the water to two particular tests which were most important in the case, namely the test for *ammonia* free and "albuminoid" and the permanganate test. On the same day I took a quantity of the unfiltered city water from the pipe and submitted it to the same analysis. Both analyses were conducted with the utmost care and with every precaution to obtain correct results. The results of these analytical determinations are as follows for the ammonia test:

RIVER WATER NOT FILTERED.	RIVER WATER FILTERED.
Free ammonia .030 per million.	Free ammonia .005 per million.
Album. " .100 " "	Album. " .015 " "

On comparing these results, we see that the filtered water shows about one-sixth the amount of both free ammonia and albuminoid ammonia which is shown by the water not filtered. Let me say at this point that the results obtained for the water not filtered are by no means high results. As the members of the Academy have been reminded on previous occasion when results of chemical analysis of the river water have been presented, this water does not show itself decidedly bad through our chemical tests. Moreover, we must be reminded that these chemical tests are not perfectly conclusive as to the real purity or impurity of a water. They do not show all that is in a water; they need to be supplemented by other methods of examination, according to circumstances. But they are very good tests *for comparative purposes*, such as we are now concerned with. Now if we had submitted to us for chemical examination a sample of water in which we found the free and the albuminoid ammonia as low in amount as we have found them in our filtered water, with 5-1000 parts of free ammonia and 15-1000 parts albuminoid ammonia per million parts of water, we should say—unless other tests gave much higher results—that the water was of a high degree of purity.

The other test to which the two samples of water were submitted was, as stated, the permanganate or Forschammer test. This is also a test for the organic matter present in water, particularly for carbonaceous matter. It consists in determining the amount of permanganate of potash solution, which is decolorized by a given amount of water, and therefrom, by calculation, the amount of oxygen which is required to destroy the organic matter on that amount of water. The result of my determinations for the two samples of water are as follows:

RIVER WATER NOT FILTERED.	RIVER WATER FILTERED
Oxygen required,	Oxygen required.
1.95 parts per million.	.11 parts per million.

Here we see a still greater difference between the unfiltered and the filtered water than in the other test, the one requiring not much more than one-twentieth of the amount of oxygen required by the other.

In fact, the filtered water by this test appears to be almost as free from organic matter as the specially prepared distilled water which we use in connection with our water analysis.

This test, then, confirms the other test. From a chemical stand-point we should be perfectly satisfied with a drinking water giving such results.

Hence, considering the filtering apparatus in question, we may conclude that it does its work well and runs out a good water.

With regard to the appearance of the water after filtering, I will say that in this respect it is above criticism, being perfectly clean and colorless, whereas before filtering it is often decidedly turbid and yellow. In palatable character also, the filtered water is excellent. In both these respects it leaves nothing to be desired.

The particular kind of filtering apparatus used is of an English make, of George Cheavins' patent. There are various kinds of filters in the market. The filtering and purifying medium used in some of them is the same as in the one described, namely granulated bone charcoal. In others the material is "spongy iron." In others it is "silicated carbon." These filters are all well spoken of. I have not at this date personally experimented with any other than my own. "Spongy iron" is said to be very effective as a means of purifying water from organic substances. It is metallic iron in a spongy state, as reduced from lumps of hematite ore by special furnace processes. Its use has been introduced on a large scale at some places in Europe for purifying the entire water supply of cities. The water supply of Antwerp, taken from a river, is purified by this means. But, on the whole, good bone charcoal is equal to any material thus far used, and on the small scale is perhaps the best material. Professor Wm. R. Nichols, of the Massachusetts Institute of Technology, says that he considers nothing better than well burned bone charcoal.

Now, in view of what has been shown here in the way of analytical results, I can but add my recommendation to the recommendations of physicians and others in this city, that we adopt the plan of filtering all the water which we are to drink. The cost of a domestic filtering apperatus is not great. One could be constructed quite cheaply from simple parts and materials.

(The plan of a cheap filter suggested by Dr. Smart, an eminent sanitarian, was given on the blackboard.)

Bone charcoal can be obtained from druggists. It is not expensive, varying according to quality from twelve cents to fifty cents per pound. It will retain its purifying power a good while before needing to be replaced. An efficient filter is something *more than a strainer.* The small globuler filters which are attached directly to the faucets of supply pipes, seem to be hardly more than strainers, as the amount of filtering medium in them cannot be great and as the water passes through rapidly and under strong pressure. A quiet and gradual passage of the water through a comparatively large amount of filtering medium seems essential to thorough effectiveness; still the small filters are much better than none. A good filter does not merely separate out the visible particles of suspended matter, such as clay and sand, from the water. Bone charcoal, by a peculiar absorptive power, separates also most of the organic matter which is in a state of partial or complete solution, and besides this, it destroys the organic matter in great measure by a process of oxidation. In this respect it is much superior to wood charcoal. In fact, wood charcoal is said by those who have investigated the subject to be of very moderate efficiency, and not much better than sand or a similar material for purifying water. In many cities the entire water supply is filtered, but on so large a scale nothing more than sand and gravel is generally employed, though as stated, spongy iron seems to be coming into use. A filtration through sand is of much advantage. It takes out all course impurities, but it does not effect a thorough sanitary purification, like bone charcoal. As we all know, no filtration of any kind is employed here in connection with the city water works. The new intake pipe terminates in a mass of loose stonework which serves the purpose of a coarse strainer and that is all. Filtration of the great amount of water pumped at the works would probably, under present circumstances, of location, etc., be impossible. Perhaps when the water is taken higher up the river, a system of filtering basins, etc., may be adopted. This is much to be desired.

For those who do not adopt domestic filtration, another resource consists in a *thorough boiling* of the water which is intended for drinking. This has some objections, chiefly on the ground of the unpalatable character of boiled water which has not been subsequently aerated. In some places apparatus for aerating boiling water or distilled water has been introduced; by aeration the water is again made palatable. It is generally believed by those who can speak with authority on the subject, as for example Professor Frankland, of London, that a thorough boiling of an impure water, say for half an hour, destroys the organic germs that may be present and removes the danger that would attend the use of the water. Opinion is a little divided on this question, some holding that filtration is more to be relied on than boiling for the removal of infectious germs and other objectionable matter.

I shall not hestitate to express the opinion that the river water, so long at least as it is taken from the same point as at present, *needs purification* before being used for drinking purposes. And I do not doubt that a good deal of the well water and cistern water used in the city needs purification too. A chemical analysis is not always necessary to support such an opinion. It is often, as in the case of the river water, enough to know the circumstances, to *see* the sources of contamination and to be aware of the contamination going on.

But, after all, far better than to depend upon filtering or any other treatment for the improvement of a water once made impure, far better would it be to have a water free from contamination in the first place, and to prevent the influx of all impurities, so far as the most strenuous efforts can accomplish that result. For, with the best of our methods and apparatus for the purification of water there always remains the possibility that some of the impurities are left in the water, and with that the further possibility that what so remains in the water may be potent for the making of a good deal of mischief.

April 8, 1884.

[*Paper J.*]

A MISSIONARY'S NOTES ON A SILICIFIED WOOD FROM PYRAMID PARK.—*Rev. L. J. Hauge.*

[NOTE—The editor has omitted several paragraphs and made a few verbal changes in the following paper.]

My wanderings in life began in a land of low islands, with no rocky cliffs nor mountains of importance.

In that land and at that time geology was not taught in our schools; still one of our professors used to say: "Look at the stones, boys!" and this injunction of our worthy teacher I have now followed, as opportunity has been given, for over a quarter of a century. * * * In my collection are over 700 species of wood, leaves and other parts of plants, mainly from the glacial drift of Minnesota and neighboring states.

Some of the specimens are taken from quite a depth in the ground; here in Minnesota 35 to 45 feet; farther west, deeper; north of Bismarck, Dak., some 50 miles, and on the east bank of the Missouri river, was found a stump of some height and one foot in diameter. The stump stood 59 feet below the surface of the ground and about 25 feet below the first bed of coal. The entire stump was solidly petrified.

In McCook county, Dak., was found, 67 feet below the surface of the prairie, a well preserved piece of wood, dry and hard, but not at all petrified. This wood seems to be cedar, and I might here say that of the many specimens apparently of this wood there are found all stages of perservation, from the clear non-mineralized to the completely petrified condition. Well diggers find many specimens of this character, and their stories about some of them are very good, though the evidence is sometimes wanting.

Leaves are not often found well preserved in the drift, and only two or three species of fruit have come to my hand. But to the west of the Missouri river large numbers of leaves are found and often the specimens are both large and beautiful.

Last fall I secured the exceedingly beautiful piece of petrified wood,* which I now present to your Academy, and I discovered it in the following manner: I joined a little party of hunters, partly for adventure and game, but mainly to see and if possible have a talk with old man Sitting Bull, who was then between the

*This is a large specimen of silicified wood.

head waters of Cannon Ball and Hart rivers with his band, said to number 3,000 braves, burning the grass and driving the buffaloes into their resevations for winter food. * * * * * * *

After being out several days without seeing the object of our search, we resolved to retrace our steps and once more come into civilization. The time passed pleasantly; when we were not hunting for Sitting Bull we were hunting the beaver and the antelope. Many an adventure was ours. On the last day of our stay in the Bad Lands, when we were at the close of a day filled with exciting hunting scenes, I started toward our camp alone. It was only four miles away, yet before I was half way there, my only guide, my instinct, had failed me, and I was lost among the rounded hills. I resolved to climb one in order to direct my course better. Choosing the highest to be seen I rode my pony as high as he could go, and using hands, legs and knees for the rest I finally got to the top. * * * * * * * * * *

In looking around me I found the top somewhat flat and elongated, and at its highest point stood a pile of stones evidently built by human hands either for an altar or a landmark, and right in front of the pile was lying athwart the ridge a remarkably fine specimen of a tree trunk, about 10 feet long, but broken in several places; of this I took the piece which now lies before you. * *

This specimen was found in the east part of what is called Pyramid park, about 20 or 25 miles south of the Northern Pacific railway. Many logs and stumps occur in this region, not infrequently two to three feet in diameter.

May, 1884.

[*Paper K.*]

EVIDENCES OF EARLY MAN IN NORTHEASTERN MINNESOTA.

—George R. Stuntz.

Forty years of my life have been spent in prosecuting the public land surveys of the government. My field of operations has been both sides of the Mississippi river from the northern boundary of Missouri to the international boundary on Rainy lake. I could only *read as I ran* over the surface of the country undisturbed by modern civilization.

The facts in my possession I give you, perhaps some conclusions. These last you can take for what they are worth.

Some months since the Rev. Dr. J. H. Tuttle of your city, gave us in Duluth a very interesting lecture in which,mixed up with incidents of travel, he gave us stereoptican views of ruins, some of which have a record of over forty centuries. And in that connection, he remarked, that America had no ruins unless the mounds and tumuli of the Mississippi valley could give us a clue to its former inhabitants.

That these earth works have a history and one of a very interesting character and that a race of people occupied the country in a very remote age and that their colonies penetrated the regions in the northeastern portions, not only of this state but of Canada, we have plenty of evidence. In the north, mounds do not occur so frequently but always occupy a sightly position near some natural highway of travel, or on some locality near a lake having the best food supply the country afforded.

They did not live entirely by the chase but cultivated the land. They introduced and cultivated certain fruits. They planted and protected certain forest trees such as the oak, the sugar maple and the linden in regions far beyond where they are indigenous. These forest trees growing as they do in isolated orchards in the extreme northeastern portion of the state, a mountainous, rocky region, stripped of alluvial soil by the stupendous glaciers of two glacial periods, the mountains crumbled to fragments, a debris scattered for hundreds of miles to the south and west, forming the drift hills and alluvial or partially alluvial jack pine sandy plains of Wisconsin and Minnesota, could hardly have had their seeds scattered to the north by any ocean currents, or up stream against the currents of rivers. It hardly seems possible that the seeds of these trees could have been brought from the north and survived the terrible abrasion of centuries of glacial action.

They are all esential for the wants of a half civilized people—the acorns for food, the sugar for diet in connection with the rice and corn they cultivated and the bark of the linden for cordage and twine and in the manufacture of nets and mats.

The alluvial lands in the Mississippi valley, as evidenced by the extensive mounds and numerous tumuli supported a large population. These people penetrated the north and in the ascent of rivers, obstructed by rapids of bowlders and by broad shallow channels, they began to leave monuments of their skill as engineers. Nearly or quite all the streams leading from the Mississippi and

Lake Superior to the north and into the Rainy lake region have been improved by some former race possessing more mechanical skill than the Indians now residing there.

These ancient mound builders, for such we will assume these prehistoric *voyageurs* to be, had two or three important routes from the Mississippi to Lake Superior. The St. Croix river route through Wisconsin was the nearest and most used and at Yellow lake are extensive earth works and tumuli. One mound on the shore of that lake measures about 19 feet in height and is seventy-one paces in circumference. It occupies a sightly locality. Pottery and ornaments common to these people are found in these mounds. A few miles further up the river the line of travel diverged into three routes: Up the main river and over a mile and a half portage to the Brule river and thence down to Lake Superior. The second route by water was up the Eau Claire through the lake of that name and down Pike river or White river and Bad river to Lake Superior. From the mouth of Bad river the extensive copper regions on Keweenaw Point were easily reached. The third and shorter route was over a long portage to the mouth of Sioux river, southwest of Bayfield.

The way stations for the food supply of these routes of travel are about 100 miles apart, a three to four days' trip. At Bayfield and Ashland the great fish supply was reached. At Ontanagon, Eagle river and Portage lake these people mined large amounts of copper and exported it over the routes mentioned to the extensive markets in the lower Mississippi valley.

To the country north of Lake Superior there were different routes. The most important one was up the Mississippi to Sandy lake; thence across the divide to the St. Louis river (Gichi Gummi sibi of the Chippewas *i.e. river of the Great lake.*) From the mouth of East Savannah the combined route from the Mississippi and from Lake Superior continued up the St. Louis and its northerly branch, the Embarras river, to and across the great water shed of the Mesabi mountains, then down Pike river into Vermillion lake. This was the great route from the Mississippi valley to the mining regions of northeastern Minnesota. Farther up the Mississippi there lay an important route from Lake Winnebigoshish to and through Bowstring lake and its extensive wild rice fields, down Big Fork river to Rainy river and then on to the great water way extending along the International boundary for two hundred miles.

On this route the principal town or stopping place was at White Oak Point as ancient mounds and fragments of pottery attest. Another important route from Lake Superior was up Pigeon river to its source; thence across the height of land down the valley of Rainy lake and river to the Lake of the Woods.

There were other lines of travel of minor importance leading into that country, but I have described enough of them to show that the country was occupied. The inhabitants were a mining people, and in order to get the products of their mines to the great populous centers they had to improve the rivers enumerated above, so far as to accommodate their light draft boats. This they have done, and in such a manner as to reduce the transport to the shortest possible distance. Slight dams were built to flood shoals and jetties to direct the water from bank to bank, so as to secure a sufficient depth to float their craft. I am not aware of any relics or works to indicate that they used beasts of burden or any mode of land transportation save packing on men's backs.

The St Louis river falls about 600 feet from the mouth of the Cloquet river to Fond du Lac, at the level of Lake Superior. The distance by the stream is about 24 miles. This section of the river is exceedingly rough. There are some reasons for believing that at Pine Island, 3 miles above Knife falls, the rapids are artificial or partially so—on the Grand rapids 5 miles above and at their head, a dike of bowlders of enormous size, so compactly placed and sloping down stream at such an angle as to revert the force of the highest floods. This dam floods the stream 4 miles to the mouth of the Cloquet river. About 4 miles, just below the mouth of this last stream a dam composed of heavy rocks, all rounded bowlders is thrown at right angles across the river of sufficient height (about 7 feet) to flood the stream above for 12 miles. Throughout this whole distance the scarcity of bowlders in the stream and on the banks would indicate that they had all been removed and placed in that dam.

Two more of these dams occur in Town 51, Ranges 18 and 19, and farther up river at a point 3½ miles above Whitefish, at Swan river rapids and at Cedar rapids. But the most marked improvements are on the Embarras river above Esquegamo lake. This stream is the most northerly branch of the St. Louis river. It makes a cut through the Mesabi mountains which rise, in Town 59, Range 15, to a height above the valley on each side of the stream of from 500 to 800 feet in the distance of half a mile. But the nature of this channel is now visible at a few points between the seven artificial lakes that have been made by dams of boulders thrown across the valley making the 12 miles of the river from the Esquegamo or lowest lake to Wine portage with its five portages the easiest part of the canoe route from Duluth to Vermillion lake. At the crossing of the wagon road at the bridge is a dam composed of rounded boulders entirely, and of such size that the heaviest spring floods cannot move them from the grade they are placed at. This dam formerly held the water three feet higher than at present and is about 1000 feet long on the south side of the river. It has been lowered laterally to allow canoes to pass without making a portage, and this lowering of the dam has been a damage to the navigation on two shoals between lakes above. I cannot leave this locality without calling attention to some facts that would seem to indicate that quite a settlement of these people resided in the vicinity of these lakes.

On the south side of Esquegamo lake, about forty rods from the shore, situated on a sandy plain, is a mound about twenty feet in diameter and seven feet high. This mound is in a thick growth of jack pines.

About two miles northeast of this mound opposite the third lake is a grove of plum bushes, ancient burr oak trees, lindens and elms growing on the upland. There are no other trees of these species on the uplands in the whole region.

The prevailing timber is coniferous, mixed with the white birch and aspen poplar. If these lakes are artificial the construction of the necessary dams would have required a large number of workmen a term of years. At Wine portage the stream falls 36 feet over a dam of bowlders. In seasons of high water these rapids can be run by canoes coming down stream. The fall is about six feet in a hundred for 600 feet. At this point the channel is straight; another evidence, that it was constructed to be used by boats bound down stream. No voyageur could manage a canoe in a crooked channel where the craft was moving at the rate of speed equal to a railroad train. At the upper end of the portage the dam was raised high enough to flood the water back for nine miles up the valley to a point where the Iron Range Railroad crosses the stream. The lake thus formed covered from 10,000 to 15,000 acres of land, and has been maintained so long that it is filled up with a vegetable deposit, peat bearing on its surface spruce and tamarac trees, cranberries and the peat mosses. This lake is connected with a similar one, created by a dam on Pike river, which now like the first is filled with peat. The depth of peat in this swamp may give us data from which to calculate the period of time that has elapsed since the valley was flooded. Assuming the deposit to be six feet deep and that it accumulated at the rate of one inch in a hundred years, we have a period of 7200 years.

After passing the divide we reach Pike river, a stream only about two rods wide in Town 60, Range 15. This stream empties into Vermillion lake; it has four dams on it below the one spoken of above. I will describe two of them.

The first, at the crossing of the wagon road from Duluth to Lake Vermillion in Town 61, Range 15. At this point a dam of bowlders has been placed across the valley, the largest of which are several tons weight each. These rocks have been taken from the bed of the stream above. The height of the dam does not exceed four feet, yet it makes the stream navigable for nine miles. When we consider that this country in the valley of Vermillion lake is perfectly paved with rocks, torn from ledges during the glacial period, that these rocks occupy the hill tops, and that in the excavation of the valley, of a stream having a grade of less than six feet to the mile, a stream of great volume would not even move small pebbles,nor have they the slightest action on sand, we should expect that the removal of the finer clays and sands would give more prominence to the bowlders. Here we find a stream running through just such a valley as I have mentioned and for 9 miles one can move along in an average stage of water on a placid canal. I conclude therefore, that the channel has been closed and the rocks piled into these dams. About one-fourth of a mile above Vermillion lake the stream falls over a ledge of altered slates. Above these falls there is a rapid 500 feet in length, in which distance the stream falls about 12 feet. At the head of this rapid the stream suddenly deepens to 10 feet and so abruptly that the stones appear to have been laid up in the form of a wall. For the distance of about 1500 feet above this dam the stream crosses ledges of trap rocks and then opens out into a valley flooded for six miles and a half or to to the foot of the next rapids. If the bowlders were removed from the channel above the falls, the stream would drain the valley and destroy the navigation of the stream for canoes for a mile and a half.

Vermillion Lake.—This extensive interior lake is thirty miles long, is divided into bays by long capes and is studded with numerous islands, varying in size from a few rods to several miles in length and as diversified in beauty as they are in size. They present every tint of green, and with the surrounding hills they present a landscape seldom surpassed in beauty. On the shores of such a lake, with its abundant supply of fish for food, we are naturally led to look for traces of settlements of this ancient people, and they are there. The whole region north of the Mesabi mountains is covered with bowlders so thickly scattered over the surface, that it is hardly possible to drive a team without first clearing the track. It is *Nicollet's* "land of rocks and water." The first evidence we get of improved land is on a cape about half a mile east of the mouth of Pike river. Although the area is small it is very evident it has been cleared of stones and cultivated. Here grow the oak, the linden and the plum, or they were growing there eighteen years ago, before extensive forest fires destroyed the timber around the shores of the lake. Farther east in Section 25, Town 62, Range 16, is an island of not more than two acres in extent with similar indications; at the mouth of Two rivers lies a spot now occupied by the Minnesota Iron Company and cultivated as a farm and garden. Eighteen years ago it was covered with a dense forest; successive fires destroyed the timber and the company plowed a large area without being troubled by stones. I claim that there is no locality on this lake where that can be done unless the bowlders are first removed, and if they have been removed it was done by human labor, and it was not done by the Indians at present inhabiting the region. Until quite recently these Indians knew nothing about farming and lived entirely by hunting and fishing and by gathering the berries and wild rice of the region. At Sucker bay, on a cape in sections 23 and 24, Town 62, Range 16, the present Indian farm is quite an extensive tract, now cultivated by the Indians, under the direction of a government farmer. Advantage was taken of this favorable locality, because the stones had been cleared off. Here we find additional evidence of the presence of the mound builder, in fragments of pottery which have the marks and the general appearance of similar fragments found in the mounds at Yellow lake in Wisconsin, and at White Oak Point on the upper Mississippi, in Itasca county. There are several other localities on the lake that show signs of similar improvements and the planting of oaks, lindens, elms and plum trees.

The query naturally arises: What induced these people to occupy these northern regions? Could it have been the summer resort of a people who admired the beautiful scenery and the excellence of the food supply—the fish, the rice and the game? It hardly seems possible that they would devote time and labor in improving these rivers if they did not have something more weighty to transport than ordinary baggage or provisions. The indications are that they were miners and came here to work the mineral deposits, and that these improvements on the streams were made to transport their products to a southern market.

On the north side of the bluff in section 27, Town 62, Range 15, is an excavation made in solid jasper, one of the hardest rocks known, and exceedingly tough and consequently difficult to break. The depth of this cut is not known, as the sides have given way and the pit is partially filled. Here masses of rock, from three to ten cubic yards in size, have been detached and removed out of the cut to the dump. There are no marks to indicate how these immense blocks of jasper were detached, or what mechanical appliances were used to hoist them out of the cut and place them on the banks. There are evidences that fire was used in working certain portions of the rock; in the dump pile fragments of charcoal and ashes are quite frequently found. A gravel walk is still visible and in tolerable repair, leading from the cut to the dump. This evidently was built for carrying out the materials of the mine. An examination of the bluff a short distance to the east of this cut disclosed a slate vein, carrying a notable quantity of yellow and red ocher. This may have been the material mined for; whatever it was the vein has been worked to the westward for the distance of several hundred feet across a flat, and to a depth below water level. For 200 miles to the eastward, along the international boundary, are improved river courses and ancient diggings, requiring a vast amount of labor and leaving monuments in stone of the patience, skill and industry of this ancient people.

I regret that I have not time to describe localities farther to the eastward or to enlarge on the engineering skill displayed in the construction of the stone dams. They effectually stop or hold the water at a given height in its low stages, and let it down an easy grade over a wide expanse in time of floods.

I conclude that this semi-civilized people cultivated the soil; they planted and cultivated certain forest and fruit trees; they ultivated the wild rice; they understood pisciculture and stocked the interior lakes and lived largely on a fish diet; they improved the navigation of rivers leaving lasting monuments of their engineering skill, and they worked the mines for ochers or paints, for the precious metals and for copper.

America has ruins; America has a history; but it must be read in the footprints of this ancient people.

December 2, 1884.

[*Paper L.*]

THE MOUND BUILDERS IN NORTHEASTERN MINNESOTA; THEIR OCCUPATIONS AND ROUTES OF TRAVEL.—*Geo. R. Stuntz.*

The "Mound Builders" who have left such abundant proofs of a comparatively dense population in the Mississippi valley and along its tributary streams have left traces of their occupancy of the country to and beyond the northern boundary of this state. In Town 58 north, Range 16 west, a circular mound 20 feet in diameter and seven feet high, is located at the south side of Esquegamo lake in a very pleasing and beautiful locality, commanding an extensive view of the Mesabi mountains and in common with this class of mounds, so situated as to command a view of the earliest rays of the rising sun. This mound is built from the sand and alluvial soil of the neighborhood. The chain of lakes to the north, extending up the valley of the Embarras river to and through the Mesabi mountains, cannot be surpassed in the beauty of its Alpine-like scenery.

The Embarras river route was the great thoroughfare through which this people reached the mining regions of Vermillion lake, from their settlements on the Mississippi river and their mining towns on Lake Superior. From the Mississippi the route lay through Sandy lake, across the divide to the east Savanna river, a tributary to the great St. Lawrence drainage system. Following this stream down and the St. Louis up, Embarras river is reached and ascended through the chain of lakes before spoken of, to the height of land and the mountains that divide the waters of the gulfs of St. Lawrence and Mexico from those that flow north into Hudsons bay. Crossing that summit and descending Pike river Vermillion lake is reached. Traditions of the Chippewa Indians inform us that they found these trails in their present condition when they drove the Sioux Indians out and took possession of the country.

Whoever these people were, they have left some traces of their partial civilization and some evidences of their migrations and settlements, as well as of their occupations. They were a commercial people. They navigated the rivers and improved the channels of many of them on their great water routes by rock dams, so as to shorten the portages—a species of slack water improvement that greatly facilitated their travels.

They had settlements at Vermillion lake. They reached these settlements by the route before described. The lakes, seven in number, forming the chain through which the Embarras river flows are connected by stretches of rapid, shallow water. Above the lowest or last lake, as the Chippewa name Esquegamo signifies, the channel has evidently been contracted by piling in bowlders of sufficient size to resist the power of the current and of sufficient height to flood the stream and allow boats of light draft to pass to the next lake. A second and a third rapid has been improved in the same way. At the crossing of the Vermillion road over the Embarras river, in Town 58, Range 16 west, the improvement is very marked; although the dam is not high it is sufficient to enable loaded canoes to pass through two stretches of river, several shallow bays and three lakes, a distance of five miles. The rocks (mostly granite bowlders) are of such a size and so placed as to resist the strongest currents of the spring freshets. They are altogether too heavy to have been transported there by any boat or mechanical rigging known or used by the race of Indians now inhabiting that region. The last rapid on the Embarrass river at the head of Wine portage on this route is improved in the same way, and is of sufficient height to flood the stream and make it navigable for nine miles above them. Crossing the height of land on the trail used by the present Indians, a distance of five miles brings us to Pike river flowing into Vermillion lake. This stream is only about two rods wide and about the same size as the Embarras river at the other end of the portage. The Pike would not be navigable for canoes in a dry time, were it not for a similar improvement in section 17, Town 60, Range 15, as those described on the Embarras river. At the crossing of the Vermillion road in Town 61, Range 16, is another rapid called by the Chippewas, Mukwa-manito-ka-ka-bi-ke, the Black Spirit rapid, shown in the accompanying diagram.

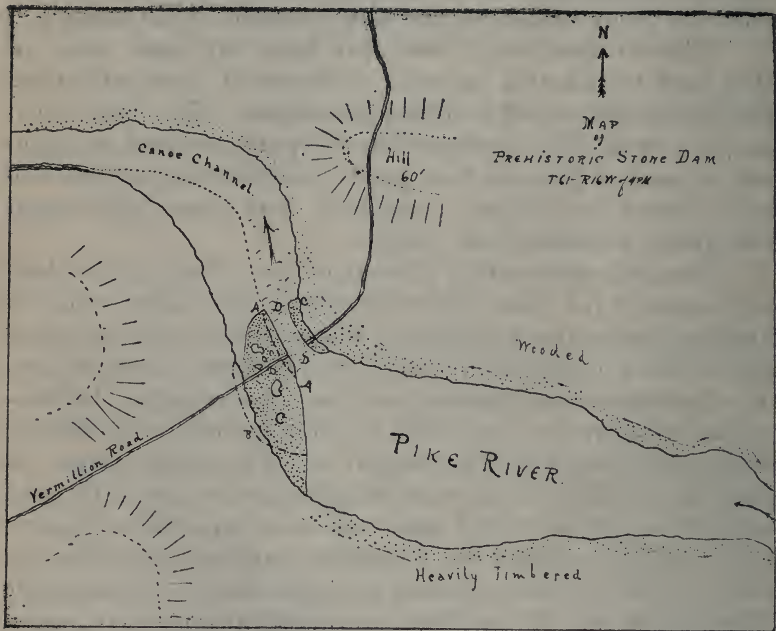

Fig 1. A prehistoric stone dam across Pike river Town 61, Range 16 west, on the old state road from Duluth to Lake Vermillion.

A A, low water portage 75 feet in length; B, high water portage 200 feet in length; C C, rock dam 3.5 feet high containing many large bowlders which floods the river and renders it navigable for nine miles above; D D, low water channel with depth of six feet in low water.*

For two miles below the foregoing dam the river runs through alluvial bottom land in a broad sandy channel, shallow in low water; then is reached a rapid 600 feet in length. This rapid has been improved in the same way but differing in construction. The cánoe channel is a straight *schute*—there is no zigzagging to throw the water against the banks on either side in order to retard its motion. The grade is uniform from the foot of the rapid to the head, where the walls present the same face up stream as in

*This is doubtless the same dam mentioned in the preceding paper, (Paper K, p. 81.)—Editor.

the preceding sketch. The banks on both sides of the stream slope gradually to the water, thus making a trough-shaped channel, navigable in both low and high water.

There is another dam below the last named where the river is crossed by a trap dike flanked by gneiss and mica slates. The rapid at this place is upwards of 1,000 feet long. The height of this rapid is 12 feet.

Similar dams are found on the great northern route from Rainy lake to Grand Portage bay on Lake Superior, the most noted of which are at Gunflint river, in Town 65, Range 4 west, fourth principal meridian.

The fact that these early inhabitants of northern Minnesota cultivated the soil and propagated forest and fruit trees for fibre and for food has already been stated.*

The best fishing stations occupied by the Indians at present are sure to have these groves of oak, linden and plum trees. Some of these oak trees are three to five hundred years old, as can be found by counting their annual rings.

The Chippewa Indians have occupied the country only about 200 years. The Sioux did not cultivate the soil but lived by hunting and fishing.

The mining operations at lake Vermillion have already been alluded to.† What mineral was worked for in this locality has not yet been found out, but probably it was for red and yellow ochers, which are quite abundant near the mines of iron. The Chippewa name for Vermillion lake signifies red ocher and not sulphide of mercury.

There are ancient diggings all along both sides of the international boundary, east of Vermillion, as far as Grand Portage bay, on Lake Superior.

These early inhabitants used a rude article of pottery in which to cook their food. Fragments of this pottery are found near Vermillion lake, identical in composition and appearance to fragments found near the mounds on Yellow lake in Wisconsin, nearly 200 miles distant.‡ They worked the mines by heating the rocks and

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*See this Bulletin p. 77—[Paper K.]

†loc. cit. p. 83.

‡The pottery here mentioned by the writer is probably similar to that found by Mr. Henry Mayhew, and described in Bulletins vol. II, p. 379. EDITOR.

dashing water upon them and then pounding them with stone hammers. Ashes and charcoal are found in great abundance in and around these old diggings.

This ancient people explored the Lake Superior region, as well as the mining region that extends across the northern part of Minnesota. A great many, if not all the valuable mines had been prospected and doubtless worked by them. The northern part of Minnesota does not seem to have been densely populated. Their largest settlements were near the most available points for securing a sufficient food supply with which to work the mines and transport such material out of the country as a half civilized people could make available for their wants.

January 6, 1885.

[*Paper M.*]

NOTES ON THE FOREST REGION OF NORTHERN IDAHO.

—By JohnB. Leiberg.

[Read, April 7, 1885.]

During the spring and summer of 1884, the writer made a trip through northern Idaho, and thence on horseback from Spokane Falls, W. T., to Jamestown, Dakota. You are all aware of the great excitement attending the alleged discovery of gold in some of the affluents of the north fork of the Cœur d'Alene river about this time. The journey was undertaken mainly with the view of ascertaining what, if any, were the prospects of mineral wealth in this region. For want of time and other facilities, it was not possible to make systematic or extensive collections of the very interesting and somewhat peculiar flora met with, and the following notes deal mainly with the arboreal vegetation, that being the most conspicuous and impresive feature of the flora of this portion of Idaho.

The mountain system of northern Idaho is mostly made up of the Cœur d'Alene range with its western spurs and branches, which commences at the southern end of lake Pend d'Oreille and runs thence in a southerly direction for two hundred and fifty or three hundred miles, finally losing itself in the main range of the Rockies. Its southern portion is called the Bitter Root mountains and the crest of the range forms the boundary line between Idaho and Montana.

Though not abounding in lofty peaks and summits, yet at not a few points does it reach the line of perpetual snow, which by the way, is far higher on the Pacific side of the Rockies than on the Atlantic side. But what it lacks in lofty grandeur is more than compensated for in the indescribable ruggedness of its contour. It has been stated that no mountain chain within the United States is so difficult of access and exploration as the Cœur d'Alenes; and a little experience in threading one's way through its dense forests and labyrinthine spurs gives a strong color of truth to this assertion.

I started from Lewiston, Idaho, in April. Though so early in the spring, the season was quite far advanced and everywhere the hillsides and valleys were covered with a profusion of flowers, giving the country in many places the appearance of a huge flower-garden. For some miles the road, a narrow Indian trail, led through the Nez Perces Indian reservation, along the Clearwater, a tributary of the Columbia river system. The country here is generally treeless, intersected by deep, narrow gorges running in all directions.

Now and then, some attempts at Indian agriculture were seen, rather sorry-looking, to be sure, yet still showing a desire on the part of their owners to adopt white men's ways; probably more prompted by necessity than any great desire to work.

After following the Clearwater for fifteen miles, the trail turned northward and ran up the valley of one of the numerous mountain streams which rise in the Cœur d'Alenes. The flora here was new and strange, but occasionally an eastern species, or species belonging to genera common in the east, would appear and remind one of home and civilization. In place of Anemone patens, var. Nuttalliana, that covers our hillsides in early spring, the slopes there abounded with Anemone occidentalis, Watson. Sisyrinchium angustifolium, Miller, was replaced by S. grandiflorum, Dougl., this plant in places covering acres in extent and presenting a most gorgeous sight. Several species of Pencedanum were common, some of these as P. farinosum, Geyer, furnishing from their farinaceous roots an important article of diet for the Indians. A number of species of Castilleia, among others C. coccinea, common in our state, were noted. Many species of Delphinium, Zygadenus, Claytonia, Brodiæa, etc., added variety to the flora. For the first thirty or forty miles along this stream, the arboreal vegetation was rather scanty, composed mostly of straggling trees of Pinus ponderosa, Juniperus occidentalis, Watson, Populus trichocarpa, Torr. & Gray, and an occasional clump of Sambucus racemosa.

As the outlying spurs of the Cœur d'Alenes were reached, where the rain-fall is more abundant, large bodies of timber of a much more stately appearance became frequent. The geological formations also commenced to undergo a change. The valley through which the trail ran had hitherto been narrow and hemmed in by high walls of lava, often over a thousand feet in height. As the head-waters of the stream were gained, the bluffs gradually decreased in height and gave way to large plateaus, densely covered with a magnificent growth of Pinus ponderosa, and intersected here and there by high rugged hills of granite, micaceous schists, and other rocks.

Of the numerous varieties of conifers on the Pacific slope at this latitute, none form forests of such pleasing aspect as Pinus ponderosa, Douglas. The tree does not attain any great height as compared with other members of the Pine family, though often of considerable diameter. Its usual habitat is on top of high ridges, and on the level plateaus, provided the soil is rather dry. Unlike other conifers which have a large spread of root, but no depth, the P. ponderosa sends its strong roots deep into the soil. In consequence of this habit, it is rare to see a tree of this kind uprooted. On the plateaus this species forms park-like forests, the trees growing at distances varying from twenty to fifty feet apart, the ground free from underbrush, and covered with a luxuriant growth of grass. It furnishes a considerable portion of the lumber sawn throughout northern Idaho. The wood is yellow in color, heavy and coarse in texture, and somewhat resinous.

Among the conifers composing the forests where the Pinus ponderosa does not flourish, the following species were the most noticeable:

Abies concolor, Lindley and Gordon, a fir of little value as a timber tree, having a soft, very tough, ill-smelling wood. The tree is rather low, and would not be conspicuous, were it not for the dense, almost impenetrable thickets it forms, by reason of the lower portion of the trunk being closely covered with long dead branches, very hard and sharply pointed, extending in all directions, remind one of the quills of the porcupine.

Abies nobilis, Lindl., and Abies grandis, Lindl., were common firs, forming the greater part of the forest at certain elevations, growing very tall but of no great thickness.

The largest fir, and with the exception of Thuya gigantea, Nutt., the largest tree seen, was Pseudotsuga, Duglasii, Carr. Usually the trees of this species grew scattered, but occasionally they formed large groves. These trees were of truly magnificent proportions, their trunks standing like huge pillars, straight as arrows, and perfectly cylindrical, free from branches, and towering from 250 to 300 feet in height, where they terminate in a short crown of branches. Many of these trees possessed a peculiar mode of growth. Starting from the ground with an enormous trunk, sometimes twenty feet in diameter, at from three to six feet from its base, it would divide into two or three perfect trunks, equal in height and size. It is safe to assume that nowhere in the temperate zone can be found so great quantity of timber on an acre of ground as in forests composed of this tree.

Pinus Lambertiana, Dougl., the so-called sugar pine, was a marked feature in the forest growth at two to three thousand feet elevation. The wood of this tree more nearly resembles our Pinus Strobus, L., or white pine, than any other of the Pacific slope. It grows to a great height, the trunk seldom exceeding four or five feet in diameter. This species of pine is usually the first to cover districts swept by forest fires, at this elevation. The young growth in such places is almost wholly made up of this species, and as close together as canes in a cane-brake.

Marshy places were generally covered with Pinus contorta, Dougl., a tree of no value either for fuel or timber, and of an unsightly appearance by reason of its branches being covered by a multitude of small, black, persistent cones.

In the valleys occasional groves of Thuya gigantea, Nutt., were seen, of which the wood closely resembles its eastern relative. The size, however, is very much greater, a diameter of ten feet at the base, being quite common. Two other species of conifers, Picea Sitchensis, Carr., and var. pendula, and doubtfully Picea pungens, Engelmann, complete the list of the more noticeable members of this family.

The only hard-wood tree (with deciduous leaves) seen was Acer circinatum, Push, and that only attaining a low bushy form.

The country west of the summit of the Cœur d'Alenes, and extending nearly to the plains of the Columbia, is almost wholly composed of steep, rocky ridges and a multitude of deep narrow canyons or ravines, at the bottom of which, during the melting of the snows in April and May, a small and rapid stream winds its way. The sides of these canyons, though very steep, are usually covered with deep rich soil, supporting an enormous forest growth. Along the larger streams are occasional pieces of meadow land, on which grasses and flowers flourish luxuriantly, but the valleys are generally as heavily timbered as the hillsides. The bottom of the smaller canyons are dark, gloomy places, hidden by the tall pines and spruces from the rays of the sun, and choked up by fallen timbers. Through these woods it is a very difficult matter to make one's way. The fallen timber lies everywhere in prodigious quantities, and the living forest stands as thick as the trees can grow. Only by constant use of the axe is it possible to get through.

To give an idea of the enormous amount of fallen timber I will mention that one morning I counted within a radius of fifty feet from my camp one hundred and thirty-five fallen trees, varying from one to six feet in diameter, and from fifty to two hundred and fifty feet in length, and this was not an exceptional place. Notwithstanding this great quantity of fallen timber, the living forest at this point was not appreciably less dense than the average.

The intense silence and gloom in these forests is remarkable. Scarcely a sign of life, except an occasional woodpecker hammering on the standing dead trunks of the tall pines, and the ants removing the decayed logs. It is quite different, however, in the few open places. Here life is in abundance. Herds of deer and elk are quietly grazing, birds of many species flutter about everywhere. In the spring strange contrasts are seen in such places. In one part of the meadow hugh snow drifts are rapidly disappearing under the influence of a hot sun. Gay flowers are blooming up to the very edge of the retreating drifts, and among them hover numbers of humming birds, while swarms of butterflies alight on the traveler, regardless of danger.

The timber belt, to which the foregoing remarks apply, has a width at the latitude of Spokane Falls of about two hundred and fifty miles. Toward the north it extends far into British America and westward to the Pacific ocean. From Cœur d'Alene lake to the Bitter Root river, along the old Mullan military road, the timber consists mainly of the varieties enumerated. It is everywhere, except where fires have ravaged it, as close and dense as described above, and of an excellent quality in an economical point of view. When the pine forests of Minnesota and Wisconsin are exhausted, attention will be turned to these vast depots of supply, in which the lumberman's axe has, as yet, made no inroads.

After crossing the Bitter Root river, the climate becomes drier, the mountain range to the west intercepting a large amount of the moisture brought by the winds from the Pacific. This dryness is prejudicial to such an excessive development of forest growth as is found on the Pacific side of the range. In consequence a a large number of conifers common there are absent here, and the rest are greatly diminished in size.

The most common species furnishing merchantable lumber from this point eastward is, Pinus ponderosa, the other varieties of pines and firs being of little value. After crossing the summit of the Rockies along the parallel of the Northern Pacific, the forest growth dwindles rapidly, and is mainly confined to the water-courses and the sides of a few of the outlying ranges. The last conifers observed while traveling eastward were near Glendive, Montana, where, in the hilly country to the east, a few pines find a precarious existence.

Before leaving this subject, I would like to call attention to the possibility of successfully introducing Pinus ponderosa as a tree of cultivation in the dry prairie region of Dakota and Minnesota. This tree appears to be able to live and flourish in a greater variety of soil, and under greater changes of temperature and moisture, than any other pine native of the northern United States. It is found growing sometimes in deep rich soil, sometimes in gravelly or rocky places; in localities where but little winter prevails, and again where the temperature often descends to forty or fifty degrees below zero. Its only marked preference seems to be for dry places. In wet or swampy districts it is not found. Unlike the other pines, its roots penetrate deeply into the ground, and it is not easily uprooted by wind. This last quality is one to be especially commended in a prairie country where strong winds are the rule and calms the exception. It would be a valuable addition to the trees of the northwest, and there is no reason why its cultivation should not be attended with success.

The soil throughout northern Idaho, is a deep rich loam of wonderful fertility. Pine forests in the east are usually associated with a gravelly or sandy soil, but it is not so here. The amount of land fit for agricultural purposes is very limited. Lumbering and mining will be the chief resources of this part of the territory in years to come.

The temperature throughout this region is much milder than in a corresponding latitude farther eastward. The winters are short with heavy snow-falls. The ground in the woods apparently does not freeze, as no trace of frost could be found under the snow drifts. The valleys in the mountain region are sometimes in early summer subject to severe frosts of sufficient intensity to cover the vegetation with a thick coating of ice. In Minnesota such a frost would kill plant life; but here, for some unknown reason, it does not injure it in the least. The summer is very warm. Winds have no chance in such a broken, heavily timbered country to cool the air, and an unbroken calm usually prevails day after day.

The precipitation of moisture is very great; much the larger portion falls during the winter as snow. Indians living there, claim that a depth of ten feet is not uncommon in the mountains. It begins to disappear in February and is nearly gone in April, yet in particularly shady places I have found snow banks two or three feet deep in June. The rain-fall in the summer is rather scanty, sometimes none at all.

It is in such seasons that enormous wanton, or I may say criminal, destruction of forest takes place. Thousands of acres of valuable pine land are thus despoiled. All that remains are great heaps of charred logs. Even the soil suffers from the intense heat generated, so that years must elapse before it can regain its former fertility.

As the mineral resources of this region in the future will doubtless be its most important feature, it may not be amiss to say a few words concerning them here. Little is as yet known in regard to the extent of the mineral bearing rocks. The dense forests and the great ruggedness of the country render prospecting and exploration extremely difficult, demanding much time and labor. The southern portion of the range has been proven to be well mineralized, and the northern portion will be found to be no less so. Enormous veins of rich magnetite and hæmatite iron ore were found, also extensive outcroppings of galena, carrying considerable quantities of silver. Copper, doubtless exists, probably also platinum and at least the *color* of gold can be found in nearly every ravine throughout the range. Reports of quarts veins carrying free gold were numerous during the Cœur d' Alene excitement, and they doubtless exist in many places.

The country rock over large areas consists of red slates, the strata of which in some places are tilted even to the vertical, for long distances, and in other places are bent and twisted in every conceivable direction. The indications are very favorable for the supposition that gold is disseminated through these red slates. Support of this theory is found in the fact that quite a number of paying placers have been discovered in ravines traversing this formation.

Until the Cœur d' Alene excitement of the last year, the country was virtually a *terra incognita*. Then suddenly there was a great influx of men, allured by the glittering tales scattered broadcast over the land. Most of them went in there without any definite plans or the requisite knowledge and experience, entertaining the wild hope of suddenly acquiring immense riches. Of course they were disappointed in the vast majority of cases. Most of them went in without any capital whatever, and were soon compelled to leave in the best way they could. The best way, and in fact the only way, was on foot. For a while every trail leading out frem the mines was crowded with small squads of half-starved men, eager to reach civilization and a " square meal " once more.

Mining is an occupation that demands skill and knowledge of the highest order, also capital and patience. With these requisites, success in this region is almost sure in the end.

[*Paper N.*]

SOME ANALYSES OF NORTHWESTERN COALS.—*J. A. Dodge.*

[ABSTRACT.]

After a review of the methods of analysis of coal usually followed, namely, the method of *ultimate analysis*, whereby the carbon, hydrogen, oxygen and nitrogen are determined as elements by the processes of "organic analysis," and the method of *proximate analysis*, whereby the volatile matter, fixed carbon and ash are determined by a process of destructive distillation and subsequent combustion in the open air, and after the exhibition of certain tables showing the ultimate and proximate analyses of various well-known kinds of coal made by a number of well-known chemists at different times, the paper proceeded to the special consideration of some analyses recently made at the chemical laboratory of the University of Minnesota, by the author and by others, of same ples of coal received from officers of the Northern Pacific Railroad Company. A table of a few of these analyses is here given:

	Moisture.	Volat le Combustible Matter.	Non-volatile Combustible Matter.	Ash.	Sulphur.
"Fort Benton" coal.......	2.23 %	25 25 %	65.68 %	6.03 %	.81 %
"Falls of Missouri"......	6.50 "	27.16 "	59 35 "	5.79 "	1.20 "
" " in blk.	1.22 "	30.53 "	62 19 "	5.90 "	.16 "
" "	1.33 "	32.11 "	59.71 "	6.80 "	.05 "
Locality unknown, but from some part of Dakota	9.65 "	22.79 "	64 59 "	1.99 "	.98 "
"Turtle Mountain".......	14 05 "	30 93 "	35.02 "	18 72 "	1.28 "
"Sims"..................	27 01 "	29 23 "	35.61 "	7.70 "	.45 "
"Toston"................	4.69 "	33.87 "	37.93 "	21.96 "	1.55 "

Considering these analyses in comparison with analyses of coals just before exhibited by tables, we see that the first five compare favorably with a number of the bituminous coals, as for example with the Belleville coal of Illinois.

	Moisture.	Volatile Combustible Matter.	Fixed Carbon.	Ash.	Sulphur.
"Belleville" (Ill.) coal..	6.0 %	33.8 %	62.66 %	1.16 %	.85 %

(Analysis by Prof. W. R. Johnson, 1844.)

So far as the chemical, or at least, the proximate composition is concerned, there seems to be little or no reason why several of these coals of the upper Missouri region should not be designated *bi-*

tuminous coal, as well as those of the carboniferous age in the locality just referred to. The "Turtle Mountain," "Sims" and "Toston" coals, on the other hand, would fall outside of the ordinary class of bituminous coals in virtue of their composition. Corresponding to the difference in composition between the five whose analyses are here first given and the other three, we observe also differences in physical properties, in aspect and texture. In the "Turtle Mountain" a wood-like texture is very plain; in the "Sims" it is perceptible, though not striking. These are unmistakably *lignites* or brown coals. In the "Toston" coal we have good specimens of the small lumps of resinous matter which is often found in these western coals.

Other qualities of these various coals have to be taken into consideration, besides their composition as learned by analysis, in order to settle their value for domestic use, or for mechanical purposes. Some of these coals crumble very badly when mined, or after exposure to the air, or when thrown upon the fire. Perhaps arrangements may be made for utilizing such crumbling varieties. One thing seems certain, that these coals are destined at some time to be much used in the Northwest. Their discovery in localities where other fuel is scarce has already promoted settlement and business. Their quantity appears to be very considerable, and their distribution quite extensive.

April 7, 1885.

[*Paper O.*]

SOME ALGÆ OF MINNESOTA, SUPPOSED TO BE POISONOUS.

J. C. Arthur.

The history of the investigation conducted in 1882 for the purpose of ascertaining the cause of a sudden mortality among domestic animals at Waterville, Minnesota, has been given in a former report.* The facts elicited were that quite a number of the animals, largely cattle, had died at a time when the lakes at that place were filled with a minute alga (then called *Rivularia fluitans*, but now referred to *Glœotrichia Pisum*), disseminated through the water and forming a thick dark-green scum when

*See vol. II, Bul. IV, Appendix.

collected by the wind. That some of the animals had drunk of the water and scum a few hours only before they died was positively known, and that all had done so seemed from the circumstances quite probable. After the most careful examination the only plausible hypothesis that could be advanced to account for the death of the animals was that the alga present possessed some toxic or other baneful properties sufficiently powerful to kill a cow in a half hour or more after drinking freely of it. The well-established reputation of all the algæ for innocuousness made this hypothesis appear from the very first extremely improbable, but for want of the slightest hint in any other direction it was thought worth while to bear it in mind, and to investigate the matter further.

In 1883 I again visited Waterville, but owing to delays did not reach there till July 26th, at which time the lakes had become quite clear of the suspected algæ. I found that two calves had died at Waterville on June 4th, and about the same time five cows at Cordova, twelve miles distant, on Lake Gorman. The most careful examination into the circumstances attending these cases threw no additional light on the subject. I arranged, however, to receive a prompt notice the next season, should any more cattle die in the same manner.

The middle of June, 1884, word was received that eight cattle had died on the shore of Lake Tetonka. I at once started for Waterville, arriving on the twentieth and found the algæ less abundant than in 1882, but still making the water green some fifty feet or more out from the shore toward which the wind had been blowing several hours. Although the conditions were not the most favorable, yet it seemed best to attempt a direct experiment by giving animals water charged with the algæ. After much delay the services of Prof. M. Stalker, state veterinarian of Iowa and professor of veterinary science in the Iowa Agricultural College, were secured to conduct the experiment. A horse and calf were employed. On June 30th, Prof. Stalker, with the assistance of Prof. Edward D. Porter of the university of Minnesota, and in the presence of citizens of Waterville, made the tests, the writer being unable to remain. The animals had not been permitted to drink for some twenty-four hours previous, and were consequently thirsty enough to take a large amount of water well charged with the algæ. No bad results of any sort followed.

The thorough and able manner in which this test was made leaves no reasonable doubt of the perfect harmlessness of the algæ *in a growing condition.* I append this last clause, because the citizens of the place still believe that the algæ are at the root of the trouble, and that the tests did not show it because they were not made at the right stage of their occurrence. Although no sufficient study of the habits of this plant has yet been made to enable one to speak with certainty, yet it does not appear from present data that in some other stage it would give different results, unless it be when decaying, when it turns brown or reddish brown and gives off a peculiar stench. At this time the microscope shows the cells of the algæ to be swarming with bacteria. Whether these are other than the common and harmless bacteria of putrefaction is at present impossible to say. The probabilities are, however, entirely against the hypothesis that the decaying algæ or the accompanying bacteria have anything to do with the trouble.

We are therefore obliged to sum up the economic part of this investigation by stating that the death of the animals is probably not due to the suspected algæ, and that no clue to the real cause has yet been obtained.

The botanical part of the investigation has yielded more interesting results, although far from being complete. The description of the structure of the alga, given in my first report, is sufficient for present purposes, if there be added to the account the fact that when the cylindrical spores are formed, not mentioned in my report, they occupy the base of the filaments, the single round cells at the end toward the centre of the mass being called heterocysts; or, to use a former illustration, if the filament be represented by a whip, the portion that the hand would grasp is where the spore forms, while the knob on the end is the heterocyst.

One of the methods by which such algæ multiply, besides the usual one by spores, is by the breaking of a filament into several parts, which then arrange themselves side by side, and grow into as many complete filaments. These fragmentary reproductive filaments are known as hormogonia.

At the time the alga is most abundant and conspicuous the spores are usually quite immature; and, as this is the period at which specimens have usually been gathered, the comparative study of the forms from different localities is rendered very difficult and unsatisfactory. I can not do better in this connection than to give a translation of a portion of a letter from M. Bornet, of Paris, the most eminent authority on these plants, in which he has kindly noted the peculiarities of the specimens forwarded by Dr. Farlow and myself at various times, and which represent the several localities of Minnesota and Iowa:

1. Lake Minnetonka, Minn., Aug. 20, 1883. Plants young; the filaments are in abundant multiplication by hormogonia. The contents of the cells are granular and opaque. There is no trace of spores. It resembles a *Glœotrichia*, probably *G. Pisum*, yet I am not certain of it.

2. Lake Phalen, near St. Paul, Minn., Aug. 4, 1882. Conforms to the preceding; but its filaments are in a simple vegetative condition [i. e. not multiplying by hormogonia]. No spores.

3. East Okoboji Lake, Iowa, July 30, 1883. On *Utricularia.* This plant has commenced to form spores. The alga is still insufficiently characterized, but I have no doubt that it belongs to *Glœotrichia Pisum.*

4. Lake Tetonka, at Waterville, Minn., July 27, 1883. The spores of this plant are nearly full grown; they are short and thick, as in the form of *Glœotrichia Pisum* that has been called *Rivularia minuta.*

5. Shallow water near Lake Minnetonka, Minn., Aug, 18, 1883. On *Naias flexilis.* Spores well formed but longer than in the preceding form. Length and thickness of the spores vary much in *G. Pisum.*

As their determination rests largely upon characters drawn from the spores, it can readily be seen how unsatisfactory such specimens are for comparison; and it is largely because such imperfect specimens have been used that authors have established so many so-called species from the single true one. Of the above specimens No. 5, having the longest spores, was composed of the smallest individual masses of any that have been collected, while No. 3 had the largest masses. Nos. 1 and 4 are the usual floating form.

M. Bornet adds that "the researches which you propose to make on the floating *Glœotrichia* of your lakes are very interesting and instructive if you could follow the complete cycle of their existence and connect them with the fixed forms from which they were derived." It was with the hope of accomplishing this that several jars were sent, in June, 1885, from Waterville, Minn., with the floating form, and from Spirit Lake, Iowa, with the fixed form, to Geneva, N. Y., where it was intended to grow them in tanks supplied with spring water, but all perished without giving any results.

The sudden appearance and disappearance of immense quantities of these minute plants, by which large bodies of water are filled with them and turned green within a few hours, is ascribed by MM. Bornet and Flahault* in a recent paper on these plants to the action of sunlight. The plants lying at the bottom of the water are started into active assimilation by strong light, which causes bubbles of gas to be given off from the cells; this is held by the gelatinous substance in which the filaments are imbedded, and when enough has accumulated the balls are rendered sufficiently light to float. When, in turn, the light becomes feeble, the gas escapes, its production stops, and the balls sink and disappear with the same suddenness with which they came into view.

More localities are now known for the algæ than at the time of my first report. The writer noticed in 1883 that the water plants of East Okoboji lake in northeastern Iowa were thickly covered with gelatinous masses. These were of various sizes up to a fourth of an inch in diameter, and often of irregular shape; otherwise they resemble the attached form of the alga, mentioned in the previous report. There were practically no free floating balls present. In June, 1884, however, the same locality yielded plenty of the floating form, which differed in no appreciable way, not even in size, from the Waterville plant. The floating form was found in August, 1883, by Dr. Farlow, with several other members of the American Association, then in session at Minneapolis, in Lake Minnetonka, although not in large quantities. It has also been reported as abundant in a lake in Minnesota (name not given) in July, 1880, and published under the name *Rivularia radians* Thur., var. *minutula* Kirch.§ What is undoubtedly the same species is reported from Iowa City, Eastern Iowa, under the name *Glœotrichia Pisum* Thur.† An alga on leaves of water plants (*Potamogeton*) was found by Rev. Francis Wolle,‡ at Bethlehem, Penn., which may be the one under discussion, as it is

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*Bull. Soc. Bot. de France, XXXI, p. 80.

§ See Wolle, Bull. Torr. Bot. Club, VIII, page 38.

† Hobby, Proc. Iowa Acad. Sci.

‡ Bull. Torr. Bot. Club, VI, page 138.

given as *G. Pisum*; but if so it is the only eastern station known to the writer.

According to our present information then the plant seems most abundant in the Upper Mississippi Valley, at least in its floating form. It is not, however, peculiar to America. The paper by MM. Bornet and Flahault§ already referred to gives the result of an examination of the present sources of information regarding the Rivulariæ forming scums, all of which are referred to the single species *Glœotrichia Pisum* Thuret, the true members of the genus *Rivularia* being salt water algæ. It was observed in the British Isles as early as 1804, and described and figured in Smith's English Botany under the name *Conferva* (*Rivularia*) *echinulata*, which was changed to *Echinella articulata* by Agardh.‖ The next record¶ of its occurrence is in a lake near Aberdeen, Scotland, in 1846-47-48. It was seen in the early part of July, and the description of its appearance corresponds essentially to its mode of occurrence at Waterville. Specimens gathered in Shropshire, England, are figured by Kuetzing,** and also by Phillips,†† from a later gathering. The similarity of our plant to the above was pointed out by Dr. Farlow.* Mr. Phillips stated that the fishermen believe it useless to try to fish while it is abundant because the fish appear to be made sick by it, and will not bite. Prof. Cohn † describes its occurrence on the river Neba in Pomerania, as seen by Dr. Schmidt, and the remarkable abundance and the suddenness of its appearance and disappearance are especially in accord with the observations at Waterville. He called it *Rivularia fluitans*. Through the kindness of M. Bornet I have been able to examine authentic specimens from this locality and do not find them noticeably different from the Waterville plants. In the same year (1877), Dr. Gobi ‡ found a Rivularia on the coast of

§ Bull. Soc. Bot. de France, XXXI, page 76.

‖ Syst. Alg., page 16.

¶ Dickie, Botanist's Guide to Aberdeen, etc., 1880, page 310; quoted by Cooke, Grevillea, X, page 112.

** Tabulæ Phycologiæ, page 4.

†† Grevillea, IX, page 4.

* Bot. Gazette, VIII, page 246; Proc. Amer. Assoc. Adv. Sc., XXXII, page 306.

† Jahres-Ber. d. Schlesischen Gesells. f. vaterl. Cultur. (1877), page 144; Hedwigia (1878), XVI, page 1.

‡ Hedwigia, XVI, page 37.

the Gulf of Finland and described it as *Rivularia Flos-aquæ.* He subsequently stated it to be the same as Cohn's plant. Dr. Gobi has also examined the Minnesota plant from specimens forwarded by Dr. Farlow, § and pronounces it to be the same as his *R. Flos-aquæ.* These, together with a single gathering in Sweden, comprise all the stations for the floating form at present known to the writer.

A phenomenon so conspicuous, and to the popular mind so mysterious, is deserving of careful study. Although the plants are probably not poisonous, a knowledge of their habits and mode of development may yet be of considerable value from a sanitary point of view.

June 2, 1885.

[*Paper P.*]

NOTICE OF THE DISCOVERY OF LINGULA AND PARADOXIDES IN THE RED QUARTZITES OF MINNESOTA.—*By N. H. Winchell.*

On the occasion of a late visit to Pipestone, in the southwestern corner of Minnesota, my attention was attracted by the aspect of a number of slabs of catlinite, or pipestone, taken from the quarry which has long been wrought by the Aborigines for the material of their calumets or peace-pipes. These slabs lay in a pile of this material gathered by Mr. C. H. Bennett, and had evidently been exposed to the weather for two or three years. They are nearly covered on one side by the impressions of small shells resembling *Discina* but which, on more careful examination, seem more likely to be a species of *Lingula.* The shell itself is wholly wanting, only the casts remain. On some smaller pieces there remains apparently a trace of the shell in the form of a white incrustation. This incrustation is quite conspicuous by reason of its contrast of color with the blood-red color of the slabs themselves, and it might at first be supposed to be the same, or analogous to the light spots which may often be seen in specimens of the catlinite, producing a kind of spottedness which has given the stone the appellation of "porphyry," by Messrs. Squier and Davis, in

§ Bot. Gaz., VIII, page 224.

their description of pipes made from it. But these white spots are wholly distinct from those. These are formed by the merest, most volatile, thin scale, which in the weather seems to disappear soon. On scraping off a quantity of the stone containing these thin scales, they are found to contain a trace of phosphoric acid. though consisting largely of carbonate of lime. These little shells are about a quarter of an inch in diameter, and one valve sometimes seems to have a beak that projects slightly more than the other, indicating the genus *Lingula* rather than *Discina*. There is on some of the impressions a faint sub-central protuberance which at first I thought indicated *Discina*, but this seems not constant in position nor in form, and is not surrounded by any concentric striation or other structure.

A short time after finding these impressions Mr. A. W. Barber of Yankton, Dak., sent me another supposed fossil found by him at the same place and in the same beds. It has the form of a distorted and folded trilobite, from which the anterior portion, and the testaceous covering of the whole animal is wanting. The tri-lobed structure is made more evident by supposing the left lateral lobe is turned under the animal and folded upon itself. The ridges and furrows formed by the folded segments of the left lobe are plainly seen on the under side of the animal running transverse to those on the upper side. This seems to be a species of *Paradoxides*, and points to the horizon of the St. Johns' group as the probable equivalent of these red quartzites.

The simple discovery of fossil remains in these red quartzites would not be of sufficient importance to warrant any special notice had not the age of these strata been a subject of some difference of opinion among the geologists of the northwest. and had not the organic nature of these impressions been doubted by some to whom they have been shown.

It is not necessary here to enter into the detailed history of opinion and investigation respecting the age of these rocks. They have been classed as Huronian, as Archæan, and as Potsdam. They are extended over a wide belt in southwestern Minnesota. At New Ulm they are separated by a quartzose pebbly conglomerate from a coarse red granite. At several places in Wisconsin they are associated with red felsite and porphyry, and become gneissic, and in the same manner they have been assigned to different ages. Red quartzites and gneisses, and red felsites and porphyries undistinguishable from these, are seen in the *Cupriferous series* of Lake Superior. there associated with dark basic igneous rocks, the nature of which is not disputed.

If these fossils be taken as guides—and they are the only ones that have ever been found in these rocks—the age of the red quartzites of Minnesota seems to be the same as the so-called lower Potsdam, or St. Johns' group, and they at the same time indicate that the Cupriferous series of Lake Superior belongs to the same age.

October 6, 1885.

[*Paper Q.*]

A BRIEF HISTORY OF COPPER MINING IN MINNESOTA.—*C. W. Hall.*

I.

THE CUPRIFEROUS ROCKS.—The copper-bearing rocks in Minnesota are those comprised in the so-called Keweenaw formation or group of rocks. There are only one or two localities at present known where attempts at copper mining have been made, which are not referred to that group of rocks, and these attempts will be mentioned further on.

The Keweenawan rocks, frequently called the Cupriferous series, enter the state in its northeastern corner, a little to the west of Grand Portage bay, Lake Superior, and are continuous along the north shore of the lake to and beyond Duluth. Passing away from the lake shore, which by the way forms the southern and southeastern boundary of this northwestern Cupriferous, and we also see the northern and northwestern border passing from Grand Portage in an almost due west course for fifty miles, and then quite likely in a very regular curve to the southwest, closing in on the southeastern boundary just mentioned. to the west of Duluth, doubtless not far from Fond du Lac.*

Another area of the Keweenawan in Minnesota lies along the eastern border of the state, entering it from Wisconsin, and exposed along the Kettle, Snake and St. Croix rivers, and in the vicinity of Taylors Falls southward from these first two named streams.

*This portion of the state, owing to the difficulty of access on account of almost impenetrable forests, has not yet been explored.

This area is not large; it is the southwestward extension of the southern portion of the Lake Superior synclinal, that which presents its most typical exposures on Keweenaw Point. For many miles occasional exposures of these rocks may be seen along the St. Croix river, which forms the boundary line for a hundred miles or so, between the two states of Minnesota and Wisconsin. The exposures along the Snake and Kettle rivers, two Minnesota branches of the St. Croix, are somewhat scattered, and at the same time are fewer than those along the St. Croix. So far as is known to the writer these Keweenawan rocks in Minnesota die out completely on the east side of the St. Paul and Duluth railroad; not a single exposure is yet reported from the west side of that road, unless the numerous dikes of the granite area of Central Minnesota, in Stearns and neighboring counties, be regarded as of Keweenawan age. That these dikes are of this age is very possible, nay probable.

Other views than the one above given have been held by geologists, with reference to the age of these copper-bearing rocks; they have, in short, been relegated to positions from the Jurassic down to the Huronian. The opinion of Irving, above stated, is both the latest one and the one best and most completely supported by field evidence; for those two reasons the writer is willing to accept it until some competent person has reviewed the ground and found grave faults in Irving's observations, arguments and conclusions.

The rocks which are included within this Keweenawan group are both sedimentary and eruptive. The sedimentary in Minnesota are red sandstones, such as occur on the north shore of Lake Superior, among other places at Good Harbor bay, in a bed upward of 200 or more feet in thickness, dipping southwesterly at an angle of 8 to 10 degrees, and conglomerates as those a mile or two below (east of) the mouth of Poplar river. Above and below these sandstone and conglomerate layers are massive flows of diabasic rocks, which in places are quite amygdaloidal with calcite, laumontite, thomsonite, lintonite, stilbite, etc. Further, sedimentary rocks appear in the St. Croix valley in the form of conglomerates associated with ash bed "trap" and amygdaloidal rocks of a diabasic type. Several localities can be mentioned.

At Taylors Falls melaphyre stands up thro' the cambrian sandstones and fossiliferous shales. In places, as along the bank of the St. Croix at the head of the Dalles, this rock is quite porphyritic; elsewhere it is quite amygdaloidal: the amygdaloidal structure is the more prevalent, and at the surface the rock usually is much decomposed. At Duluth the huge masses of rock which Streng and Kloos first called hornblende gabbro comes in, very coarse grained and massive. Further down the lake, gabbro, diabases, both massive and of the ash bed type, felsite porphyries and quartz porphyries occur.*

II.

Mining for Copper.—Copper mining has never been prossecuted on a large scale in this state. The presence of the copper bearing rocks has led to a great deal of conjecture and to no inconsiderable amount of exploration: the frequent discovery of pieces of float copper, i.e. of pieces in the material of the glacial drift, completely isolated from all rock and mineral material which would indicate the presence of that metal, has also led to the careful examination of many localities which otherwise would never have been thought of as mining districts. I believe LeSueur was the first one to find one of these masses. His find was, according to Dr. Neill, near a small lake in the Mississippi valley, four leagues above the mouth of the river St. Croix. Among the numberless pieces which have since been found, the Academy owns one of the largest:—a mass of 75 lbs. weight found three or four years ago at Taylors Falls and presented to the Academy by Mr. Geo. H. Miller.

The first mining operations were also undertaken by Le Sueur. Copper had been found at some point now unknown in the valley of the Blue Earth river and had been assayed in Paris in 1696. LeSueur wintering in 1700-1701 near the junction of the Blue Earth and St. Peter rivers, as the spring opened worked out an enormous quantity of ore, and selecting 4,000 lbs. started with it down the St. Peter and the Mississippi in order to ship his treasure to France. Since that time a great many explorers have looked for the immense deposits said to have been found by LeSueur,

*A very interesting summary of the Minnesota Keweenaw rocks appears in a paper by Professor Irving, published as an "accompanying paper" in the Third Annual Report of the Director U. S. Geol. Survey, pp. 89-188 incl. Many of the facts here given are abstracted from that report recently published.

but to this day all efforts have been in vain. High, steep walls of Cambrian rocks have been found exhibiting a color which might be like that mentioned by LeSueur, but no copper lies behind them.

Passing northward we reach the St. Croix river valley, at Taylors Falls. Copper has been known to exist since before 1865, for in that year the legislature appropriated a sum of money, $2,000, for exploring the mineral lands of the St. Croix valley. Professor James Hall came to the state and found at Taylors Falls a very distinct vein bearing copper.

This vein and several others in the neighborhood of Taylors Falls, one or two of them on the Wisconsin side of the St Croix have been worked from time to time but never with paying results. The most noticeable working for copper at Taylors Falls was done by Mr. N. C. D. Taylor on the highest part of the melaphyr near the Lutheran church. A shaft from 40 to 50 feet deep was sunk. Some little quantity of leaf copper was found. Nearer the river a mining company, "the Taylors' Falls mining company" did some work in two or three places along what were designated veins. I believe silver as well as copper was found, the latter in even smaller quantities than on the hill.

Further up the St. Croix, near the mouth of the Kettle river, considerable exploring has been done especially by Mr. D. A. Caneday, recently of Taylors Falls. This work has been chiefly in ash bed and amgydaloidal diabasic rocks. The product thus far has been a low grade ore which is unprofitable under the present condition of the market and the situation of the ore in an unsettled country and away from easy and rapid transportation.

Touching the locality at and below Chegwatona we read as follows:—"native copper occurs in these rocks on Snake river, both in the conglomerates and in some of the bands of altered amygdaloid, and in such quantity near the surface as to promise success to mining enterprise."* What effort has thus far been made has proved unprofitable although no little interest was recently aroused and no little work was done in exploring and testing the rocks. This was in 1880-1882.

Passing to the Lake Superior area of these Cupriferous rocks, there were found, according to Hon. H. M. Rice, in or about the

*Irving R. D. Monograph v, U. S. Geol. Survey, The Copper Bearing Rocks of Lake Superior, p 243.

year 1744, and north of Lake Superior, several large lumps of virgin copper; yet we note that the first mining of which we have definite record was done at French river 14 miles below Duluth.* Just when copper was discovered at this place cannot be told. The metal was first seen by Indians in the bed of the river at some distance away from the lake. In 1854 the Indians ceded to the government large tracts of land in northeastern Minnesota. In that year an association was formed by gentlemen for the most part residents of Cleveland, Ohio, for the purpose of securing possession of several locations then known. After four or five years title was obtained by R. B. Carlton & Co. In 1863, two companies were formed; one was the French River mining company, to which R. B. Carlton & Co., or their trustees conveyed the SW$\frac{1}{4}$ and lots 3 and 4, sec. 17, town 51, range 12 W; and the other was the North Shore mining company, to which the same parties conveyed the SE$\frac{1}{4}$, sec, 25, town 52, range 12 W. The first mining work so far as can be learned was done in 1864. Shortly after the mine was reopened by a Mr. Salisbury acting as foreman for the company of Cleveland capitalists, who worked for some time and succeeded in sinking a shaft of considerable depth but did not succeed in securing more than a few hundred pounds of copper. After Mr. Salisbury left the work, excavating was resumed by Mr. Tom Saxon, of Duluth, under a contract which he closed up in 1866. At this locality native copper occurs in amygdaloidal rock, partly in the form of nuggets up to 15 pounds weight and partly mingled with prehnite, forming amygdules in the decomposed and soft vesicular rock.

The mine has never been worked continuously since Mr. Saxon left it, although Mr. John Mallmann of Duluth has at different times done considerable work. Probably not more than a ton of copper in all has ever been removed from this mine.

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*We learn however, from the Minnesota Historical Collections, that "in 1770, papers were issued in England, in company with a Mr. Baxter, for a company of adventurers to work the copper mines of Lake Superior. They opened veins on both the north and south shore. But the enterprise proved a failure. In one of their mineral expeditions a Russian gentleman picked up a piece of ore of eight pounds weight, took it to England, and it yielded silver at the rate of 60 pounds of silver to 100 pounds of ore. It was deposited in the British Museum and is the first recorded specimen of silver from Lake Superior." J. H. Baker, annual address, vol. III, p. 340.

Up the Knife river a mile or two from the lake, this same Mr. Saxon did some exploring work at the same time he was working the French river mine, i. e. in 1865-66; the excavation reached only a few feet in depth. While the rock was almost identical with that at French river, only two or three miles away, and scarcely a block could be removed without disclosing native copper, the amount was too small to make the work profitable. At both places, French river and Knife river, the early reports were most flattering and the owners always felt assured that the work was giving indications of valuable results.†

At Mr. Wakelin's, farm 10½ miles below Duluth, copper is also found. Here the rock is partly amygdaloid (commonly called ash bed amygdaloid) and partly conglomerate. The copper in small quantities is found everywhere, sometimes disseminated through the rock in fine threads and minute irregular masses, sometimes in leaves and bands and again in nodules and loose fragments. No veins have here been found; native copper can often be seen on the rock surfaces beneath the shallow water off the lake shore.

In Town 60, range 2 west, Mr. Henry Mayhew of Grand Marais did considerable work at mining for copper ore in 1868-'69.

This location is on a vein of bornite which Mr. Mayhew found at the edge of the water on the lake shore, three or four years before. The vein is four feet wide; it dips slightly to the north and it carries the sulphide in seams or bands one-eighth inch and upwards in thickness. From where several veinlets unite quite a large piece of clear ore was taken out and shipped to the Vienna Exposition. The vein was followed but a short distance before it divided and work then stopped and has never been renewed. Probably 1,200 to 1,500 pounds of ore were shipped from this mine.

In Town 61, range 1 west, section 24, native copper has been found. This location is in the bed of the Rosebud river, one and one-half miles from the lake shore and three miles west from Grand Marais. In the year 1876 two men named Johnson and Maguire worked here and secured some hundreds of pounds of copper. The rock is a coarse grained, dark green gabbro or gabbroid. Since there is felsite or felsite porphyry both above and

†For details of these two early enterprises at French and Knife rivers, consult a paper by Hon. H. M. Rice of St. Paul, in the Minnesota Historical Collections, vol. II, pp. 11 and 12.

below this exposure the copper bearing rock may be regarded as a dike. The copper is found in thin sheets and bands in the massive rock.

About the year 1879 the Minnesota silver and copper mining company did some preliminary mining work on a vein running across a small island off the south side of Pigeon Point. The vein carried a belt of copper ore, mingled bornite and chalcopyrite with a little silver which was penetrated by a shaft 50 feet deep. The country rock is a gray quartzite generally regarded as of Animike —Huronian—age. The general position of this formation along the south side of Pigeon Point is east and west with a southerly dip of 10 degrees to 15 degrees. Many barrels of ore were raised at the time of opening the mine but so far as the writer knows no systematic work has been prosecuted. Maj. T. M. Newson of St. Paul, has, I believe been the leading spirit in this enterprise.

The foregoing notes are the result of a recent attempt by the writer to discover the past results and a possible future of copper mining in Minnesota. Many efforts have been made, and particularly in the Lake Superior Keweenawan region from which the results are too meagre and futile to be mentioned here. Stratigraphically the first work was done in the Cambrian rocks (Le Sueurs' labors) but more recently investigations while largely carried on in the Keweenawan, the true Cupriferous series, have to some extent, been pursued down into the Huronian.

Finally the results have been meagre and the impression of the writer is that copper mining will never become a profitable industry either in the southwestern extension of the Keweenawan series around Chegwatona or in the larger area to the north of Lake Superior in Minnesota.

October 6. 1885.

[*Paper R.*]

THE LITHOLOGICAL CHARACTERS OF THE TRENTON LIMESTONE OF MINNEAPOLIS AND SAINT PAUL, WITH A NOTE ON THE BORINGS OF THE WEST HOTEL ARTESIAN WELL.—*C. W. Hall*

THE QUARRY STUDIED.—As a representative exposure of the Trenton limestone of this vicinity, the quarry at the foot of 6th avenue southeast was taken. From this quarry, rock has been hoisted for some years, but recently the Saint Paul, Minneapolis and Manitoba railway has worked it extensively, in securing material for the great viaduct across the river from the upper end of the quarry to the Union depot. The layers suitable for working stand up above the level of the river, so that the drainage of the quarry is all that could be desired, and the horizontal position of the stone and the pronounced vertical joints conspire to make the quarrying of the rock highly satisfactory.

The description below and the figure following it will serve to make clear the thickness and relative position of the different layers constituting the so-called Trenton limestone at this quarry.

THE UNDERLYING ST. PETER SANDSTONE.—Beginning at the bottom we note that a bed of St. Peter sandstone underlies the limestone beds of the quarry. This sandstone has a thickness at this city of 164 feet, according to the record furnished by Col. J B. Clough, former city engineer.* Yet the river at the quarry is not more than 30 feet below the bottom limestone layer. This sandstone shows a medium texture throughout its whole extent, the grains are thoroughly rounded and of very uniform clearness and purity.** The rock is extremely friable: rarely does one find a block sufficiently cemented to hold its own weight when overturned, save where at the edge of the gorge, a cement of calcium carbonate has become infiltrated. A spoonful of the sand plunged in a glass of water produces a cloudiness caused by a fine and white kaolin; it is doubtless this kaolinic constituent occurring all through the stone which causes the marked friability already mentioned, by preventing the cementing of the quartz grains with the silica cement carried by the water percolating through the formation.

The color of the sandstone varies with the local conditions, although as a rule in this vicinity the prevailing color is white. Where any other color is taken on, it is due to the infiltration of coloring matter from the overlying rocks, and is not seen to penetrate the quartz grains themselves. The percentage of impurity in this sandstone is so small that it has been thought that a good

*These Bulletins, vol. I, p. 187.

**In this formation Chamberlin notes the medium coarseness of the quartzose grains and its comparatively freedom from that admixture of coarser and finer material which is common in sandstone. Geol. Wis. vol. i, p. 145.

quality of glass could be manufactured from it. The most serious difficulty to overcome will undoubtedly be found to lie in the rounded form of the grains, this making the fusion of the material a work of much difficulty.

The purity of this sandstone has been alluded to. Some examinations by the writer show its contents of silica to be from 96 per cent. to 98.50 per cent., the kaolinic constituent mentioned being the greater portion of the difference between the numbers given and 100 per cent. The parties who a few months ago became interested in the establishment of a glass manufactory in this city had a number of determinations of iron oxide made by Professor Dodge, of the University of Minnesota, whose several determinations averaged a little over 17 hundredths of one per cent., an extremely low proportion for a bed which undoubtedly underlies hundreds of square miles of the state, and is everywhere so uniform in texture and apparently equally so in chemical composition. The professor made no further determination of the composition of this sandstone than is specified above. The upper portion of this formation possesses a green color which is quite persistent over large areas. This is perhaps due to the presence of protoxide of iron coming from the formation above and deprived of an opportunity to oxidize to sesquioxide. In places however the almost uniform friability is lost; when the waters bearing carbonate of lime, trickle down over the edges of the bluffs or through fractures into the sandstone, a calcium carbonate cement solidifies the mass into a very compact rock.

There is no chemical analysis of this green intermediate layer at hand, by which to compare it with the white sandstone lying below it.

The Trenton Limestone Beds.—Resting directly upon this green and somewhat shaly sandstone is the bottom layer of the "Lower Trenton." It shows some interesting features. For some inches up from the bottom a blue-green-gray finely textured rock appears which lacks adhesion to such an extent that it very easily crumbles under the hammer and for economic purposes is worthless. While the contact of this modification with the green upper layer of the sandstone is quite sharply defined, its relation to the limestone above and of which it stratigraphically seems to form a part is not so easy to make out. If it were of the same thickness and presented the same lithologic characters over a considerable extent, an explanation of its origin could more easily be made. The most probable supposition is that at the close of the St. Peter epoch a deposition of shallow sea—argillaceous—material took place as the sea bottom subsided and the change from a shore line of sands to a deep sea area, with its varied molluscan and crustacean fauna was brought about. After this formation of clay had occurred, and in the deep sea, cavities and canals seem to have been formed in the clay and calcium carbonate, with some impurities, was infiltrated and packed into the pockets formed, thus becoming the replacing material. So the line of contact is a very uneven one, and fairly represented by figure 2, Plate I. which shows a hand specimen 3x4 inches in size.

The limestone spoken of as lying directly upon this argillaceous and corroded layer is quite crystalline. Yet its texture is uneven. For a thickness of about 15 feet, there is a constantly recurring alternation of layers of tolerably pure calcium carbonate with other thin and interrupted layers of a shaly and argillaceous material. The last named series of layers possesses a darker and bluer color than the former; it lacks as well the crystalline habit, the firm compact appearance, and the real hardness and toughness under the hammer. These thin layers weather and decompose more rapidly than the others when the rock is exposed in the walls of buildings, the piers of bridges and other places where the air and rain and frost have free access to it. Nearly all the older buildings of the two cities, built of this stone, which have stood for some years, show a very marked corrosion of this portion: indeed to such an extent has the corrosion gone in the oldest of them, that blocks standing on edge have not infrequently split apart along these lines of easy cleavage and large pieces have fallen from their place, a suggestion to builders always to place blocks of this stone in walls in the same horizontal position they occupy in the quarry. This layer commonly called the "building stone layer" carries but few fossils, although it must have been largely formed from them. The molecular alteration the limestone has undergone, has served almost entirely to obliterate the fossils at this quarry. Occasionally an Endoceras magniventrum, Hall or E. rapax, Hall is exposed, as the quarrymen separate horizontally the blocks of stone along the blue argillaceous bands.

The chemical and lithological characters of this stone will be considered on a subsequent page.

Lying immediately above the building-stone layer just described, is a more massive appearing bed nearly seven feet in thickness. This contains few fossils, as does the layer below it. The color is slightly darker and more uniform than that of the building stone. Traces of sedimentation, while in places quite clear and distinct, are, as a rule, very slight. On a fresh face in the quarry, this rock looks to be a reasonably firm and serviceable one, but on exposure to the air it rapidly crumbles into a finely shattered and worthless mass. It is not even suitable for macadamizing streets, since in a short time it becomes a fine and insufferable dust, or, if sprinkled, a slippery, clayey mud. It could have been only partly made up of fossils; about all of them have been absorbed, leaving only the mould and the interior cast, the walls of which are lined with minute calcite rhombohedrons or occasional iridescent crystals of pyrite. While that is the rule, there are occasional fossils found where shells are well preserved, as in some linguloid forms near the city gas works, on the West Side, and at the Maloney quarry, just below the State University, on the East Side.

This modification is separated from the building stone layer below it by a seam several inches in thickness, rather finer textured, and more crumbling than that above. A shaly consistency pervades this seam, which does not appear elsewhere except as a dividing band between this layer, number four of the following figure, (Fig. 2) and layer number five.

Layer number five, the next in ascending order, is different in several respects from either of those below. While it resembles number three, the building stone layer in the alternation of calcareous and argillaceous bands, it is much more weathered and more easily separated along the aluminous (argillaceous) bands. Its thickness is five feet four inches, varying a little from that at other quarries. The color where it has been exposed along the river gorge or in the quarry is a mixed light brown and gray. Some bands are quite hard and fine, while others are extremely soft. This is a very fossiliferous bed but, for the most part, only casts remain, the fossils themselves being entirely absorbed. In the cavities left by this absorption an incrustation of glistening calcite rhombohedrons is often seen. The crystals are exceedingly minute and frequently exhibit a brilliant iridescence which gives them a beautiful appearance. Pyrite is sometimes associated with the calcite and occasionally either mineral appears massive in the rock itself, but never in large quantities. While many cavities are scattered throughout the compact bands which go to make up the mass of this layer, by far the larger part are arranged in horizontal layers from a fraction of an inch to an inch and a half in thickness. The fossils are so numerous along these harder bands that the composition of the rock must be almost clear calcium carbonate.

As the glacial drift was removed, in stripping the quarry, a very prominent glacial striation was disclosed. The striæ had a direction nearly north and south. The evenness and continuity of these markings and the plane surface on which they lie are another evidence that the river gorge has been formed since glacial times.

The layers of this quarry, as just enumerated, are in other places capped by a layer of green shale. This is the case at Finn's Glen, in Ramsey county, at South Saint Paul, near the linseed oil works and at several other known places. At our quarry this soft, shaly layer could not withstand the severe ploughing of the glacial period, and became mingled with the sand and gravel from more northern localities. It is still here in the city in places, as a well recently dug by M. D. Rhame, just south of the University grounds, abundantly shows. This green shale abounds in fossils,—brachiopods, lamellibranchs, gasteropods, cephalopods and bryozoans are all intermingled in great profusion. This layer is doubtless the representative of what occurs at other places in the state as Middle Trenton, in N. H. Winchell's Geology of Hennepin county as "the Green shales,"* and in Wisconsin where it is called by T. C. Chamberlin the Lower Blue Limestone.†

The drift material itself is of the common coarse gravel with bowlders scattered through it. These bowlders often reach the weight of several tons.

*5th An. Rep., Geol. and Nat. Hist. Sur. Minn., p. 147.

†Geology of Wisconsin. Vol. I, p. 162.

FIG. 2.

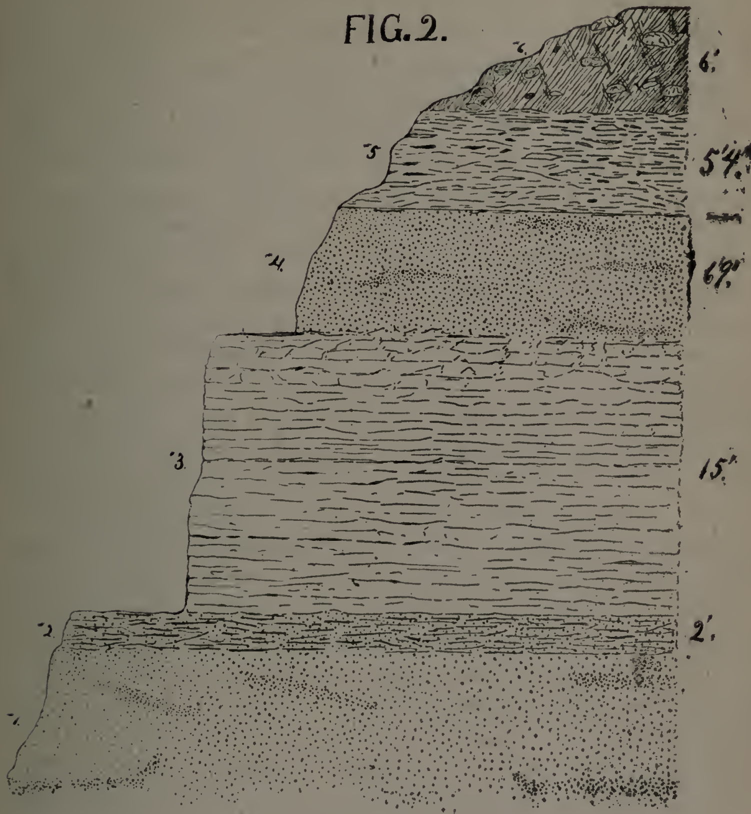

Fig. 2. Section of the Lower Silurian at the quarry, foot of Sixth Ave. S. E., Minneapolis. Numbered in ascending order.

No. 1. The underlying Saint Peter Sandstone. Texture, color and composition very uniform. Thickness 164 feet. Only a portion of this thickness is represented in the figure.

No. 2. The layer of green shaly sandstone two feet in thickness.

No. 3. "The building stone layer." Thickness about 15 feet. Bottom portion quite argillaceous with an irregular contact zone with the carbonate above. Throughout the whole thickness of this layer there is an irregular alternation of calcareous and argillaceous bands, and the calcareous bands become thinner towards the top.

No. 4. A layer which is highly aluminous and silicious. It exhibits but slight banding due to sedimentation. It crumbles easily on exposure to the air. Thickness, 6 feet 9 inches.

No. 5. The upper fossiliferous layer strongly marked by alternating abundance and paucity of fossil forms. These fossils are largely the Strophomena minnesotensis Winchell called in Owens' report on the Geological Survey of Wisconsin, Iowa and Minnesota, the Leptæna deltoidea Hall, with which are S. alternata Conrad, Streptorhynchus filitextum Hall, Orthis tricenaria Conrad, and several lamellibranchs and gasteropods. The layer is 5 feet 4 inches thick. It carries glacial striæ on its surface.

No. 6. The glacial drift covering the rocks to a depth of six feet. The "Green shales" are not present at this quarry.

Comparisons With Other Quarries.—But little time can be taken here in comparing this quarry in its general relations with others in the neighborhood. The broader characters of this spot can be seen almost everywhere that limestone is broken within the two cities. At the Maloney quarry, a mile below this one, and on the same side of the river, the beds appear to be more compact; the upper layer is less shaly and yields some stone for rubble work, while the building stone layer contains fewer of those argillaceous bands which are so deleterious. At Saint Paul the building stone layer is somewhat thicker than here, but on the whole it yields no perceptibly better stone. The belt of green shale which occurs at Finns Glen and in South Saint Paul contains numerous slabs of lenticular shape and small area, which seem to be entirely made up of fossils.* In composition they must be very pure calcium carbonate, while the shale itself cannot contain more than 60 per cent. or 70 per cent. of that material.

In Northeast Minneapolis, on the other hand, the quarries lie nearly on the northern boarder of the Trenton area of the state. All the layers are badly stained and loosened by the action of water carrying solvents and staining mixtures, especially hydrous ferric oxide. In some quarries where the central portions of the layers are quite fresh and blue, the rock next the vertical joints and the bedding joints is stained to the depth of an inch or so with a light brown limonite stain, either brought down from the overlying drift material or obtained by the oxidation of a ferrous oxide in the rock itself.

The Lithological Characters of the Trenton.—These characters harmonize closely with the structural and stratigraphical details already outlined. The building stone layer contains, in some of its bands tolerably pure calcium carbonate. It does display, however, an occasional minute pyritous mass or a granule of carbonaceous matter. But as a rule under the microscope almost the whole field is made up of rhombohedrons of calcite or dolomite, and these forms are very perfect, excepting only when they are developed from nuclei so near together that contact soon interrupts their growth. One fact noted in all the slides examined, was the scarcity of twinned forms. Were it not for the results of the chemi-

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*These fossils consist of several species of orthis, rhynchonella, strophomena, etc., but the largest proportion is made up of many species of bryozoa and, probably, several sponges.

cal analyses, any entire area might be taken for dolomite rather than calcite, were this character of the mineral constituents to be relied on as a distinguishing one, as Zirkel* suggests may be done. Figure 3. Plate I is an attempt to represent the texture of this rock. The rhombohedral cleavage is nearly universal.

As the bands of shaly and argillaceous material are reached argillaceous and silicious substances enter into the composition of the rock as quite constant constituents. The former appears as an earthy matrix holding rhombohedrons of calcite. The silicious constituent lies partly in the argillaceous mineral and partly in the small grains of quartz which polarize brightly and are well filled with fluid cavities. These grains are all well rounded. Pyrite is seen in every part of the formation. It occurs frequently in segregations as shown in Fig. 4 c, Plate I, and almost everywhere in minute crystals, sometimes cubes and sometimes pyritohedrons. They are most plentifully grouped around the absorbed fossils, and occasionally with the transparent, coarsely crystalized calcite, they fill the cavities thus formed.

In certain minor respects the layer immediately above the building stone layer differs from the description just rendered. A large proportion of argillaceous material is present. Where fossils once were, absorption has taken place, and beautiful but small crystals of calcite fill the cavities left. Sometimes the calcite is accompanied by segregations of pyrite crystals, also small but well formed. Both calcite and dolomite are held to appear in the more or less transparent grains, although no traces of twinning are to be seen. All the individuals of both minerals are sharply and uniformly rhombohedral in habit. Pyrite appears in segregations too fine to be detected with the unaided eye. See Fig. 4, Plate 1.

The upper and weathered layer at this quarry presents but little of lithologic interest. The microscopic structure of the compacter bands is very like that of the layer below. At other points, however, as at the Maloney quarry, there is a band in this layer which has a thickness of only a few inches, but of a hardness far in excess of any other band in the whole quarry. Since there is but little save the carbonates of calcium and magnesium in this band, the hardness must lie chiefly in the compact condition of the stone. There is certainly more cohesion in this than in the more heterogeneous portions of the rock.

*Mikroskopische Beschaffenheit der Mineralien und Gesteine, 1873, p. 395.

THE CHEMICAL COMPOSITION OF THE LAYERS.—Through the kindness of Professor J. A. Dodge several analyses of these layers of limestone have been secured. The following shows the composition of several samples with the results given in two tables, the first with the soluble and insoluble portions analyzed separately, and the second with both combined.

Soluble and insoluble portions analyzed separately:

COMPOSITION OF THE SOLUBLE PORTION.

	I	II	III	IV
Silica SiO_2	0.09	0.08	0.23	0.07
Alumina Al_2O_3	0.49	0.39	0.48	7.81
Iron Oxide Fe_2O_3	0.71	0.63	2.09	13.74**
Calcium Carbonate $CaCO_3$	79.18	83.24	56.47	28.16
Magnesium Carbonate $MgCO_3$	6.38	5.40	14.21	11.18
Potash K_2O	trace *	trace	trace	
Soda Na_2O	trace	trace	trace	
Total soluble	86.85	89.74	73.48	60.96

*As shown by the spectroscope.
**Determined as FeO instead of Fe_2O_3

COMPOSITION OF THE INSOLUBLE PORTION.

	I	II	III	IV
Silica SiO_2	8.07	5.71	15.61	20.31
Iron Oxide Fe_2O_3	1.72	1.26	1.91	1.57
Alumina Al_2O_3	2.18	1.65	4.45	18.96
Lime CaO	trace	0.13	trace	0.70
Magnesia MgO	0.04	trace	0.14	
Organic Matter	0.80	0.46	1.26	
Total insoluble	12.81	9.21	23.37	41.54
Total soluble and insoluble	99.66	98.95	96.85	102.50

Soluble and Insoluble Combined.

SiO_2	8.16	5.79	15.84	20.38
Al_2O_3	2.67	2.04	4.93	26.77
Fe_2O	2.43	1.89	4.00	15.31*
$CaCO_3$	79.18	83.24	56.47	28.86
CaO combined with SiO_2	trace	0.13	trace	
$MgCO_3$	6.38	5.40	14.21	11.18
MgO combined with SiO_2	0.04	trace	0.14	
K_2O	trace	trace	trace	
Na_2O	trace	trace	trace	
Organic Matter	0.80	0.46	1.26	
Total	99.66	98.95	96.85	102.50

*Fe_2O_3 and FeO calculated together.

I. The building stone layer: the rock analyzed as a whole. Professor Dodge.

II. The building stone layer: the clean calcareous portions with the dark alumino-silicious bands carefully removed. See Plate. I, Fig. 1 a. Professor Dodge.

III. The building stone layer: the dark alumino-silicious bands with the calcareous portions removed. See Plate I, Fig. 1 b. Dr. W. A. Noyes.

IV. The layer directly above the building stone layer: the one which crumbles badly on exposure to the air. Figure 2, layer 4. Horace V. Winchell.

Several other analyses of this limestone have been made in the chemical laboratory of the University by Professor Peckham, Professor Dodge, Mr. Sidener and the students, but the exact stratigraphic position of the material is not known.

In the preceding description of the microscopic characters of the several layers pyrite was mentioned as occurring in all portions of the formation but particularly in layer numbered four in figure two (p. 117). In the building stone layer only occasional segregations of this mineral were seen and it is quite likely that what iron appears in the analyses is in the form of an oxide as Professor Dodge and Dr. Noyes have reported. In the layer above that the presence of pyrite in hand specimens and in their sections is so constant the absence of sulphur in the analysis reported was a matter of surprise.*

The Economic Aspects of the Trenton.—For lime this rock seems to be entirely unsuited. The miscellaneous mixture of materials which the analyses disclose prevents the formation of a firm binding material by the process of calcining. Although silica and almuina are both present, the rock in all its layers is unfit for hydraulic cement.

For economic purposes, the upper layer, number five of Fig. 2. (p. 117)is used in places as a sort of rubble, and the best portions of number four can be used when the work is to remain underground, and a perpetual dampness is insured. The building stone layer has the best set of qualities. Where the stone from this layer is placed in horizontal position, its strength and durability are both very good; but the whole formation is far from beautiful, and is rapidly going out of use, save in certain kinds of foundation work. The peculiar effects of weathering which this stone exhibits, and

*Subsequently a partial analysis was made by Mr. A. D. Meeds, who determined nearly two per cent. of sulphuric acid present in a portion of the same supply of material from which the foregoing analysis was made.

which seriously injure it for any building purposes, have already been alluded to. (p. 114.)

Several cubes were prepared and submitted to Professor W. A. Pike, of the State University, for a test of crushing strength. The samples from the middle of the building stone layer gave, as an average of several tests, a resistance on bed of 6,250 pounds per square inch. Several tests were made with the stone at right angles to bed, but the results were not satisfactory; no more than the jar produced by the hammer in dressing hand specimens is sufficient to separate the bands of aluminous from those of calcareous material.

The lowest part of this layer, that lying directly above the contact with the green shaly sandstone (see Fig. 2, p. 117) and also (Plate I, Fig. 2) is considerably stronger than that in the middle and upper portions of the same layer. This showed a resistance on bed of 10,312 pounds, and on edge of 8,112 pounds per square inch. These tests show that the lowest portion of the bed is much stronger than the middle; and a mere inspection of the material will show that the middle layers are much stronger than the upper ones.

A Note on the Borings of the West Hotel Artesian Well.—The boring of the artesian well at the West Hotel in this city a short time ago was followed with considerable interest. Mr. E. J. Swan, who did the work, kindly furnished the writer with a carefully preserved set of borings, the numbers and descriptions of which may be summarized as follows:

1.	Soil, gravel, sand and clay, thickness	34 feet
2.	Limestone and shale (Trenton)	20 "
3.	First waterbearing stratum. The St. Peter sandstones and shales,	164 "
4.	Magnesian limestone	114 "
5.	Sandstone with some alternating layers of shale. Second waterbearing stratum	100 "
6.	Shales blue and green with some sandstone layers intercalated	163 "
7.	White sandstone. Third and abundant flow of water	23 "
	Total depth	618 "

The foregoing figures show the thickness of the glacial drift and overlying soil to be 34 feet, the Lower Silurian 20 feet and the Cambrian penetrated through 564 feet of its thickness. The borings also agree very closely with those from the well bored at the Washburn "C" by Mr. C. C. Whelpley. These borings belong to this Academy, and were described in 1882 by Professor N. H. Winchell.*

But the especial point to which attention is now to be called is the character of the upper part of the magnesian limestone immediately underlying the St. Peter sandstone, the layer numbered 4 above in Mr. Swan's West Hotel record and numbered 16 in Mr. Whelpley's record as published by Professor Winchell.

Mr. Swan, at the time he reached this layer, handed the writer some chips from the borings, remarking that he had been told to watch for a quartzite layer.

The chips proved the rock to be nothing more than a layer of limestone, probably dolomitic, with grains of quartz sand intermingled. In the upper part of the layer the color was of a brownish red, due to the presence of ferric oxide, distributed somewhat irregularly through the stone. This irregularity consisted in the intenser staining of scattered spherical masses of rather minute size, giving the stone the appearance of a dolomitic clastic rock scattered through which are numerous grains of quartz. These grains are usually small but there is occasionally one of considerable size.

Figure 6, Plate I, shows a section of one of the chips furnished by Mr. Swan. Several of the grains of quartz can be seen but the rounded reddish areas mentioned do not well appear in the figure. The material effervesces and rapidly disintegrates in hydrochloric acid, leaving the quartz grains behind as an insoluble residue.

This lithologic condition of the borings led the writer to look over the borings of the Washburn "C" artesian well, a series of which belongs to the general museum of the University of Minnesota. In the description of these borings already referred to, the layer in which the boring ceased was pronounced a quartzite, like that at Baraboo, Wisconsin.† But when a piece from these borings is placed in hydrochloric acid, it effervesces rapidly and breaks

*Tenth annual report, Geol. and Nat. Hist. survey of Minnesota, 1881. pp. 211–215.

†The description is as follows: "No. 16, which is the red limestone, so-called, of the East Minneapolis well, has not any of the qualities of a limestone. It is a coarse red gritstone, or arenaceous felsite, the grains being pure white silica, and the cement itself an amorphous red feldspathic substance, seen to result in many cases from incipient metamorphism of the shales of the formation, disturbed by igneous eruptions, at Lake Superior. In other words, it is a layer of the red quartzite formation seen at New Ulm and at Baraboo, Wisconsin. The East Minneapolis well found this layer to be 102 feet thick. * * *" Loc. cit. pp. 213, 214. That is a most

up into a dissolved portion and a collection of clear, smooth and well rounded quartz grains, etc. A thin section was made and it showed the rock to be an arenaceous limestone. Doubtless it is magnesian, as all our Minnesota limestones of Cambrian age are strongly so; yet it is assumed that calcium carbonate predominates since effervescence begins and proceeds rapidly in cold acid. Numerous grains of quartz are embedded in this carbonate matrix; they are all well-rounded and filled with liquid inclusions like those of any ordinary sandstone. Figure 5, Plate I, is a fair representation of the thin section magnified about 35 times.

The conclusion from the borings of the two wells named is that the upper portion of the uppermost layer of the Cambrian dolomitic limestone, or dolomites of Minnesota contains a proportion of silica in the form of rounded grains introduced in a very natural way at the time of transition from a period of limestone or dolomite formation to one of sandstone building.

As a summary of these descriptions we can note: The general stratigraphic characters of the Lower Silurian in the neighborhood of these two cities are very persistent. The St. Peter sandstone everywhere underlies the Trenton; a band of arenaceous shale lies along the contact of the two formations; the Trenton is an impure limestone constantly interrupted in its lower portion by argillaceous bands and giving place in its upper portion to a rock less distinctly stratified and more fossiliferous.

In chemical composition it is seen that the purest bands of the building stone layer contain only about 83 per cent. of calcium carbonate and nearly 6 per cent. of silica. The upper portions of the formation carry as low as 40 per cent. of calcium carbonate and magnesium carbonate combined. This diversity of contents produces a rock which poorly resists weathering and rapidly disintegrates when exposed to the air.

Consequently the formation gives a poor quality of building material for general use. Its comparatively rapid distruction in the air and its low resistance to crushing force are noticeable; these qualities, taken together with the dull, bluish gray color, yield a building material which has in Minnesota many superiors.

remarkable rock description. The material in the University museum shows a rock too fine for a gritstone, (Dana's Manual of Geology, p. 65) and it is not a felsite. (ibid, p. 71). The cement is not amorphous nor is it feldspathic. The "red quartzite" of Baraboo is pronounced by Professor Irving to be a non-granular rock, Geol. Wis. vol. 2, p. 505; the material under discussion is decidedly granular.

PLATE I.

[To accompany Paper R.]

Fig. 1. A piece of the building stone from the East Side quarry; size, 4½x7½ inches. *a*. The calcareous bands possessing a light gray color and containing 88.64 per cent. of calcium and magnesium carbonates. *b*. The interrupted siliceous bands, darker colored than the others, rapidly weathering and containing 70.68 per cent. of calcium and magnesium carbonates.

Fig. 2. The contact between the "blue-green-gray" argillaceous material which forms the base of the lower Trenton and the sub crystaline limestone overlying it. A hand specimen 3x4 inches in size.

Fig 3. The normal building stone layer of the Trenton, —x75.

Fig. 4. The argillaceous bands which abound in the building stone layer. *a*. Calcite in rhombohedral individuals and in granular transparent aggregates. *b*. The argillaceous matrix. *c*. Segregated pyrite grains and crystals.

Fig. 5. The upper part of the magnesian limestone layer just below the St. Peter sandstone, as shown by the borings of the Washburn C Mill, from 204 feet below the surface, —x35. *a*. The granular limestone. *b*. Grains of quartz, many of them carrying numerous fluid inclusions.

Fig. 6. The upper part of Mr. Swan's layer No. 4, 218 feet below the surface at the West Hotel, —x35. *a*. Normal granular dolomitic limestone. *b*. Grains of quartz, usually rounded.

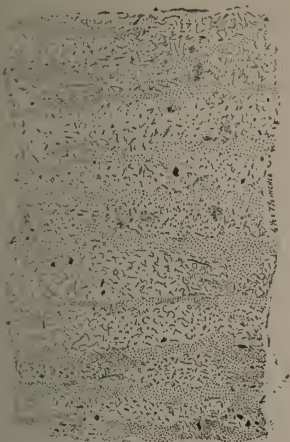

Fig 1

Fig 2.

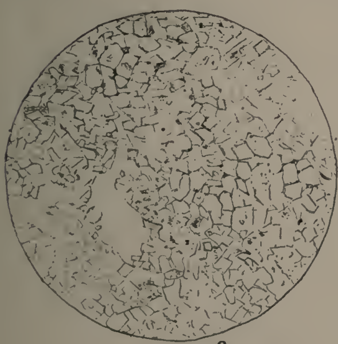

Fig. 3.

Fig. 4.

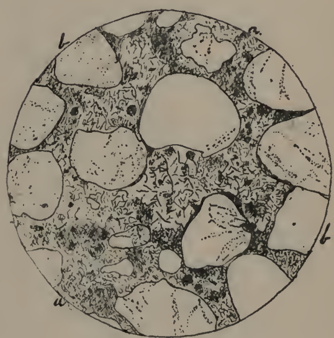

Fig. 5.

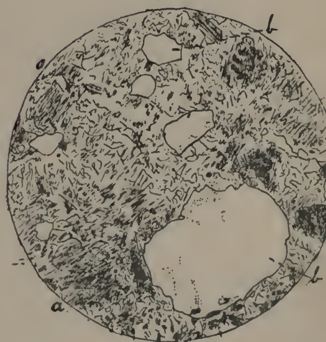

Fig. 6.

[*Paper S.*]

I. THE WATER OF ARTESIAN WELLS; ITS QUALITY AND THE POSSIBILITY OF ITS BECOMING A SOURCE OF SUPPLY IN MINNESOTA.—*C. N. Hewitt.*

II. THE GEOLOGICAL CONDITIONS WHICH CONTROL ARTESIAN WELL BORING IN SOUTHEASTERN MINNESOTA.—*C. W. Hall.*

I.

[ABSTRACT.]

The speaker presented the analyses of thirty-two artesian or drilled well waters, made in the laboratory of the State Board of Health of Minnesota under his direction, and presented a brief study of their history, quantity and composition, as bearing upon the question of such water for domestic water supply. He preferred the term "drilled" wells, as implying the essential fact that the water supply was obtained from beneath one or more strata of soil or rock, impermeable to surface water, and, therefore, comparatively free from the dangers of surface wells, or even deep wells not so protected. It will be seen, too, that the question of depth is not of so much importance as that of character of soil or rock penetrated. The "drive well" is excluded from this list, as not fulfilling the conditions, i. e. supply below impenetrable strata of soil or rock, and wells so tubed as to prevent the entrance of surface water to the supply. As to tubing, he advised the iron pipe, thoroughly coated with asphaltum inside and outside, or coated with black oxide of iron by one of the several processes used for that purpose. Galvanized iron was condemned as almost always imperfectly made, and as adding salts of zinc to the water. The so-called kalamein pipe was also objected to as not proved to be safe.

The plain wrought iron pipe is safe and good. The iron compounds which it adds to the water are harmless and may serve a good purpose (in pipes not directly connected with pumps) by precipitating the part or whole of organic matter. To prevent surface water trickling down through the bore, outside the pipe, into the water supply, tamping around the pipe after it is in place with pure clay or water cement, should be carefully done, and the pipes should come well above the ground.

As to the chemical composition of the artesian or drilled wells in Minnesota, the analyses afford some important conclusions not in accord with the pre-conceived notions of those best qualified to judge.

Those analyses and the average analysis of seventy-five good, ordinary wells in the same districts as the drilled wells (taken from the records of the State Board Laboratory) are given at the end of this paper.

Studied from this side, it appears (in grains per Am. gallon) that the "total solids" are: drilled wells, 29,590; common wells, 24,791. Loss by ignition: drilled wells, 3,439; common wells, 4,136. "Chlorine" drilled, 1,680; common, 1,005. "Oxygen used:" drilled, 0.0707; common, 0.0687. "Hardness total:" drilled, 16.6 degrees; common, 14.50 degrees. "Permanent hardness:" drilled, 4.4 degrees; common, 4 0 degrees. "Removable hardness:" drilled, 12.20 degrees; common, 10.5 degrees.

The differences are so slight that in the present state of the inquiry they may be ignored. Both are good domestic supply waters.

A comparison of drilled well waters by region shows some differences worthy of note: (In estimating permanent and removable hardness, the averages represent the majority but not all of the waters. This determination was not made in a few of the early analyses.)

	Solids	Vol.	Chlor.	O. used	Hardness Total	Rem.	Per.
1. Red River Valley,	35.815.	3.185	3.288	.0751	13.5	3.	10.5
2. H. P. Region	32.894	5.139	0.315	.1309	19.1	4.7	14.4
3. Minnesota R.	32.173	2.725	0.300	.0627	21.4	7.3	14.1
4. Mississippi R.	17.733	3.263	.856	.0329	16.6	4.4	12.2
Gen'l average 75 common wells	24.791	4.136	1.005	.0687	14.5	4.	10.5

The marked character of the Red River Valley series indicates clearly the geology of the district, as do those of the Minnesota River Valley. The majority of the Mississippi River Valley specimens came from cities, and do not perhaps fairly represent the averages of the whole district. This work is going on steadily in the Laboratory of the Board. This paper was written to answer the frequent inquiries as to the prospect and character of the "drilled well" water supply. As these statistics show, it has been favorable, and the drilled well may yet solve the question of water supply for families and smaller towns, if not for cities in Minnesota.

The comparison of good common well water with the drilled well supply, is not at all unfavorable to the common well, so far as the figures go, but to one familiar with this study, there is a solid satisfaction in the aid which a well made drilled well gives in answering the question, Is the "organic matter" of animal origin, and whether plant or animal, is it recent? In deciding whether to class a common well water as fair or doubtful; the history of the well enters largely into the problem, and it is often very difficult to get all the facts required for accurate judgment. By the assistance of Prof. C. W. Hall, of the University, the geological history of the drilled wells, so far as known, will be furnished hereafter with the analysis. Much aid in this direction is expected from the firms engaged in the business of drilling.

The railroads are making these wells for station and engine supply. Some of the waters are used to clean engine boilers of "scale." Those most efficient are alkaline, and contain a considerable proportion of the alkalies.

AVERAGE OF ARTESIAN WELLS.

Depth, feet	Solids Total	Solids Volatile	Hardness Total	Hardness Perm.	Hardness Rem.	Chlorine	Oxygen Used
Red River Valley.							
169	35.815	3.185	14.5	3.	10.8	3.288	.0751
(12)	(12)	(11)	(14)	(11)	(11)	(14)	(11)
Minnesota River Valley.							
48	32.173	2.725	19.5	7.3	14.1	.300	.0627
(5)	(6)	(6)	(6)	(5)	(5)	(6)	(5)
Mississippi River Valley.							
308	17.733	3.263	15.4	4.4	12.2	.856	.0329
(7)	(9)	(8)	(7)	(6)	(6)	(9)	(5)
High Prairie Region.							
95	32.894	5.139	16.7	4.7	14.4	.315	.1309
(5)	(5)	(5)	(5)	(3)	(3)	(5)	(3)
Whole state.							
164	29.590	3.439	16.	4.4	12.2	1.680	.0707
(29)	(32)	(30)	(32)	(25)	(25)	(34)	(24)

For comparison, are given averages of good ordinary wells throughout the state.

	Solids Total	Solids Volatile	Hardness Total	Hardness Perm.	Hardness Rem.	Chlorine	Oxygen Used
	24.791	4.136	12.7	4.	10.5	1.005	.0687
	(75)	(75)	(92)	(39)	(39)	(85)	(44)

Figures in parenthesis, number of specimens averaged.

Hardness in degrees of Clark's scale.

Other figures, grains per American gallon.

II.

Almost the first thing which a community demands is a supply of wholesome and abundant water. This demand is often a factor which locates centers of population and commercial interests. To bring from a distant and uncontaminated supply enough water for human needs, always requires the expenditure of large sums of money, as population increases and local supplies have become contaminated.

In our western states, with their level surface over large areas, and the consequent scarcity of springs, the question of a sufficient water supply becomes a very serious one in every community. Along our streams the excessive cost of a large supply is put off by the pumping station or the conduit from a higher level. The objections against such a supply have led some communities and several private individuals to attempt to secure, by boring artesian or deep wells, a supply free from those objectionable qualities which our river water is universally admitted to possess. A number of artesian wells in the upper Mississippi valley is the successful result of their efforts, and as this mode of securing a supply of water will be more and more followed, it is proposed in this paper to give a hurried outline of the geology of the Mississippi river valley so far as that valley lies in Minnesota, and tell what experience has pointed us toward, rather than what it has proved to us in the matter of deep wells in the southeastern portion of the state.

Around the headwaters of the Mississippi and around all its tributaries southward from Lake Itasca to a point this (south) side of Saint Cloud, the underlying rock is Archean. In part it consists of schists and slates, usually regarded as Huronian, and in part of gneisses of Laurentian time with eruptive granites and diabases. From the northeast to the southwest these rocks stretch entirely across the state. In all these areas experience gives no hope whatever that water will be found by boring into these rocks. They are covered however, by a layer of glacial drift, which reaches in places a thickness of 250 feet. This drift covering can contain vast quantities of water from that supply percolating into it from the yearly rains and snows. In this drift, then, must lie the chief supply of spring and well water for the whole region.

But to the south and east of the area named, younger rocks occur. They are of Cambrian and Silurian age. Their limit in

Minnesota may in general terms be said to be on the east the eastern boundary of the state, on the south Iowa, and on the north and west a line from Iowa to Duluth, so drawn that it would pass through New Ulm, Elk River and Hinckley. Very likely in the northern part of this territory the Cambrian rocks stretch beyond Anoka and Hinckley; that area is not yet fully explored. These rocks are made up of alternating sandstones, shales, limestones and dolomites, whose position is nearly horizontal. Again, no profound movements of the earth's crust have occurred here in the northwest since these rocks were laid down as Cambrian and Silurian sea sediments; therefore no shattering of the rocks has produced great fissures through which streams of water may escape.

Therefore, any water settling down into the porous portions of these strata naturally seeps along for great distances without passing to a level greatly lower than that which it strikes when first starting on its underground course. These sandstones, shales and limestones* vary in thickness from thin, interstratified beds to formations hundreds of feet in thickness. They vary, too, in composition in different portions of the state. The limestones in places become shaly, and the shales give place to sandstones as the beds are followed from one end to the other, or more exactly, as one follows the beds from the southeastern corner of the state towards the north and west, where the formations thin out and give place to the Archean rocks of the upper Mississippi and Minnesota river valleys.

Yet most of the formations are very persistent. The sandstones and the limestones which are exposed along the river gorges can be followed from one gorge to another, or from one deep well to another, over nearly all southeastern Minnesota, and are known to occur in Wisconsin and Iowa. The sandstones are the waterbearing strata, and this persistence is important to the well borer. It enables him to calculate to a very close figure the depth in any part of this area to which he must bore in order to reach a formation that everywhere, according to experience, yields an abundant supply of water.

*The term "limestone" is used here in its generic rather than in its specific sense to include the carbonates. Strictly speaking, a limestone is a carbonate of lime, or, more modernly expressed, a calcium carbonate. The Silurian carbonates of Minnesota contain magnesium carbonate in amount from 5.40 per cent. (p. 120) upwards, while the Cambrian carbonates are in places almost typical dolomites, and no where are they free from considerable magnesium carbonate.

By consulting the accompanying plate (Plate II) it will be seen that there five or six of these layers of sandstone. All of them yield water, the lower ones very freely.

Successful well boring for water depends on certain conditions, partly physical and partly geological. They may be briefly summarized as follows:

A. There must be a porous stratum of rock lying between two impervious strata.

B. There must exist an area at the surface of the ground, where the porous stratum is exposed to saturation from rainfall.

C. There must be a sufficient fall from this exposed area to the region of the wells to insure a steady and abundant flow of water.

D. There must be a sufficient freedom from fissures, faults and dikes to insure a steady flow without great loss of water from the rainfall district to the region of the wells.

It is not necessary that the porous stratum be a sandstone further than the natural qualities of the rocks themselves determine the question. No other rock species is sufficiently porous to permit a free flow through it of large quantities of water, save by fissures, and these form an unreliable passageway, even more likely to cause defeat than to insure success in the search for water.

The sandstones of southeastern Minnesota can very easily be parallelized by means of the deep wells already bored; and their general relations to each other, and to the interbedded limestones and dolomites can be made out.

Mr. Warren Upham has of late given considerable attention to the stratigraphic relations of these sandstones, and he has generously placed his manuscript at my disposal. In preparing these statements, and in sketching the accompanying plate, I have drawn freely from Mr. Upham's notes.

1. The Glacial Drift.—In enumerating briefly the formations in the southeastern portion of our state with reference to their water-bearing qualities, it is not necessary to do more than mention the glacial drift. This deposit, scattered almost entirely over the state, is the universal source of our ordinary well water. This is usually secured by excavating, rather than by boring. Yet where boring is done, it is no unusual thing to secure a flowing well by penetrating the rock to where a layer of clay covers the

sand or gravel over an area sufficiently large to catch and carry a supply of water.

2. The Cretaceous.—Cretaceous rocks are found in a few places in this state. They are sandstones, shales, clays and carbonates. The extent of these rocks is not great, and mere isolated areas have thus far been found. This formation is not distinguished as a water-bearing one for deep wells.

3. The Devonian is equally insignificant from the standpoint of the well-borer. It occurs only in the southern portion of the state, so far as known. Its outcrops lie in Fillmore and Mower counties, with possibly some beds to the east and west of this central location. Doubtless the rocks of this formation are limestones and dolomites.

4. The Trenton.—The Lower Silurian represented by the Trenton limestones and shales is the next in order of the Palcozoic rocks. This is a bed of 30 feet in thickness, more or less, and it is a persistent one. The upper part of it is very impure limestone, containing some fossils* and lying nearly horizontal over a considerable portion of southeastern Minnesota. Its extent is not so great as that of the underlying Cambrian rocks, although it is found in Hennepin, Ramsey and Washington counties and thence southerly in Dakota, Goodhue, Rice, Steele, Dodge, Olmsted, Winona, Fillmore and Houston counties, and very probably in Wabasha and Mower. While this formation is quite impervious, it is interrupted through the erosion of streams and thus does not afford a satisfactory covering for the porous stratum beneath it.

5. The St. Peter sandstone lies next beneath the Trenton limestone. To the north this formation reaches beyond Minneapolis on the Mississippi, but it is too high to be seen in the banks of the St. Croix river. It is found in the central portions of Washington county, where it is protected from erosion by the overlying Trenton limestone. For some miles southward from St. Paul it has been eroded to a considerable extent, but still remains in a few isolated knolls or buttes in Dakota county. It again comes in as a quite persistent formation in eastern Rice, Goodhue, Steele, Dodge, Olmsted and Fillmore counties. It is more than likely that this rock may underlie parts of the following counties in addition: Waseca, Winona, Houston, Mower and Freeborn. It certainly occurs in the western part of Winona and Houston, and must run

*This Bulletin page 115.

under the Devonian in Mower and to the westward. The thickness of this formation at Minneapolis is 164 feet, and in the southern counties, in those locations where it can be measured, it has been found by N. H. Winchell to be as thin as 115 feet.* It may be said in passing, that Professor Chamberlin has found this same formation in Wisconsin, where it is widely distributed, varying in thickness "from two hundred and twelve feet down to a single layer of sand grains."†

The porous condition of this sandstone enables large quantities of water to percolate through it and saturate it, but its high position in this state prevents a flow from it. Yet by means of pumps and stationary engines large quantities of water may be drawn.

6. The Shakopee A.—All geologists of the northwest are not agreed to refer the St. Peter sandstone to the Silurian; indeed, the burden of opinion inclines to the Cambrian age as its true reference. But immediately below it is the Shakopee, a great formation which is undoubtedly Cambrian. This was first noted as a distinct bed of dolomite and dolomitic limestone at Shakopee in 1873.‡ "Its thickness in Minnesota varies from 96 feet at Shakopee to 200 feet in Houston county; in southeastern central Wisconsin it is from 50 to 250 feet; in eastern Wisconsin 62 to 141 feet; in Missouri, as the Second Magnesian limestone of Swallow, it is 230 feet in thickness. In the Minnesota reports this is the limestone of the Minnesota valley, and both the Shakopee and St. Lawrence in the southeastern counties, e. g. Houston, Winona, Olmsted and Fillmore, except the limestone referred to the St. Lawrence at Whalen and Lanesboro. It is the Shakopee of well borings at Minneapolis, Mendota, St. Paul and Hastings."

7. Elevator B Sandstone.—"This formation (the Shakopee) encloses a more or less persistent layer of sandstone 20 feet in thickness in the well at Elevator B, St. Paul, which is probably the Jordan sandstone of Houston and Fillmore counties, except perhaps Lanesboro; of Olmsted county, except perhaps Quincy.

"The sandstone found in this formation at Elevator B may be the cause of the terrace made by the lower part of this

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*Geological and Natural History Survey of Minnesota. Final report, Vol. I, p. 656, and at other places in the county descriptions.

†Geology of Wisconsin, Vol. ii, p. 285.

‡Geol and Nat. Hist. Sur. Minn., 2nd An. Rep't. 1873, p. 138.

limestone* at Shakopee and Louisville, where a terrace is made by the upper part of the Shakopee limestone, and between Kasota and Mankato. The three divisions may be called, in descending order:

1. Shakopee or Lower Magnesian limestone A.
2. Elevator B sandstone.
3. Shakopee or Lower Magnesian limestone B."

Well-borers have not found the Elevator B sandstone in other wells bored in this valley, although from Mr. Upham's statements we may suppose it to be spread very widely through this Upper Cambrian dolomite.

8. THE SHAKOPEE B.—It need only be mentioned here that this layer is essentially the same in lithologic characters as number six and has already been described in Mr. Upham's own words.

9. THE JORDAN SANDSTONE.—Beneath Upham's Shakopee B layer which at Elevator B is a "buff magnesian limestone, 55 feet in thickness," lies the Jordan sandstone. This formation is almost identical with the St. Peter and Elevator B sandstones in lithologic characters. "It is 116 feet thick at East Minneapolis, 103 feet at Elevator B, and 95 feet at Hastings. It has a wide distribution in the Mississippi valley, occurring in Missouri as the Second sandstone of Swallow, 115 feet thick, and in Wisconsin as the Madison sandstone of Irving, in thickness from 35 to 60 feet. The white, evenly granular, medium textured, easily crumbling Jordan sandstone is found at Jordan, St. Peter, Kasota, Mankato

*Mr. Upham calls this rock a limestone in conformity with the usage of several other geologists. Analyses by Professor Dodge and Mr. Sidener give from 54.78 per cent. calcium carbonate and 42.53 per cent. magnesium carbonate in the building stone at Frontenac to 50.68 per cent. and 33.61 per cent. respectively, in the Red Wing stone. As a mean between those two extremes the following analysis of the rock at Ottawa made for the writer by Professor Dodge in January 1886. is given:

Carbonate of lime. Ca CO_3	50.46 percent.
Carbonate of magnesia, Mg CO_3	36.26 "
Silica, Si O_2	8.58 "
Alumina, Al_2 O_3	3.18 "
Peroxide of iron, Fe_2 O_3	1.72 "
Soda and potassa	traces
Chlorides, Sulphates and phosphates	traces
Total	100.20

Amount of the stone not soluble in hydrochloric acid, 10.61 per cent.

Consisting of Si O_2	8.50 percent.
" " Al_2 O_3	2.00 "
" " Fe_2 O_3	traces

Since a typical dolomite has the proportion of 54.35 per cent. calcium carbonate and 45.65 per cent. magnesium carbonate, and Dana's list of analyses of the mineral dolomite (System of Mineralogy, 5th edition, p. 683) shows a greater variation from the type than do the analyses of Professor Dodge and Mr. Sidener, there can be no serious objection to calling these beds dolomites or dolomitic limestones.

and Minneopa in the Minnesota river valley; probably at Lanesboro and Quincy; in Barn bluff at Red Wing; and in the bluffs of eastern Winona county and of Hokah."

It yields more water than either of the layers above it.

10. The St. Lawrence.—Then comes the St. Lawrence formation of dolomitic limestone and shales underlying an equally large area with the Jordan sandstone above. "Thickness in Minnesota, 128 feet in E. Minneapolis well; 213 in Hastings; 160 feet in Mankato; and 170 in the old quarry east of Hokah; in Wisconsin, the Mendota limestone of Irving, with 30 feet of strata below, 60 to 75 feet; in Missouri, the Third magnesian limestone, 350 feet. This is the St. Lawrence of the Minnesota geological reports at St. Lawrence, Hebron and Jordan, but not in Houston, Olmsted, Fillmore and Winona counties, where this name is applied to the same formation that is called Shakopee in the Minnesota river valley, lying above the limestone at St. Lawrence; excepting perhaps at Whalen and Lanesboro, where apparently the true St. Lawrence is found." Upham.

11. The Dresbach Sandstone (The upper Saint Croix).—The fourth sandstone is the one that Mr. Upham locates "at the top of the Saint Croix." It is the formation which appears in the banks of the Mississippi at Dresbach, Dakota, etc., and is called in Minnesota the Dresbach sandstone. Its color is at Dresbach a light, rather pleasant gray, and its thickness in Minnesota is 50 feet or more; in Wisconsin near Madison, 54½ feet; in Missouri the Third sandstone of Swallow, 60 feet.

12. The Saint Croix Shales (The middle Saint Croix).—Below the preceding number, called the Dresbach sandstone, the second member of the great Saint Croix series consists of shales and shaly sandstones. A calciferous character is taken on in places as near St. Croix Falls, Wis.; and in Missouri it becomes the Fourth Magnesian limestone, 200 or 300 feet thick. In this state, so far as determined by well borings, its thickness is 115 feet at Hastings; 75 feet at Mendota; and 170 feet at East Minneapolis.

13. The Saint Croix Sandstones (The lower Saint Croix).—This formation consists chiefly of white sandrock which at Hastings is 230 feet thick, and 395 feet at Brownsville. "This is the sandstone of the Chippewa, Black and Wisconsin rivers, 50 to 100 feet thick." Upham. Water is always found in this layer, and so far as tested, the supply is a large one, as shown by the

Brownsville well and by several Iowa wells which have penetrated what I presume is the same sandrock.*

The St. Croix series, as a whole, is of great extent and thickness. In southeastern Minnesota it is found everywhere that the overlying rocks occur, and whenever it has been penetrated, water has been found in it. It measures up to 478 feet in thickness at East Minneapolis, and over 400 feet at Hastings. In Wisconsin, according to Professor Irving, the rocks which in Minnesota are included in the St. Croix, reach a thickness of 700 feet† and are chiefly sandstones. Large quantities of water are obtained in the city of Madison by boring into these sandstones.

14. The Potsdam Sandstone. — Beneath these three formations which constitute the Saint Croix series, sandstones still continue. They possess a red color, and vary considerably in texture; some of them are coarse enough for conglomerates, and others are fine like shales. This series is waterbearing like those above it; indeed it could not well be otherwise. These rocks are conformable with those above them so far as our investigations enable us to determine.

Mr. Upham regards this series as the westward extension of what is called in New York the Potsdam formation, and he would give it the same name in this state which it has carried in New York and along the south shore of Lake Superior for so many years. It "constitutes a floor upon which the lowest member of the Saint Croix was laid in nearly uniform thickness" throughout southeastern Minnesota and over a large extent of Wisconsin and Iowa and other western states.

The thickness of the Potsdam is difficult to make out. At East Minneapolis it must be at least 1,050 feet. At Mankato the borings from 915 feet to the bottom, 2,204 feet, disclose these red sandstones and shales, a thickness of 1,289 feet, and the underlying rocks were not reached. But to the southeast the sandstones

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*I take the following notes from Upham:

It is 550 feet to the granite at La Crosse, Wis.
" " 750 " " " " " Lansing, Ia.
" " 1,475 " " " " " Mason City, Ia.

There is here no flow, but water in abundance comes within 28 feet of the surface. It is 1,250 feet to the granite at Decorah, Ia. No flow of water, but it comes within 20 feet of the surface. At Calmar, 10 miles from Decorah, and 300 feet higher, boring ceased at 1,223 feet in sandrock. An inexhaustible supply of water, not, however, rising to the surface.

†Geology of Wisconsin, Vol. ii, p. 534.

are thinner. At Brownsville granite is struck at 590 feet, at La Crosse at 550 feet, and on the high prairie at Mason City the granitic rocks are 1,475 feet below the surface. So it would appear that there is but little room for the Potsdam in this section between the white sandstone of the lower Saint Croix and the granitic floor beneath the Cambrian of the Northwest. It is quite likely that during the early part of the period of sedimentation which followed the forming of the Lake Superior trough, the highland of northern central Wisconsin extended down to and across the Mississippi river at La Crosse, and that the shore debris did not cover it until the Saint Croix deposits of white sand were formed.

15. Below these red sandstones and shales lie the crystalline rocks which have in the northwestern states an enormous development. It is not necessary here to enumerate their sub-divisions, nor the rock species representing them. We will designate them simply as Pre-Cambrian. They are permeated with water throughout, but it percolates so slowly that no supply can be secured from that which ordinarily seeps through the rocks. Exceptionally, wells penetrating these rocks furnish a water supply, but it is when fissures are struck through which the water runs in streams.

It will be seen, if now we glance back, that the formations numbered 1, 5, 7, 9, 11, 13 and 14 are water-bearing. For ordinary well supply number one is universally used; for deep wells numbers five, nine and eleven are the most important sources of supply, because of their texture, which permits them to hold large quantities of water reservoired, and allows it to seep through them with great rapidity. Judging from experience, a well borer who reaches either one of these layers will never fail to secure a permanent supply of water, while his supply will very likely be increased if he goes beyond the layers named and into those below them.

The quality of this water supply is high. The great depth from the surface from which it is drawn prevents contamination from organic impurities and insures constant uniformity in composition. It is not pure water—pure water is an unknown thing in nature—but it is wholesome and at all times safe. The doctor has just told us of the composition of these waters as compared in bulk with those of surface wells, page 127; he has given the analyses of a great number of wells to show what artesian water is, as a rule. Let me give two analyses from well known wells, that we may see how these two localities compare with the general results just given you.

1. Deep well water from Hastings, furnished the writer by W. H. Holden; analysis by Professor J. A. Dodge:

Silica, SiO_2	0.62	grains per gallon
Carbonate of lime, $CaCO_3$	9.29	" "
Carbonate of iron, $FeCO_3$	0.17	" "
Sulphate of magnesia, $MgSO_4$	5.84	" "
Chloride of mganesia, $MgCl_2$	1.82	" "
Chloride of potassium, KCl	1.15	" "
Chloride of sodium, $NaCl$	26.15	" "
Total	45.04	" "

The large amounts of sulphate of magnesia and chloride of sodium make this water a peculiar one. The action of these substances on locomotive boilers has proved very injurious.

2. West Hotel water, Minneapolis. Analysis by C. F. Sidener:

Silica, SiO_2	0.81	grains per gallon
Alumina, Al_2O_3	0.02	" "
Carbonate of lime, $CaCO_3$	12.88	" "
Carbonate of magnesia, $MgCO_3$	6.04	" "
Carbourte of iron, $FeCO_3$	0.12	" "
Sulphate of magnesia, $MgSO_4$	0.14	" "
Sulphate of potash, K_2SO_4	0.33	" "
Sulphate of soda, Na_2SO_4	1.25	" "
Chloride of sodim, $NaCl$	0.06	" "
Phosphates	traces	
Nitrates and nitrites	traces	
Total	21.65	" "
Free ammonia	.02	" "
Albumenoid ammonia	traces	
Hardness, 15 degrees.		

To show before the eye the succession of strata just named with the relative thickness of each, as well as the comparative depth of the wells thus far bored in the Mississippi river valley Plate II has been prepared. To make it clear to all, the following synopses are given:*

I. Lakewood Cemetery Well—*C. W. Hall.*

Formation 1. Extends from the surface, about 925 above the sea, to a depth of 256 feet. Consists of gravel with large bowlders of granite and diabase with some sand stone, sand and clay.

2. Not known to occur in this portion of the state.

3. Not known to occur in this portion of the state.

4. Not detected in the borings, save as pieces in No. 1; very likely absent at this place.

*The Roman numerals in these synopses refer to the well numbers; the Arabic numerals correspond with those of the formations described on the preceding pages.

5. From 256 to 302 feet. Not the entire thickness of this bed as shown by the other wells in this city, so this is undoubtedly the lower portion.

6. From 302 to 314 feet. At 302 feet the borings consisted chiefly of grains of white sand, but mingled with them were numerous light brown chips of dolomite.

The formation seems to be quite thin at this locality, the drillings from 302 to 314 feet being dolomitic, and below that becoming very sandy. The bottom of Shakopee A is estimated to be 320 feet from the surface.

7. At 323 the drillings were mostly a white sand, which continued very uniformly to 360 feet; the lower portion takes on a yellowish to light brown color.

8. The drillings between 360 and 403 feet show a dolomite which is referred to this formation, the Shakopee B.

9. The Jordan is represented by the white sands, sometimes fine and sometimes coarse, and at the top with some dolomitic chips lying between 403 and 558 feet in depth.

10. Green shales and sands extend down to the depth of 607 feet. [Compare the Mendota and Elevator B wells].

11. This formation, the Dresbach sandstone, characterized for its white sands, occupies the depth between 607 and 780 feet; towards the bottom it becomes somewhat green.

12. As green shales we have this bed reaching down to 844 feet.

13. Sand again occurs at 844 feet, which has a somewhat greenish color at the top; becomes white and clean at 960 feet and assumes a reddish tint at 1,010 feet.

14. From 1,010 feet to the last drillings taken from the well the material was a red sand, mingled towards the bottom with a light green shale. At 1,560, 1,850, 1,975, 2,100 feet, there was no perceptible change in the appearance of the drillings; at 2,150 feet a sample was referred to the writer by the superintendent of the cemetery. An examination showed pieces of quartz, hornblende, feldspar, both orthoclase and plagioclase, and some chloritic mineral. As those minerals were evidence of granitic material, the opinion was given that the Pre-Cambrian rocks were reached. The well was sunk no further and the hole was allowed to fill, as no flow of water was secured.

Total depth of the well, 2,150 feet.

II. The Washburn C Well*—*N. H. Winchell.*

Formation 1. From 825 feet above the sea, the first 10 feet downwards is made up of soil and glacial drift material.

2 and 3. Not represented.

4. Twenty-six feet in thickness; the last two feet of a blue shale.

5. In varying shades of color; this sandstone is 168 feet in thickness.

6. This formation was penetrated only one foot.**

Total depth of the well, 205 feet.

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*See also Tenth An. Rep. Geol. Nat. Hist. Sur. Minn., p. 211.

**Compare note on this well; this Bulletin, p. 123.

III. The West Hotel Well—*C. W. Hall.*

[Compare this Bulletin, p. 122. The slight discrepancies which may be noted arise from the fact that the former summary was made up from Mr. Swan's written notes, while this synopsis is compiled from a series of drillings preserved for the writer by Mr. Swan at the time the well was sunk. N. H. Winchell received a series of drillings.]*

Formation 1. Consisting of ordinary drift material, from 835 feet above the sea, downwards to a depth of 18 feet.

2 and 3. Not represented.

4. Limestone and shale 20 feet.

5. White and yellow sand 164 feet. At 164 feet from the surface a layer of red shale four feet in thickness was penetrated. The first flow of water came from beneath this shale. The supply was not sufficient.

6. Dolomitic limestone 82 feet thick. At the top the color is reddish and the rock contains many grains of sand. (This Bulletin, p. 123.) Below a yellowish drab color prevails.

7. Below the preceding, a layer 15 feet in thickness occurs, which is referred to Upham's Elevator B sandstone. The drillings seem to contain about 30 per cent. of dolomite chips.

8. Thirty-six feet of dolomite, or dolomitic limestone underlies the preceding.

9. A bed of sandstone 96 feet in thickness yielded the second flow of water. This rock varies from fine to coarse in texture, the coarser lying near the bottom.

10. A thickness of 161 feet is grouped as this number of the series. The first 45 feet in descending order, is a fine white sand with some light gray calcareous material intermingled. It is quite near No. 9 in general characters, and it is not certain but it should be grouped with the sands of that formation rather than with the shales of this. The following 116 feet consists of green shales quite hard and firm at the bottom.

11. The clear white sand of this formation "at the top of the Saint Croix," was penetrated 30 feet. A supply of water running 300 gallons per minute was struck, when boring ceased.

Total depth of this well 622 feet.

IV. The East Minneapolis Well**—*From Warren Upham's Notes.*

Formation 1. First 42 feet "sand and till" from 850 above the sea downwards.

2 and 3. Not present in this vicinity.

4. From 42 to 70 feet; 28 feet in thickness.

5. To 234 feet, clear white sand; 164 feet thick.

6. To 352 feet; first 102 feet red limestone, then 16 feet of gray limestone.

7 and 8. Not distinguished in this well from No. 6. No. 8 may lie however, in the "gray limestone" of the lower portion.

9. In this well is 116 feet thick; from 352 feet to 468 feet. The sand is white and clean.

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*Fourteenth An. Rep. Geol. and Nat. Hist. Sur. Minn., p. 11.

**Compare N. H. Winchell, these Bulletins, vol. I, p. 187.

10. The "blue shale" of the well borer between 468 and 596 feet in depth is regarded as Saint Lawrence.

11. The white sandstone which was next penetrated through 82 feet, represents this number, the Dresbach sandstone, at East Minneapolis.

12. What is termed the Upper Saint Croix in Mr. Upham's stratigraphy occupies a thickness of 170 feet. It consists chiefly of a blue shale.

13. Then comes a white sandstone 217 feet in thickness, in the middle of which a layer of sandy marl 12 feet in thickness was detected.

14. At 1,074 feet a red marl layer 57 feet thick was passed, and a red sandstone was reached. Boring continued in this rock until work ceased.

Total depth reached, 1,421 feet.

V. The Elevator B Well—*Warren Upham.*

Height 855 feet above the sea.

Formation 1. Represented by 58 feet of modified drift.

2 and 3. Not present.

4. The Trenton limestone is 25 feet thick.

5. As clean white sand this number is 152 feet thick.

6. Calcareous sandrock 30 feet; buff magnesian limestone 35 feet; total 65 feet.

7. White medium grained sand 20 feet in thickness.

8. Buff magnesian limestone like the lower part of No. 6, 55 feet in thickness.

9. This formation, a white sand, is 103 feet thick.

10. The Saint Lawrence as shales and calciferous sandrock is 194 feet thick.

11. As white and gray sandstone 66 feet thick.

12. The gray and green shales of No. 12 were penetrated 100 feet or more and the boring ceased.

Depth reached 850 feet.

VI. The Saint Paul Harvester Works Well*—*Warren Upham.*

Formation 1. As stratified gravel and sand from 871 feet, downward 235 feet.

2, 3, 4 and 5. All wanting.

6. "Buff magnesian limestone and sandrock 125 feet."

7. A sandstone layer 10 feet thick.

8. "Light yellowish buff magnesian limestone 10 feet."

9. A gray sandstone 100 feet.

10. Shales calciferous sandrock and dolomitic limestones down to the bottom of the well, 191 feet.

Total depth of the well 871½ feet. Two wells have been drilled by the Harvester Works company. The first part of each, between 500 and 600 feet, was drilled in the ordinary way, but the last part was penetrated by a diamond drill, and a core rather than pulverized drillings was examined. Water stands in both wells at 35 to 40 feet below the surface, and yields a constant supply.

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*Also Geol. and Nat. Hist. Sur. 13th An. Rep., p. 59.

VII. The Mendota Well*—*Warren Upham.*

Formations 1, 2 and 3. Not present.

4. Twenty-two feet in thickness.

[This must be drift i.e. fallen pieces of the Trenton, as the well was bored at the edge of the bluff, along which in many places large slabs of limestone are broken down. Standing on the north side of the river, the Mississippi, the white St. Peter sandstone can be seen to the eastward of the station at a higher level than the roofs of the buildings. —C. W. Hall.]

5. Consists of brown sand rock 60 feet; blue shale 30 feet, and sand rock 35 feet; total, 125 feet.

6, 7 and 8. These thin formations are not here separated; total, 145 feet.

9. A white sandstone 95 feet thick.

10. A series of layers made up as follows: Gray shale, 50 feet; green shale, 110 feet; limestone, 10 feet; blue shale, 30 feet. Total, 200 feet.

11. This sandstone "at the top of the Saint Croix" is 50 feet thick.

12. As gray shale, 40 feet; green shale, 35 feet. Total, 75 feet.

13. This does not appear.

14. As a "very hard, red sandrock enclosing beds of shale." The Potsdam was penetrated 145 feet.

Total depth 857 feet.

VIII. The Hastings Well**—*Warren Upham.*

Height, 700 feet above the sea.

Formations 1, 2, 3, 4 and 5. Not represented.

6. A thickness of 80 feet was passed. This dolomite is seen in the streets of Hastings at a height considerably above the top of this well.

7. Sandstone 15 feet in thickness.

8. A dolomite or dolomitic limestone 12 feet thick. [Winchell designates this as a "dolomitic grit."]

9. "Sand rock" 95 feet.

10. "Shales; doubtless also calcifirous sandstone." Colors, gray and green; 213 feet.

11. A sandstone containing pyrites. From the last 20 feet of this formation came the first flow of water; thickness 60 feet.

12. This formation, while consisting chiefly of blue shale (70 feet), contains also some green sand (20 feet), and dolomitic grit (5 feet). Total thickness, 115 feet.

13. A series of sandstones of varying coarseness, with some shale towards the bottom, having a total thickness of 230 feet.

14. From 820 feet down to the bottom of the well the rocks were chiefly sandstones, but with some red shales; thickness of these beds 340 feet. These are grouped by Upham as Potsdam.

Depth of well, 1,160 feet. Flow of water 100 gallons per minute, which reaches only a few feet above ground. The quality of this water is not satisfactory for railroad uses. Note this Bulletin, p. 137.

*N. H. Winchell has also copied Mr. Swan's notes. Geol. and Nat. Hist. Sur. Minn., 13th An. Rep., p. 55.

**See also N. H. Winchell, Geol. and Nat. Hist. Sur. Minn., 13th An. Rep. p. 56.

IX. The Red Wing Well*—*C. W. Hall.*

Height above the sea, 686 feet.

Formation 1. Wanting. A heavy deposit of river silt and gravel, probably to a large extent made up of No. 1, was passed through. Thickness, 40 feet.

2, 3, 4, 5, 6, 7, 8 and 9. All wanting.

10. One hundred and forty-five feet of blue shale sands and mingled sandstone, quartz—and limerock are assigned here. These would form only the lower part of the St. Lawrence, which at Hastings, 20 miles away, shows a thickness of 213 feet.

11. From the bottom of the preceding, 185 feet deep, to the bottom of the well, no material variation in the drillings was noted; all were "sandstone, white and soft." The drilling stopped in a hard streak possessing a red color, probably the top of the Potsdam formation.

"Total depth of the well 500 feet. Great abundance of water, slightly impregnated with iron. Pressure at the R. R. depot 40 lbs. per square inch." —W. E. Swan.

X. The Lake City Well†—*C. W. Hall.*

Height of Lake City depot above the sea, 705 feet.

Formation 1. Wanting. Here also as at Red Wing, a river deposit is passed. Thickness, 207 feet.

2, 3, 4, 5, 6, 7, 8 and 9. Wanting.

10. "Blue sand shale, 68 feet."

11. Gray sand and shale, 25 feet.

12. Gray sandstone and gray sandy shale, 112 feet.

13. Red and yellow sandstones and gray sandy shales, 88 feet.

14. "Red shale and quartzite, 320 feet."

The above references are based on Mr. W. E. Swan's notes to the writer. Water comes to within 45 feet of the surface. Well bored for the C., M. & St. P. Ry. Depth, 820 feet.

XI. The Brownsville Well‡—*C. W. Hall.*

Height above the sea about 640 feet.

Formation 1. Wanting. A blue clay, probably river deposit, occurs, 40 feet in thickness.

2, 3, 4, 5, 6, 7, 8, 9 and 10. Wanting.

11. Limestone,§ 25 feet.

12. Blue shale 60 feet and a green shale 70 feet; total thickness of the Saint Croix shales 130 feet.

13. Sandstone 395 feet.

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*Mr. Swan's notes are also given in the 13th An. Rep. Geol. and Nat. Hist. Sur. Minn., p. 57.

†Also Geol and Nat. Hist. Sur. Minn 13th An. Rep. p. 58.

‡From notes given Warren Upham by W. E. Swan, who drilled the well. Some changes have been made, for which Mr. Upham should not be responsible.

§As N. H. Winchell observes, 13th An. Rep p. 59, this is a doubtful determination. If it be based on an acid test it could be only partially satisfactory, for even the Dresbach sandstone effervesces to a considerable extent in hydrochloric acid. A little further admixture of carbonates into this sandstone would form a rock answering to what are presumed to be the conditions of this layer.

PLATE II.

[To accompany Paper S.]

Figure I. The Lakewood Cemetery Well, Minneapolis; bored in 1884-5 by Gray Brothers; depth, 2,150 feet.

Fig. II. The Washburn C Well, Minneapolis; bored in 1880 (?) by C. C. Whelpley; depth, 205 feet.

Fig. III. The West Hotel Well, Minneapolis; bored in 1884 by W. E. Swan; depth, 622 feet.

Fig. IV. The East Minneapolis Well; bored in 1874-75. City Engineer J. B. Clough in charge; depth, 1,421 feet.

Fig. V. The Elevator B Well, Saint Paul; bored in 1883 (?) by N. W. Carey; depth, 850 feet.

Fig. VI. The Saint Paul Harvester Works Well; bored in 1882-83 by N. W. Carey, (the diamond drill work was done by Mr. Joseph Susor); total depth, 871½ feet.

Fig. VII. The Mendota Well; bored by W. E. Swan; depth, 857 feet.

Fig. VIII. The Hastings Well; bored in 1880 by W. E. Swan; depth, 1,160 feet.

Fig. IX. The Red Wing Well; bored by W. E. Swan; depth, 500 feet.

Fig. X. The Lake City Well; bored in 1881 by W. E. Swan; depth, 820 feet.

Fig. XI. The Brownsville Well; bored by W. E. Swan; depth, 590 feet.

Fig. XII. The Mankato Well; bored in 1874-75 for the city; depth, 2,204 feet. [The writer's series of borings was presented partly by the Mankato high school, A. F. Bechdolt, superintendent, and partly by W. Hodapp].

Fig. XIII. A generalized section through Southeastern Minnesota from Stearns county to Iowa.

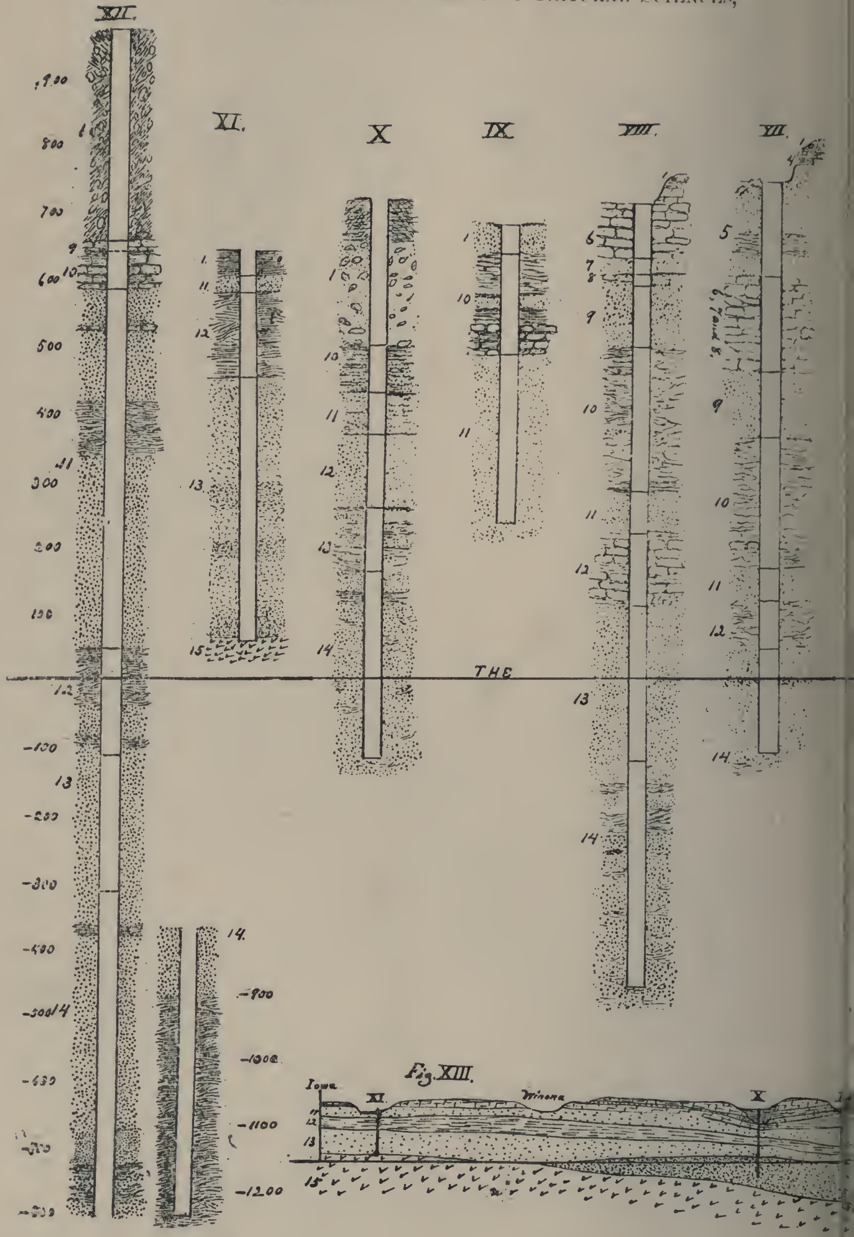
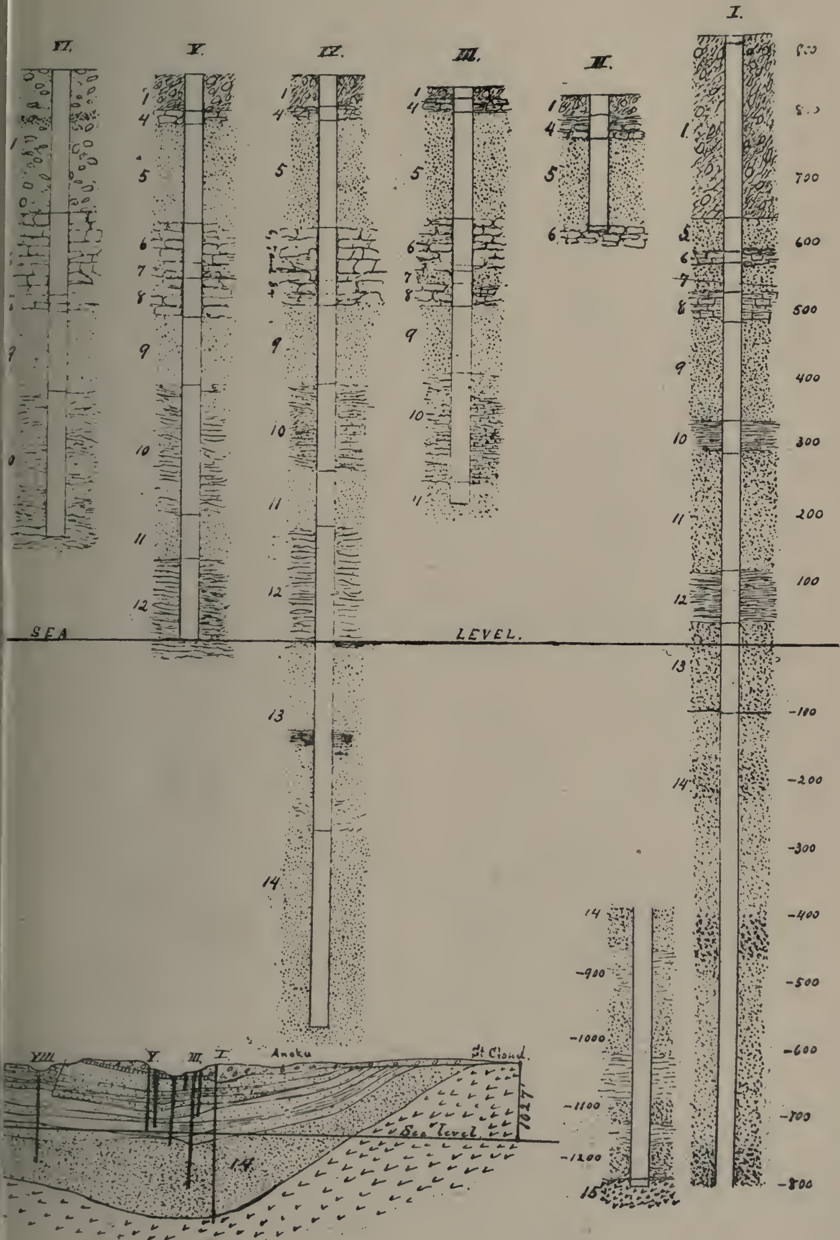


Fig. XIII.

Vol. III, Plate II.



14. No red sandstones or shales were reported by Mr. Swan.

15. Below the sandstones of formation 13, granite was reached. Possibly this was quartzite (see Lake City well, formation 14), and so, formation 14 instead of 15. Unfortunately no borings are at hand.

The well was bored to increase the water supply at the grist mill. Flow, 1,000 gallons per minute of soft water. Total depth, 590 feet.

XII. The Mankato Well*—*C. W. Hall.*

Formation 1. Ordinary bowlder clay or till 290 feet.

2, 3, 4, 5, 6, 7 and 8. Wanting.

9. This formation is present beneath quarries and in all the surrounding bluffs. It is quite possible that a part of the material referred to formation 1 belongs here.

10. The borings at 380 feet show a dolomitic rock, possibly somewhat shaly. At 390 feet a green shale and sandstone comes in. Estimated thickness of this formation 160 feet.

11. The drillings from 450 feet to 850 feet show a clear white sand having at the top a slightly pinkish tint. Thickness of these white sands 400 feet and more.

12. At 915 feet a red shaly sandstone appears which may be the representative of this formation in the southwest.†

13. From 1,010 to 1,240 feet the drillings are entirely sands and rather coarse in texture. The color at 1,010 feet is pink, at 1,240 feet nearly white. Thickness not less than 230 feet.

14. At 1,265 feet a pink color comes in which at 1,340 becomes red. The red color with an occasional fading into pink continues to the bottom of the well. The drillings saved from 1,875 feet down to the bottom, seemed to show a fine red shale at every point. Total depth 2,204 feet. The well is not at present used for water supply.

[*Paper T.*]

On the reproduction of lost or mutilated limbs of insects.—*O. W. Oestlund.*

The reproduction of a lost limb is a fact well known to take place among the lower arthropods, especially the crustaceans and spiders. Such a lost limb is not produced by a gradual growing out, as might be supposed, like the growth of a limb or twig of plants, but the growth is internal and the limb does not appear

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*See further details by Warren Upham in Geol. and Nat. Hist. Sur. Minn. Final report vol. I. pp. 422 et seq.

†Another view is that this rock may represent the top of the Potsdam, and that here, near the margin of the Saint Croix sea, no shales corresponding to formation 12 of the Mississippi river valley were formed. In that case No. 11 above would stand for the entire thickness of the Saint Croix, or formations 11, 12 and 13. There is no sufficient geologic reason why the Potsdam may not contain white and gray sandstones as well as pink and red.

until after the next moult, when the same will expand and become filled with the fluids of the body just as all the appendages of insects are first formed within the skin of the pupa and on emerging from the same expand. Such a reproduced limb is easily distinguished by not acquiring the same size as the original, being always somewhat smaller.

The hexapods, or true insects, apparently make an exception, as there is no case on record, as far as known to me, where a lost or mutilated limb will be reproduced in comparison with the very common occurence of this among the spiders and crustaceans.

From the nature of the reproduction of a lost limb for the lower arthropods, which takes place only after a moult, it would follow that the same would not be reproduced if lost after the last moult has been passed. This is just the case with insects in the imago-stage, and we have only to show that such a limb can be reproduced if lost or mutilated previous to the emerging of the insect from the pupa, to put the hexapods on the same footing as the lower arthropods in this respect.

A fine specimen of *Tremex*, one of the "horntails" of the hymenoptera, that I had the good fortune to find some time ago, would seem to cast some light on this subject. It is apparently a five-winged specimen, the left fore-wing of which, from some cause or other, has become injured to such an extent as to be of no further use for flight: less than one-half of it is still left, torn up in threads hanging down the body. Along side of this torn wing there is a second one that has grown out to take its place. This additional wing has the characters of a reproduced organ, being smaller and the venation less perfectly developed. What still remains of the torn wing would indicate, on the other hand, that it would have been of the same size as the right fore-wing, if not injured. Both the hind wings show perfect development. Fig. 3.

Fig. 3.

Two explanations might be given for the condition of this specimen. If we suppose, in the first case, that the injury to the wing was received after the insect had emerged from the pupa, the new wing would then have been produced irrespective of moulting, a case which stands at variance with all known facts in regard to the reproduction of lost limbs of arthropods. On the other hand we may suppose that the injury was received while still in the immature stage, and that the new wing was produced from internal growth, and ready to take the place of the injured one on the emerging of the insect from the pupa, thus analogous with the reproduction of lost limbs of spiders and crustaceans.

If this be the case. which appears most likely, we may draw the following conclusion: *All the arthropods, including true insects, are capable of reproducing lost or much mutilated limbs, if the same takes place previous to a moult or while yet in the immature stage.* From the difference in habit of true insects from the lower arthropods, we might also infer that the reproduction of a lost limb would more readily and often take place among the latter, while not absent in the former, as facts also show.

March 2, 1886.

[*Paper U.*]

SOME NOTES UPON THE MORE RECENT FOSSIL FLORA OF NORTH DAKOTA AND AN INQUIRY INTO THE CAUSES THAT HAVE LED TO THE DEVELOPMENT OF THE TREELESS AREAS OF THE NORTHWEST.– *John B. Leiberg.*

A most noticeable feature of the prairies of North Dakota, west of the Missouri river, is the immense amount of silicified wood scattered everywhere over the surface.

This, in a region now almost devoid of arboreal vegetation, naturally leads one to speculate on the causes that have operated to destroy this ancient forest growth and prevent any other from taking its place in modern times.

We find that the land is covered by a rich and fruitful soil, producing various kinds of herbaceous plants in great abundance, and the average rainfall is sufficiently large to warrant us in not classing the climate as arid.

Various theories have been advanced to account for this absence of forest covered areas in the Northwest; one of the most commonly accepted being that which ascribes the cause to the annually occurring prairie fires, consuming with the dry grass such seedlings as during the summer had found a lodgment.

For some portions of the western prairie region this theory is doubtless, in the main, the true one; but in the extreme Northwest, from the Rocky Mountains eastward, other causes have been and are yet at work to prevent any extensive forest growth, either wild or cultivated; and if the views hereafter set forth prove to be the true ones, the same causes will be constantly tending to enlarge the timberless areas towards the east.

As before remarked, the portion of North Dakota lying west of the Missouri river possesses no timbered areas aside from the forest growth on the Missouri river bottoms.

Scattered groves of stunted trees are found here and there lining the banks of the small streams on the northern and eastern slopes of the buttes, and in the deep ravines that occasionally radiate from these hills. The number of species of trees that compose these groves are not many; boxelders and cottonwoods occupying the chief place. With them occur Prunus Americana, wild plum, confined to the region of the Little Missouri river; Prunus pumila, dwarf cherry, Shepherdia Canadensis and argentea and Eleægnus argentens, the buffalo berries; various species of gooseberries and currants, while the Coniferæ are represented by a trailing Juniper, that usually covers the driest portions of the hills with its widely creeping branches.

The forest growth now so scanty was not always so. On every hand we see abundant remains which testify to the fact that in a not so very distant geologic epoch, vast forests flourished, where now only their fossil or carbonaceous remains are met with.

On crossing the Missouri river at Bismarck one notices within a distance of 20 or 25 miles to the westward, the drift sheet that covers eastern Dakota and so much of Minnesota gradually thinning out, and the underlying rocks coming to the surface. At the same time numerous seams of lignite or brown coal, some of considerable thickness, begin to crop out in the banks of streams, deep ravines, and wherever the surface has suffered any extensive denudation. Large slabs, or pieces of fossil-wood likewise become abundant. These features increase constantly the farther westward we go. The pebbles in the beds of the streams are all fossil-wood in every variety of silicification, often very beautiful, the grain of the wood, the ducts, the annual layers, the knotty and gnarled branches are all faithfully preserved. Not only is the wood of the limbs and trunks of these ancient trees preserved, but even their stumps still remain in the ground apparently in the identical place where they once grew. In numerous places not an acre of ground can be found for long distances, but has dozens of these fossil tree stumps protruding from the ground. These stumps are transformed into the hardest kind of silica, and the actions of the winds and the driving dust and sand have put an unapproachable polish on them.

It may be remarked in passing that it is a rather novel and strange arrangement, that the settler upon these prairies should, in order to clear his farm, be obliged to pull the stumps of trees that flourished perhaps 50,000 years ago. Yet such, in many localities, is the fact.

Occasionally, a huge trunk is found silicified as it fell.

The rocks and clayey subsoil abound with leaf impressions, and at times remains referable to the fruit or seeds are found.

The leaves enclosed in the rocks have usually been transformed into a black carbonaceous substance, which crumbles quickly upon exposure to the air, but the outline of the leaf, as well as the minutest features, are found perfectly preserved when first exposed. In the clay, nothing but the impressions of the leaf commonly remain, but every detail is plainly marked.

Where the rocks or the clays have been subjected to heat by the burning of the underlying lignite beds, the fossil stumps have melted into huge fantastic humps, and the contained leaf impressions have baked into the clay, leaving almost indestructible imprints.

Upon investigation, it has been found that the species of trees that made up these ancient forests were in a great measure composed of species that yet have living representatives in our own country.

Among genera to which these fossil trees have been referred may be mentioned the oak, birch, poplar, willow, beech, sycamore, sassafras, magnolia, sumach, tulip tree and many others, showing how closely the then existing sylva was related to our own. The abundance and size of the fossil remains indicate a luxuriance and vigor of growth not found now except on the western slope of the continent. Many of the trees must have been of immense size. On the bluffs bordering the valley of the Green river in Stark county, Dak., I have measured stumps that showed a diameter of fully twelve feet. The heavy beds of lignite, occurring everywhere, and of which the upper beds, at least, are composed almost wholly of semi-carbonized wood, betoken a long continued growth.

Without attempting to fix the exact geological epoch in which these forests flourished, it can be safely said that the character of the fossil remains indicates very clearly, climatic conditions similar to those existing at the present day in portions of our territory 5 degrees or 6 degrees farther south.

It has been supposed that the country in which we find these fossils, at this time was low and marshy, only here and there rising into low hillocks. Be this as it may, we know that forest growth is closely related to, and dependent upon the amount of the annual rainfall, and the evidence we have proves conclusively the existence in the past of a much more humid climate than the same region now enjoys.

To the cutting off of this supply of atmospheric humidity, I attribute, more than to any other cause, the extinction of these forests, and the prevention of others from taking their place.

If we travel westward, we find as we progress, the timbered areas increasing in extent, the forests become denser and evincing a more vigorous growth, until on the Pacific slope they reach their maximum in the heaviest and densest forests on the North American continent. This exuberance of growth is closely graduated according to the amount of the annual precipitation.

The rain and snowfall on the Pacific slope is usually accompanied by winds from the southwest or west. These winds coming from the ocean bring up an immense quantity of moisture. Much of it is deposited on the Coast and Cascade ranges, but the broken character of these ranges, and many low passes furnish an avenue of escape for a not inconsiderable portion of the rain clouds to the plains beyond. Comparatively little precipitation takes place here, and the clouds travel almost without interruption eastward, until intercepted by the Bitter Root range. This range, for a distance of 250 miles north and south, stands in the way like a gigantic wall. Its mean altitude is higher than the elevation of the heavy rain clouds; it has but few passes and they not low. In consequence the clouds are banked up against this rocky wall in immense masses, filling the canons and ravines with a thick, heavy vapor. Condensation takes place, and great quantities of rain or snow fall on the western slope and summit of this ridge, while but little is deposited on the eastern slope. A portion of the packed-up cloud masses is deflected towards the north, and rounding the Bitter Root range is spread out over northern Montana. For this reason the heavy forest-covered area extends near the 49th parallel much farther towards the east than is the case two degrees or three degrees southward.

One cannot help noticing the sharply drawn line of demarcation between the western slope of the above mentioned mountain range and the eastern. The Pacific side being exposed to the moist winds from the ocean, the forests are very similar in character to those that cover the Coast and Cascade ranges, but on gaining the summit and descending on the eastern slope, a change is seen at once. Although the timber is principally composed of the same species that are found on the western slope, yet it is far from retaining the same size and vigorous growth that characterizes that. From this point eastward, the timbered areas dwindle very rapidly in extent and frequency, until the western declivity of the main range of the Rockies is reached. Here, whatever moisture escaped over the Bitter Root range and the evaporation from the country lying between the two ranges is condensed, and in consequence we see here and there stretches of fairly well developed timber areas.

Over the range to the eastward, the arboreal vegetation thins out rapidly, finally ceasing altogether a few hundred miles from the mountains.

If we now conceive the altitude of the ranges to the west lowered 2,000 to 3,000 feet, a great change would take place. Much of the moisture now deposited on the western slopes would be carried over the Bitter Root range to the eastward, causing a large increase in the annual rain fall, and elevating the mean annual temperature very considerably.

This was doubtless the existing condition at the time these now petrified forests of the northwest flourished. The Coast, Cascade and Rocky Mountain ranges had but recently emerged from the ocean; the Bitter Root, though elevated long anterior, had not yet reached a height sufficient to offer any obstructions to the uninterrupted flow of atmospheric humidity from the Pacific; besides there certainly existed large bodies of water in the basins between the ranges. Gradually the country was elevated, the marshes, ponds and basins were drained, and the ranges to the westward deflected and cut off the air currents from the Pacific. This led to a great decrease in the annual rainfall and temperature, and a gradual dying out of the forests.

I have before noticed that the mean annual rainfall is probably yet sufficient to maintain a fair amount of forest growth, were it only more evenly distributed. As it is now, much the greater portion falls as snow or as very early or late rains, leaving nothing for the growing season. Again the extremes of temperature in the summer months is rather inimical to the successful growth of a forest. The writer remembers well how a few years ago, in the latter part of June, the thermometer registered in the shade 114 degrees for days in succession. The wind was blowing briskly from the south, and was like a rush of hot air from an oven. All kinds of native herbaceous plants dried up—cured on the stalk—and the foliage of the trees partly wilted and fell off. A few days later the mercury descended to the freezing point.

Did this ancient Tertiary (?) forest extend east of the Missouri river? This we do not know with certainty as the greater portion of the country here is so deeply covered with the drift deposit, but from the occurance of beds of lignite in place, at various localities, it is reasonable to infer that it did, though perhaps only in more or less scattered groves. Possibly the ridges now called the *coteaus* are granitic in origin, and at this time presented a bare rocky surface upon which a forest could not exist.

The present timbered areas in the northwest are due in a large measure to the vast quantity of water left behind by the melting ice of the glacial period, in the form of numerous marshes, ponds and lakes. The evaporation from these sources tends to maintain a tolerably constant degree of atmospheric humidity. This condition does not exist west of the Missouri. There are no ponds or lakes to retain the moisture, which drains off as rapidly as it falls.

A question now suggests itself: Is this portion of the continent still rising, and if so what will the ultimate result be?

We know that the earth's crust is constantly changing, elevating certain portions and depressing others. The Sierra Nevada which may be considered the continuation of the Cascades, is said to be rising at the rate of six feet in a century. There is nothing to disprove the supposition that the ranges to the north and northeast are not also rising in a more or less rapid ratio.

The smoking volcanic peaks among the Cascades and the thermal springs of the interior basins, show that the underground forces of the globe, so largely instrumental in elevating and shaping the continents, are by no means wanting here. If it is the case that the western side of the continent is continually rising then the climate of the plains to the east will continue to grow drier until it becomes too arid to support any form of vegetable life. Our records do not cover sufficient time to say if the mean annual rainfall is diminished. It is a noticeable fact, however, that there is a gradual drying up of many marshes and small streams throughout Minnesota and North Dakota. It is usually supposed to be due to the breaking up of the sod, causing the rain and melting snows to sink into the ground instead of collecting in ponds. But it is plainly to be seen that there has been a gradual loss of water long before any ground was broken. The river channels are more contracted, the lakes show that they formerly stood at a much higher level, and narrow arms or inlets of lakes, together with numerous small ponds, have become shallow marshes and peat bogs. These results should in the main, I think, be ascribed to a continuous slow elevation of the country, causing more or less disarrangement of the subterranean water courses, as shown in the drying up of springs, in furnishing a more rapid drainage and in decreasing the mean annual rainfall and temperature.

May 4, 1886.

[*Paper V.*]

DESCRIPTION OF MAPS SHOWING THE CLIMATE, GEOGRAPHY AND GEOLOGY OF MINNESOTA.—*By Warren Upham.*

The exhibit in the New Orleans exposition, 1884–'85, by the geological and natural history survey of Minnesota, included twenty maps showing the climate, geography and geology of the state, prepared by the writer under the direction of Prof. N. H. Winchell, the state geologist.

Four of these maps show the climatology.

1. Mean annual rainfall: 34 inches in the southeast corner of the state; 28 to 32 about lake Superior and Rainy lake; thence diminishing westward to 22 at Moorhead and Fargo and at lakes Traverse and Big Stone on the west boundary of the state. It is

about 28 inches at St. Paul and Minneapolis, and 23 inches (mean for eleven years) at Winnipeg, in Manitoba.

2. Mean temperature for the year: 46 degrees in the southeast corner of the state; 44 degrees at St. Paul and Minneapolis; 36 degrees to 34 degrees in northern Minnesota; and 33 at Winnipeg.

3. Mean temperature for January: 14 degrees in the southeast corner of the state; about 12 degrees at St. Paul and Minneapolis and at Duluth; thence diminishing northwestward to zero at the Lake of the Woods,—2 degrees at Saint Vincent and Pembina, and—4 degrees at Winnipeg.

4. Mean temperature for July: 76 degrees in the southeast and southwest corners of the state; 74 degrees at Saint Paul and Minneapolis: about 72 degrees at Moorhead and Fargo; 68 degrees at Saint Vincent; 67 degrees at Winnipeg: and 64 degrees to 62 degrees in northeastern Minnesota, north of Lake Superior.

Thirteen maps show geographic features.

5. River systems: Red River of the North, draining about 15,100 square miles in Minnesota, and Rainy river, about 10,300, making 25,400 square miles tributary to Hudson bay, the total area of the state being 84,286 square miles; basin of lake Superior and the Saint Louis river tributary to the Saint Lawrence, about 8,500 square miles; the Mississippi river, about 48,700 square miles; and the Missouri river, whose basin includes about 1,700 square miles in this state.

6. Distribution of lakes: showing areas of abundant lakes, others having comparatively few lakes, and others having no lakes. The last named areas are the southeast and southwest corners of the state, which lie beyond the limit of the drift of the last glacial epoch, and also the flat land of the Red river valley. It is estimated that this state contains 10,000 lakes; and the portion of its area covered by water is approximately 5,600 square miles.

7. Areas of forest and prairie, and approximate limits of some of the principal trees and shrubs: forest covers the northeastern two-thirds of the state; while the other third, lying at the south and southwest, and reaching in the Red river valley to the international boundary, as also the part of this valley farthe north to lake Winnipeg, is prairie.

8. Chief topographic features: the Red river flats, 800 to 950 feet above the sea; the basin of the Minnesota river, a slightly undulating expanse, 900 to 1,100 feet above the sea; the Coteau des Prairies in southwestern Minnesota, 1,800 to 1,950 feet above the sea; the Leaf hills, 100 to 300 feet high, being 1,000 to 1,750 feet above the sea; the Giant's range and the Mesabi range, near the international boundary north of lake Superior, each 1,800 to 2,200 feet above the sea, being the highest land in the state; the Sawteeth mountains, near the shore of lake Superior in Minnesota, 1,500 to 1,800 feet above the sea, or 900 to 1,200 feet above the lake; and the valley of the Mississippi river, from lake Pepin southward, several miles wide, and inclosed by bluffs 200 to 600 feet high.

9 to 16. Contour-lines for each 100 feet above the sea level: shown in successive pairs on seven maps with areas colored, and finally all presented on a single map, delineating only the course of the lines. To the elevations already stated, the following may be added: lake Superior, 602; Rainy lake, about 1,175; the Lake of the Woods, 1,062; the Red river at the northwest corner of the state, 758; lake Itasca, about 1,500; the Mississippi river at Minneapolis above the falls of Saint Anthony, 800; in lake Pepin 664, and at the southeast corner of the state, 620; Red lake, about 1,160; Mille Lacs, 1,246; lake Traverse, 970; Big Stone lake, 962; and the southwest corner of the state, about 1,400. Professor Winchell estimates the average elevation of the entire state to be approximately 1,275 feet above the sea.

17. Historical chart showing the geographical names and their dates prior to Nicollet's map: already published in *Geology of Minnesota*, vol. I, the first in the series of final reports of this survey.

Three maps show geological structure, glacial drift and the subsoils.

18. The geological systems below the drift and Cretaceous: Devonian limestones and shales, belonging to the Hamilton and Marcellus epochs, in Fillmore and Mower counties, and extending into Iowa; Silurian limestone and shales, belonging to the Hudson river and Trenton epochs, reaching from Saint Paul and Minneapolis south and southeast to Fillmore county and northeastern Iowa; Cambrian sandstones and limestones, including the Saint Peter sandstone, Shakopee limestone, Jordan sandston

Saint Lawrence limestone and Saint Croix sandstone, together regarded as the equivalent of the Chazy and Calciferous formations in the northeastern states and Canada. extending in southeastern Minnesota from the Kettle river and Taylor's Falls, southeast to the lower portions of the Minnesota and Blue Earth rivers, and occupying a considerable belt along the Saint Croix and Mississippi rivers to the southeast corner of the state; the Potsdam or Cupriferous formation, of lower Cambrian age, consisting of red sandstone, conglomerate and trappean rocks, on the shore of lake Superior, and in Pine, Chisago and Kanabec counties, but in southwestern Minnesota being mainly red quartzite, exposed near New Ulm, and thence westward to Pipestone and Rock counties, in the southwest corner of the state; and the Archæan system, divided into three parts, namely, Upper Gneisses, Taconic and Laurentian, together covering more than half of the state, reaching on the international boundary from the Lake of the Woods east to lake Superior, and extending thence southwest to the Minnesota river between Big Stone lake and New Ulm, but terminating twenty or thirty miles southwest of this river.

19. The glacial geology: showing post-glacial alluvium, to which is referred the stratified clay bordering the Red River of the North, apparently deposited after lake Agassiz was drained to Hudson bay; modified drift or stratified gravel, sand and clay, washed from the ice-sheet and assorted and deposited by the streams produced in its melting; loess, belonging to the modified drift, extending from the Missouri river over western Iowa and into Rock county in the southwest corner of Minnesota; till, or bowlder clay, covering the greater part of the state, mostly having a moderately undulating surface; terminal moraines, belts of hilly and knolly till, with associated deposits of modified drift, accumulated along the margin of the ice-sheet of the last glacial epoch, including, besides the moraine found at the extreme limit reached by that ice-sheet ten others indicating successive stages in its recession; glacial striæ, having a southwest course from lake Superior to the Mississippi river, over which region is spread a red till with no limestone, but in the west part of the state running to the south and southeast, the till there being gray or blue with much limestone; changes in the currents of the ice-sheet during its recession, shown by the course of the successive morainic belts, he most notable change being the extension of the western ice-

current from Wright county east, northeast to the edge of Wisconsin, proved by the presence of the gray or blue till with limestone bowlders overlying the red till; the driftless area, extending into the southeast part of the state to include Houston and Winona counties and the eastern portions of Fillmore, Olmstéd, Wabasha and Goodhue counties; the surface of this area being residual clay from eroded strata, partially modified by the water of a lake confined there by the ice-sheet confluent farther south; the beaches of the glacial lake Agassiz, held by the retreating ice-sheet in the basin of the Red and Rainy rivers, the outlines of a similar glacial lake which existed earlier in the basin of the Blue Earth and Minnesota rivers, and the former shore of lake Superior, which in like manner was held 500 feet higher than now, having its outlet southwestward to the St. Croix and Mississippi rivers; and the thickness of the drift as shown by deep wells, being found to average 100 to 200 feet upon the western two-thirds of the state, where it conceals the older rocks over large districts, including all of the basin of the Red River of the North in Minnesota.

20. The subsoils: clay and loam in the Red river valley, in the southwest corner of the state, and on the driftless area; sand and gravel covering considerable tracts from Dakota county, Saint Paul and Minneapolis northwestward to the Crow Wing river and the sources of the Mississippi; gray or blue till, occupying the greater part of the state; red till, reaching from lake Superior southwest to Brainerd and south to Saint Paul; and a track bordering the international boundary eastward from Rainy and Vermilion lakes, where only scanty patches of soil are found, the surface being mostly bare rock with many little lakes.

May 4, 1886.

[*Paper W.*]

AN ACCOUNT OF THE TORNADO WHICH VISITED SAINT CLOUD, MINNESOTA, APRIL 14, 1886.—*C. W. Hall.*

At seven o'clock on the morning of April 11th, last, an area of low barometric pressure was detected by the U. S. Signal officers centering a few miles north of San Francisco, Cal. This area moved steadily eastward. At three o'clock, the same day, it had reached the center of Nevada; at 11 o'clock that evening, (75th meridan time,) it had reached the Great Salt Lake valley. It continued to move eastward until three o'clock p. m. of the 12th, when it turned towards the north, and moved forward at a much slower rate. Its rate was so slow that 48 hours later, or at three o'clock of the 14th, by turning northeasterly in its course, it had only reached the Missouri valley a few miles from Bismarck. Continuing onwards northerly, swinging even a little towards the west, and then northeasterly, this low pressure center was last seen by the Canadian observers at lake Winnipegosis, on its northeasterly course to Hudson bay.

The progress of this area of low pressure was a remarkable one. Its course was characterized by great weather disturbances, and even some severe storms, until the culmination of disasters in the tornado, which swept over Saint Cloud, Sauk Rapids and Rice's Station a little after 4 o'clock on the afternoon of the 14th. The records of the U. S. Signal service recount them. From that hour on until the final disappearance of the cyclone, the winds and the storms kept almost perfect peace.

It appears that the towns named were upon the southeastern quarter of the great cyclonic rim, whose center on the afternoon of the 14th was west and northwest of Bismarck, Dakota. The tornado which proved so destructive moved from the southwest towards the northeast. Its effects could be seen and studied long after the storm had passed; what it was and how it looked, as a tornado, can only be known on the authority of eye witnesses. One of them says;*

"The tornado must have formed rapidly, and just about over the lake, as it was there when first noticed. It was very black and seemed constantly in motion. It was moving rapidly across the lake when first seen, was flat and oval in shape, with a sort of spiral at each of the extremities, one extending upward and the other downward. It was peculiar in appearance and I watched it closely. After having passed across the lake it seemed to stop. The movement resembled that of a fan opening and closing, and it remained stationary for some seconds. Almost instantly the form changed. Instead of lying flat it seemed to turn on end and the spirals that ran up from the other end formed a part of a big double spiral. It had a movement that was peculiar, as if there was a commotion within it. The course was rapid, and as soon as the big spiral was formed it began moving at a

*Monthly Weather Review, Washington, April 1886, p. 100.

terrific rate in a course that was somewhat zigzag. It dropped down to the ground, and I saw the entire work of ruin. The course of the tornado after crossing the river was rather sinuous, though hardly as much so as before. It swept across the country, and in five minutes from the time of reaching Sauk Rapids the work of destruction was done. There were two clouds at first that came together directly over the lake, and then turned on end and swept onward."

Other observers have told the story of this tornado. Their accounts, while differing slightly in one or two statements of fact touching the place of origin and the movements of the storm, all agree in describing this as one of the most destructive storms that has ever visited the northern states. One of the keenest of these observers was Rev. E. V. Campbell, of Saint Cloud: he, too, was one of the most assiduous in relieving the suffering caused and industrious in gathering the whole story of the storm. Chiefly from him in personal conversation, and in perusing the columns of the *Northwestern Presbyterian* of three days ago the writer has gathered the following data:

During nearly all of Wednesday the weather was chopped into little bits—rain, puffs of wind, sunshine and one brief hailstorm.* The atmosphere was peculiar; one tired easily; he was restless; the air was oppressive, almost muggy; storms threatened and would pass away, when the sun would shine out bright and beautiful. About three o'clock clouds again rose in the south and it seemed certain to rain. In half an hour the thought of a fire was suggested by a horrible, black object, a mile away to the west of the Campbell parsonage. It was not a fire; the object moved. Then was noticed the terrible grinding, crunching, low agonizing wail, once heard never to be forgotten. The writhing, whirling monster was steadily crossing the city. It had taken in its embrace a frightful, funnel-shaped, coal-smoke colored body from above, and on it moved. Its body seemed to carry hundreds of pieces of paper; now it is known that these were broken boards and timbers and shingles. Hundreds of feet up in air, how it tossed and toyed with these things as if they were only feathers, sometimes carrying them around in graceful curves, then, swift as lightning, shooting them sideways or downward out of sight.

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*At Minneapolis between four and five o'clock in the afternoon, a terrific hailstorm took place, covering the ground with hailstones, some of them as large as small hens' eggs.

The tornado seems to have had its birth in the Masonic cemetery two miles south of Saint Cloud. East of this cemetery there is a depression with a considerable hill on the other three sides, making, at its foot, a basin. Here among the oak trees, the power of the tornado began to display itself. Trees as thick as a man's body were wrenched nearly square off 15 or 20 feet above the ground. Straight up the hill in a northwest direction the storm moved, leaving a clean track perhaps 100 feet wide. It swept along, tearing its way through timber and across fields, demolishing a Roman chapel and houses, and killing people on its way. As it entered the city it widened out to 600 feet, and changed its course to due north. More houses were destroyed, many of them utterly obliterated. The Saint Paul, Minneapolis and Manitoba railway freight depot was crushed like an eggshell. Loaded cars of immense weight and coupled together counted as nothing. 60 houses were destroyed in Saint Cloud and many people were killed, besides many more injured.

As the tornado crossed the Mississippi river to enter Sauk Rapids, it seemed to lift the water clear from the bottom, leaving the bed of the river bare. A portion of the bridge across the Mississippi at this point, standing in the course of the storm, was instantly removed, as was a large mill standing near. Court house, school house, stores, the hotel, and dwelling after dwelling all were swept away from the widening path of the tornado. Still going north, and when four miles east of Rice's Station and nine miles from Sauk Rapids, it struck a house where there had just been a marriage; the guests were kneeling at prayers. Without warning, nine, including the groom, the officiating clergyman and his wife were killed, and many more hurt, some of whom have since died.

Personal experience and incidents cannot here be mentioned; neither can particular instances of the destruction of property be enumerated. The total loss of life was over seventy, with many maimed who still survive. At least half a million dollars worth of property was destroyed, most of it belonging to private individuals, and those, too, who could ill afford to lose it. But public generosity has come promptly to their aid.

Many attendant phenomena could be mentioned, but only a few are selected. One iron safe was carried across the street without touching the ground, and landed on its top; another weighing five tons was moved six feet and turned partly around. Some houses were turned on their foundations; others were neatly unroofed, and still others escaped with holes punched into them. A block of hardwood was found with a pine stick driven into it as an iron spike; a pine lath was found driven inches into the body of a tree. Chickens were literally stripped of their feathers, and barn doves were dashed to the ground, flattened as if a heavy stone had crushed them.

To many, and particularly to Mr. Campbell, this storm seemed evidently enough to be an *electric body*. It had not all the phenomena of a current, for it had distinct lateral limits. Outside its given track it left no traces save those made by flying timbers. Yet with the atmospheric conditions peculiar to a cyclonic area, the rush of the wind and the clearly defined limits of the spirally moving column, these same phenomena would be left.

When we have the details of the disaster, and look for its causes, we shall see as Professor Payne has pointed out,* that it was only the culmination of a series of causes extending over the preceding ten days. At this time, the winds which had been blowing since morning up the Mississippi valley, were warm and slight: at La Crosse, Saint Paul, Moorhead and Vincent, the temperature was 70 degrees Fahr. and above, really a summer's warmth; while at Duluth, and along the south shore of Lake Superior, the thermometer stood at 38 degrees Fahr., with the wind moving steadily towards the southwest. When this cold wind from the lake region had spread itself over a considerable area of the warm, stifling air of the Mississippi valley instead of becoming mixed with it, in the economy of nature a terrific movement must result. The relative positions of these two currents of air, the warm and the cold, were as unnatural as if a lake of oil were held down by an invisible film beneath an equal area of heavier water; when once this film should be punctured, the oil would seek its true place at the top of the water with irresistible energy.

The local conditions are never the same in any two tornadoes. These conditions,—the contour of the surface, the altitude of the contact zone of air, the direction of the winds, the humidity of the air,—all tend to modify to a marked degree the

*Monthly Weather Review, April 1886, p. 113.

force, and consequently the destructiveness of these storms. The latitude of Minnesota has saved our state from many of these visitors as Professor Payne has shown.*

NOTE.—In 1884, Sergeant John P. Finley, of the Signal Corps, U. S. Army, published a list of 600 tornadoes, which had been recorded in the United States, to the close of 1881. Twenty-two of that number occurred in Minnesota. For reference, a list of the Minnesota tornadoes is extracted from Sergeant Finley's table:

1875, August 25th; near Hutchinson. A very sultry day.

1876, May 20th; Fort Ripley.

1877, May 30th, afternoon; near Saint Paul. Storm went northeast.

1877, June 14th, afternoon; Langdon. Storm went northeast.

1877, June 29th; near Minneapolis. The day very sultry.

1877, July 1st; Waverly.

1877, July 7th, afternoon; Breckenridge. Time of passing, 3 minutes.

1875, July 3rd, evening; Goodhue county. Nine persons killed and thirty injured.

1880, June 5th; Lake Crystal.

1880, June 11th, afternoon; Mower county.

1881, June 12th, 4 p. m.; Blue Earth City. Storm went northeast.

1881, June 12th, 5 p. m.; Rice County. Storm went northeast.

1881, July 11th, 5 p. m.; Winona. Storm went northeast.

1881, July 15th, afternoon; West Newton. Five persons killed and twelve wounded; fifteen buildings demolished.

1881, July 15th, afternoon; Wellington. Many animals killed, some of which had pieces of timber driven through their bodies.

1881, July 15th, afternoon; Fairfield [Fairfax?]. Storm went southeast.

1881, July 15th, afternoon; Cairo.

1881, July 15th, 4:45 p. m.; New Ulm. Storm went southeast; forty-seven buildings demolished and two hundred partly wrecked; six persons killed and fifty-three wounded; loss estimated at $300,000 to $500,000.

1881, July 15th, 6 p. m.; Blue Earth county. Storm went east-southeast.

1881, July 16th, afternoon; Cottonwood county. Storm went northeast.

1881, July 16th, afternoon; Redwood county. Storm went northeast.

1881, September 29, afternoon; Owatonna. Storm went northeast; one hundred buildings more or less damaged.

May 4, 1886.

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*Loc. cit., p. 113.

PROCEEDINGS

OF THE

MINNESOTA ACADEMY OF NATURAL SCIENCES.

VOLUME III. BULLETIN 2.

January 11, 1887.

Ten persons present.

The reports of the retiring officers were rendered.

Secretary Hall made the following financial statement:

Cash brought over from preceding year, - - -		$39 50
" received during the year, - - - - -		93 00
		$132 50
Rent and gas bills paid and incidental expenses met, -	Total,	$129 00
	Balance on hand at date,	$3 50

The Corresponding Secretary reported the following additions to the library received during the year 1886.

THE UNITED STATES.

Baltimore, Md.—Johns Hopkins University: Circulars, Vol. v, Nos. 46-51; Vol. vi, Nos. 52-54.

Boston, Mass.—American Academy of Arts and Sciences: Proceedings, Vol. xxi, Pts. i and ii.

Boston Society of Natural History: Proceedings, Vol. 23, Pt. ii.

Horticultural Society: Transactions, 1885, Pt. ii; 1886, Pt. i; Schedule of Prizes, '86.

Brookville, Ind.—Society of Natural History: Bulletin No. 2.

Buffalo, N. Y.—Historical Society: Annual Report for 1885.

Society of Natural Sciences: Bulletin, Vol. v, Nos. 1 and 2.

Cambridge, Mass.—Harvard College Observatory: A Plan for the Extension of Astronomical Research.

Museum of Comparative Zoology: Bulletin, Vol. XII, Nos. 3-6.

Champaign, Ill.—State Laboratory of Natural History: Bulletin, Vol. II, Art. IV.

Chapel Hill, N. C.—Elisha Mitchell Scientific Society: Journal for 1884-5.

Charleston, S. C.—Elliott Society of Science and Art: Proceedings, Vol. II, pp. 41-80, 1860.

Cincinnati, O.—Society of Natural History: Journal, Vol. VIII, No. 4; Vol. IX, Nos, 1, 2 and 3.

Davenport, Ia.—Academy of Natural Sciences: Proceedings, Vol. IV, 1882-4.

Denver, Col.—Scientific Society: Proceedings, Vol. I, Pt. 1.

Iowa City, Ia.—State Historical Society: Historical Record, Vol. II, Nos. 1-3.

Lansing, Mich.—Michigan Agricultural College. State Board of Agriculture: Bulletins, 10-21; 24th Annual Report, 1884-5.

Madison, Wis.—State Historical Society: 32d Annual Report.

New York, N. Y.—American Geographical Society: Bulletin, 1882, No. 6; 1883, No. 7; 1884, No. 5; 1885, Nos. 2 and 3; 1886, No. 1.

New York, N. Y.—American Museum of Natural History: Annual Report, 1885-6; Bulletin, Vol. I, No. 7, 1886.

New York Microscopical Society: Journal, Vol. I, Nos. 8 and 9; Vol. II, Nos. 1, 2, 3, 5 and 7.

Torrey Botanical Club: Bulletin, Vol. XIII, Nos. 1-11.

Philadelphia, Penn.—Academy of Natural Sciences: Proceedings, 1885, Pt. 3; 1886, Pt. 1.

Second geological Survey of Pennsylvania: Annual Report, 1885.

Report,	A.	History of the First Geol. Sur. Penn., from 1836 to 1858, 1876.
"	AA.	Second report of progress of the anthracite survey, 1885.
"	A2.	Causes, etc., of waste in anthracite mining, 1881.
"	AC.	Report on mining methods in anthracite fields, 1883.
"	C.	Report on York and Adams counties, 1876.
"	CC.	" " " " " (Iron ores, etc.) 1877
"	CCC.	" Lancaster county, 1880.
"	C4.	" Chester county, general description, 1883.
"	C5.	" Delaware county, Pt. 1, 1885.
"	C6.	" Philadelphia and counties near, 1882.
"	DD.	Second report on Lehigh county iron mines, 1878.
"	D3.	Vol. I, Report on Lehigh and Northampton counties, 1883.
"	D3.	" II, Pt. 1, Report on Berks county, 1883.
"	E.	Pt. 1, Trap dikes and Azoic rocks, 1878.
"	F.	Report on the Juniata river district, 1878.
"	F2.	Pt. 1, Geology, Report on Perry county, 1884.
"	G.	Report on Bradford aud Tioga counties, 1878.
"	GG.	" Lycoming and Sullivan counties, 1880.
"	GGG.	" Potter county: Report on its coal fields, 1880.
"	G4.	" Clinton county, 1880.
"	G5.	" Susquehanna and Wayne counties, 1881.
"	G6.	" Pike and Monroe counties, 1882.

Report, G7.	Report on Wyoming, Lackawanna, Luzerne, Columbia, Montour and Northumberland counties (i. e , outside of the anthracite coal fields), 1883.	
" HH.	Report on Cambria county, 1877.	
" HHH.	" Somerset county, 1877.	
" H5.	" Armstrong county, 1880.	
" H6.	" Jefferson county (*compare H*), 1881.	
" H7.	" Clearfield county (*compare H*), 1884.	
" II.	" Oil Well records and levels, 1877.	
" III.	" Venango, Warren, Clarion and Butler oil regions, 1880	
" I4.	" Warren county oil region, 1883.	
" KK.	First report on Fayette, Westmoreland and S. E. Alleghany counties, 1877.	
" KKK.	Second report on Fayette and Westmoreland counties, 1878.	
" K4.	Pt. 1, report on the Monongahela river coal mines, 1884.	
" L.	Report on the Youghiogheny coke manufacture, 1876.	
" M.	Report of chemical analyses in 1874-5, Survey laboratory, 1875.	
" MM.	" " " 1876-8, " " 1879.	
" M3.	" " " 1879-80, " " 1881.	
" O.	Catalogue of specimens collected by the Survey (1 to 4264), 1878.	
" OO.	" " " " " (4265 to 8974), 1880.	
" P.	Report on the coal flora of Pennsylvania and the United States, Vols. 1 and 2, 1880; Vol. 3, 1884.	
" PP.	Report on the permo-carboniferous plants, Green county, Pa., etc., 1880.	
" P3.	Description of *Ceratiocaridae* and *Eurypteridae*, 1884.	
" Q.	Report on Beaver, N.W. Alleghany and S. Butler counties, 1878.	
" QQ.	" Lawrence county and correlation of coal beds, 1879.	
" QQQ.	" Mercer county, 1880.	
" Q4.	" Crawford and Erie counties; pre-glacial outlet for Lake Erie, 1881.	
" R.	Report on McKean county, etc., 1880.	
" RR.	Pt. II, report on township geology of Cameron, Elk and Forest counties, 1885.	
" T.	Report on Blair county, 1881.	
" T2.	" Bedford and Fulton counties, 1882.	
" T3.	" Huntingdon county, 1885.	
" T4.	" Centre county; with special report, etc., 1884.	
" V.	Report on N. Butler county; Pt. 2, Beaver and Shenango river coal measures, 1879.	
" VV.	Report on Clarion county, 1880.	
" Z	" the terminal moraine across Pennsylvania, 1884.	
Atlas, AC.	To accompany report AC.	
" AA.	Of the Northern anthracite field, Pt. 1. 1885.	
" AA.	" Southern anthracite field, Pt. 1, 1882.	
" AA.	" Western middle anthracite field, Pt. 1, 1884.	
" AA.	" Eastern middle anthracite field, Pt. 1, 1885.	

Atlas (CCC.) To accompany report CCC.
" (D3.) " " D3.
" (D5.) " " on Adams, Franklin and Cumberland counties.
" (III.) " " I3.
" (P.) " " P.
" (R.) " " R.
" (R2.) " " RR.
" (T.) " " T.

Grand Atlas, Div. I, Pt. I. A geological atlas of counties of Pennsylvania.
" " II, " I. Anthracite coal fields.
" " II, " II. " " "
" " III, " I. Petroleum and bituminous coal.
" " IV, " I. Various portions of Pennsylvania.
" " V, " I. Topography of palaeozoic districts.

Zoological Society: 14th Annual Report.

Poughkeepsie, N. Y.—Vassar Brothers Institute: Transactions, Vol. III, Pt. I.

Providence, R. I.—Rhode Island Historical Society: Proceedings, 1885-6; Atlas; Life and services of Hon. J. R. Bartlett.

Salem, Mass.—American Association for the Advancement of Science: Proceedings, Vol. 33, Pts. 1 and 2, 1884; Vol. 34, 1885.

San Diego, Cal.—Society of Natural History: West American Scientist, Vol. II, Nos. 13, 14 and 17.

San Francisco, Cal.—Academy of Sciences: Bulletin, No. IV, and Vol. II, No. 5.

Savannah, Ga.—Historical Society: Freemasonry in Georgia.

Topeka, Kan.—Washburn College, Laboratory of Natural History: Bulletin, Vol. I, Nos. 5 and 6.

Trenton, N. J.—Natural History Society: Journal, Vol. I, No. 1.

Washington, D. C.—Census Office: Tenth Census, Vol. 13, Precious Metals; Vol 14, Mining Laws of U. S.; Vol. 16, Water Power; Pt. I, Vol. XX, Statistics of Wages, etc.

Chemical Society, Bulletin No. I.

Smithsonian Institution: Annual Report, 1884.

Patent Office: Official Gazette, Vols. 34, 35, 36 and 37; Lists and Index to Vol's 31, 32, 33 and 34; Annual Report of Commissioner, 1885.

U. S. Geological Survey: 5th Annual Report 1883-4; Bulletin, Nos. 15-26; Monograph IX; Mineral Resources of U. S.

FOREIGN.

Bath, Eng.—Postal Microscopical Society: Journal, Vol. 4, Pt. 16.

Barcelona, Spain.—Real Academia de Ciencias Naturales y Artes: Transactions of Opening Session.

Bombay, India.—Royal Asiatic Society, Bombay branch: Journal, No. 43, Vol. XVI.

Brussels, Belgium.—Societe Maalacologique de Belgique: Proceedings, 1885, pp., 81-144.

Haarlem, Netherlands.—Musee Teyler: Catalogue of Library, Vols. 1 to 4. Archives, Series II, Vol. II, Pts. 3 and 4.

Honolulu, Sandwich Is.—R. Hawaiian Agricultural Society: Hawaiian Fisheries. Leprosy—a Report of Board of Health, with Appendix. Leprosy in Hawaii. Leprosy in Foreign Countries.

Cairo, Egypt.—L'Institut Egyptien: Bulletin No. 14, 1876-78; 2d Series, No. 6, 1885.

Cassel, Germany.—Verein fur Naturkunde: Papers read at 50th Anniversary of Society.

Calcutta, India.—Geol. Survey of India: Manual of Geol. of India, Pt. III, 1
Memoirs, Vols. IV to XXII, complete, 46 parts.
Series X, Vol. IV, Pt. I, 36 parts.
Paleontologia Indica, 71 parts, viz:
Cretaceous Fauna of S. India.
Flora of Gondwana System.
Jurassic Fauna of Kutch.
Indian Pretertiary Vertebrata.
Indian Tertiary and Post-Tertiary Vertebrata.
Tertiary and Upper Cretaceous Fauna of W. India.
Salt Range Fossils.
Records, Vols. I to XVIII, and XIX, Pts. 1-4.
Memoirs, Indian Tertiary and Post-Tertiary Vertebrata

Christiania, Norway.—Kongelige Norke Fredericks Universitetet: Anatomy, by S. Laache; Norwegian Botany; Lakis Crater and Lava Stream.

Cordoba, Argentine Republic.—Academia Nacional de Ciencias Exactes: Bulletin, Vol. VIII, Nos. 1-4.

Florence, Italy.—Biblioteca Nazionale: Bollettino, 1886, Nos. 1 to 23.
" R. Instituto di Studi Superiori, etc: Archivs of School of Pathological Anatomy, Vol. I., Epileptic Convulsions.

Liverpool, Eng.—Geological Society: Proceedings, Vol. V., Pt. II.

Lyons, France.—Societe Linneene de Lyon: Annals, 1884., Volume 31.

Montreal, Can.—Natural History Society: Record of Science, Vol. II, Nos. 1-5
Dr. Robert Bell: Forests of Canada; The Medicine Man; Mineral Resources of Hudson's Bay.

Moscow, Russia.—Societe Imperials des Naturalistes: Bulletin, Vol. 60, Pt. 4, 1884: Vol. 61, Pt. 1, 1885: Vol. 62, Pt. 1, 1886.

Ottawa, Canada.—Geological and Natural History Survey: Summary Report to Dec. 31, 1885.

Rome, Italy.—Biblioteca Nazionale Vittorio Emanuele: Bollettino, 1886, Nos. 1, 2 and 3.

Saint John, N. B.—Natural History Society: Bulletin, 1886, No. V.

St. Petersburg, Russia.—Geological Committee of Institute of Mines: Fauna of Lower Devon of the Urals; Memoirs, Vol. III, No. 1, 1885.

Sydney, N. S. Wales.—Department of Mines: Annual Report, 1885.

Toronto, Canada.—Canadian Institute: Proceedings, Vol. III, Nos. 3 and 4; Vol. IV, No. 1.

Turin, Italy.—Musei di Zoologia ed Anatomia Comparata, R. Universita: Bolletins, Vol. I, Nos. 1-15.

Vienna, Austria.—Imperial Royal Natural History Museum: Annals, Vol. I, Nos. 1 and 2.

The officers for 1887 were elected as follows:

President, - - - -	A. F. Elliot.
Vice-President, - - - -	J. A. Dodge.
Recording Secretary, - -	C. W. Hall.
Treasurer, - - - -	N. H. Hemiup.
Corresponding Sec'y,	Miss Gertrude J. Leonard.
Trustees for three years, -	W. H. Leonard. C. W. Hall.

February 8, 1887.

Seventeen persons present.

N. H. Hemiup read a paper on "the star Groombridge and its relation to the known laws of gravitation."

The paper brought out some discussion touching the methods used by astronomers in determining the velocity of stars in their orbital movements.

The secretary read a paper by Mr. F. L. Washburn on "Thomas, Jefferson as a naturalist."

Mr. Washburn quoted the claim made by some that to Jefferson and Agassiz, America owes most for its advancement in the pure and applied sciences.

March 8, 1887.

Eighteen persons present.

Conway G. MacMillan presented some "notes on wheat rust," which embodied a summary of the life-history and morphology of *Puccinia graminis*, *Pers.*

The secretary read a paper sent by Mr. F. L. Washburn to the section of botany, on, "the life-history of the common fern and a morphological comparison of fern and flowering plant."

The papers were both of unusual interest and by a unanimous vote the thanks of the academy were extended to Mr. Washburn and Mr. MacMillan.

April 12, 1887.

Twenty-three persons present.

Professor J. A. Dodge reported from the section of chemistry "some general considerations on methods of purifying water for domestic uses."

The subject aroused much interest and a free discussion.

May 3, 1887.

Ten persons present.

Professor L. W. Chaney, of Carleton College, read a paper on "earthworms, their anatomy, their economic value and some points on their embryology." A general discussion followed.

Mr. O. W. Oestland then read a paper on, "the position of Minnesota in the zoological provinces of North America.

(ABSTRACT.)

Three of the largest and most important zoological provinces of North America come to a common point within the state of Minnesota. The Mississippi valley, with nearly all of the United States east of it, is included in the eastern or Atlantic province, to which also the greater part of Minnesota belongs. To the north, the Boreal or Canadian province extends across the continent, including the northeastern part of the state, and corresponds in the main to the British possessions and the greater part of Alaska. To the west, the central province includes all of the high mainland west of the Mississippi valley, extending into the British possessions north of Montana and to the south into Mexico, with exception of California, which forms a part of the small but distinct western or Pacific province.

The fauna and flora of Minnesota agree in the main with those of the eastern province, but in the great pine district and along the lake shore in the northeastern part of the state are found many species peculiar to the Canadian province, and along the western border of the state not a few peculiar to the central province have already been observed These facts will, no doubt, show the fauna and flora of Minnesota richer in number of species than those of any other state of like area. Many questions of great interest can also here be studied to most advantage on the borderland of these provinces. Minnesota, favorably situated in many respects, is no less so in regard to the study of the fauna and flora of North America.

June 4, 1887.

No quorum present.

Herbert W. Smith, of St. Paul, presented a specimen of hornblende biotite granite from the Mesabi quarries, in the northern part of the state.

October 4, 1887.

Twenty-three persons present.

Under communications and presentations, thirteen species of Minnesota fish were presented by F. L. Washburn, as follows:

37,899.	(4).	Lepomis pallidus.
37,900.	(14).	Micropterus salmoides.
37,901.	(3).	Ambloplites rupestris.
37,902.	(12).	Amia calva.
37,903.	(13).	Esox lucius.
37,906.	(16).	Pomoxys sparoides.
37,908.	(15).	Amiurus natalis var. cupreus.

37,911. (17). Lepomis gibbosus.
37,912. (2). Coregonus artedi.
37,913. (19). Perca americana.
37,914. (9). Percina caprodes.
37,916. (1). Lota maculosa.
37,917. (1). Uranidea (small, and mouth injured).

The secretary was directed to extend the thanks of the Academy to Mr. Washburn for this valuable series of specimens.

Mr. M. F. Hulet presented a key to the Academy which was accompanied by the following description:

"This key was at one time used at Jamestown, Va., and afterwards with its lock taken to Crab Orchard, Ky., and there used on the first jail ever built in the state of Kentucky. It has been in use over one hundred and twenty-five years and how much longer is not known."

The secretary was instructed to convey the thanks of the Academy to Mr. Hulet.

N. H. Winchell then presented the topic, "the iron bearing formations of Northeastern Minnesota."

[ABSTRACT.]

Professor Winchell gave by means of a sketch-map of the geology of the northeastern part of the state, the distribution of the formations that carry the principal ore deposits.

In ascending order he mentioned first the green schists in the vicinity of Tower, which he described as embracing the ores mined near Vermillion lake and as extending northeastward in two forks, one running on to Hunter's island and the other as extending further south to the neighborhood of Gunflint lake and passing unconformably below the Animike slates and quartzites. These green rocks are mainly basic and probably of volcanic origin, but much changed. Above this formation he found the Animike rocks stretching from Pigeon point to the Mississippi and St. Louis rivers. These strata, with their associated gabbros and quartzites make the Mesabi range. They overlap the foregoing and also the gneiss of the Archean. In the vicinity of Gunflint lake, and at points considerably further southwest they are known to carry large amounts of iron ore. While the most of the ore in the underlying rocks is hematite, the most of that in the Animike is magnetite, while hematite and limonite prevail further west. In the former the sheets stand nearly vertical. In the latter they are generally nearly horizontal. Overlying the Animike is the great gabbro overflow in which are found large deposits of titaniferous magnetites. This rock, being considered the base of the Keweenawan, grades off by various alternations of eruptive with sedimentary rocks, with indefinite variations of lithology, into the Keweenawan.

He described a great quartzite, which he had named *Pewabic quartzite*, as the rock first below the gabbro, and its upper portion interbedded with the gabbro, fixing the date of the eruption of the gabbro. This quartzite furnishes olivenitic magnetite, non-titanic, and is at the bottom of the

Animike, its line of strike being such as to cause it to come into contact, at many places, with the Archean gneiss, and further southeast, with the green stones of the Vermillion lake region.

December 20, 1887.

Twenty-four persons present.

Dr. C. N. Hewitt, chairman of the section of Sanitary Science, presented for his report, "some advances in Sanitary Science made during the years 1886-87, with forecasts for the future."

The speaker outlined the plans of the American Public Health Association for the protection of the continent against a visitation by cholera; he presented the latest views on bacteriology, and spoke of matters of vital interest in the field of public health and public morals.

Slides were displayed, showing the bacteria of some diseases, as cholera, consumption, etc.

January 3, 1888.

ANNUAL MEETING.

Eight persons present.

Reports of retiring officers were presented.

The recording secretary presented the following financial statement.

Balance brought over from preceding year..........................	$ 3 50
Cash received from dues collected during the year...............	225 00
Total..................	$228 50
Rent and gas bills paid and incidental expenses met..............	168 84
On hand at date........	$59 66

The corresponding secretary presented the following list of accessions for the year 1887:

THE UNITED STATES.

Ames, Ia.—Agricultural College, Botanical Department: Bulletin, Nov., '84, and Nov., '86.

Baltimore, Md.—Johns Hopkins University: Circulars, Vol. VI, Nos 55 to 61; Eleventh Annual Report of President.

Boston, Mass.—American Academy of Arts and Sciences: Proceedings, Vol. XXII, Pts. 1 and 2.

Horticultural Society: Transactions, 1886, Pt. II.

Buffalo, N. Y.—Historical Society: Annual Report, Jan. 11, 1887.

Cambridge, Mass.—Harvard College Observatory: Henry Draper Memorial; Museum of Comparative Zoology: Annual Report of Curator for 1885-6 and 1886-7. Bulletin, Vol. XIII, Nos. 1-5.

Champaign, Ill.—State Laboratory of Natural History: Bulletin, Vol. II Art's V and VI; Vol. III, Art. I.

Chapel Hill, N. C.—Elisha Mitchell Scientific Society: Journal, Vol IV, Pt. 1, and for 1885-6.

Charleston, S. C.—Elliot Society of Science and Art: Proceedings, Vol. II, pp. 81-120.

Chicago, Ill.—Ridgway Ornithological Club: Bulletin, Nos. 1 and 2.

Cincinnati, O.—Society of Natural History: Journal, Vol. IX, No. 4; Vol. X, Nos. 2 and 3.

Columbus, O.—State Board of Agriculture: Crop Reports, Dec., 1885, April, 1886, and Aug., 1887.

Denver, Colo.—Scientific Society: Proceedings, Vol. II, Pt. 2.

Iowa City, Ia.—State Historical Society: Historical Record, Vol. II, No. 4, and Vol. III, Nos. 1-4.

Lansing, Mich.—Agricultural College—State Board of Agriculture: Bulletins, 22-24 and 27-31.

Madison, Wis.—State Historical Society: 34th Annual Meeting, Jan. 6, 1881.
Academy of Science, Arts and Letters: Transactions, Vol. VI, 1881-83.

Meriden, Conn.—Scientific Association: Transactions, Vol, II, 1885-6.

Middletown, Conn.—Museum of Wesleyan University: 15th Annual Report of Curator.

Minneapolis, Minn.—State University, Geological and Natural History Survey: 13th and 14th Annual Reports, 1884 and 1885.

New Haven, Conn.—Academy of Arts and Sciences: Transactions, Vol. VII, Pt. 1.

New York, N. Y.—Academy of Sciences: Transactions, Vol's II, III, IV and V.
American Geographical Society: Bulletins, 1885, Nos. 4 and 5; 1886, Nos. 2-5; Vol. XIX, Nos. 1-3.
American Museum of Natural History: Bulletin, Vol. I, No. 8, Vol. II, No. 1; Annnal Report of Trustees, 1886-7.
N. Y. Microscopical Society: Journal, Vol. II, Nos. 4, 6, 8, 9 and 9a; Vol. III, Nos. 1-4.
Torrey Botanical Club: Bulletin, Vol. XIV, Nos. 4-10 and 12.

Peoria, Ill.—Scientific Association: Bulletin, 1887.

Philadelphia, Pa.—Philadelphia Academy of Natural Sciences: Proceedings, 1886, Pts. II and III; 1887, Pts. I and II.
Second Geological Survey of Pennsylvania: Annual Report, 1886, Pt. I.
Wagner Free Institute of Science: Transactions, Vol I.
Zoological Society: 15th Annual Report, 1886-7.

Poughkeepsie, N. Y.—Vassar Brothers Institute: Transactions, Vol. IV.

Providence, R. I.—Rhode Island Historical Society: Proceedings, 1886-7.

Rochester, N. Y.—Warner Observatory: History and Work of Observatory.

St. Louis, Mo.—Academy of Science: Transactions, Vol. IV, No. 4.

St. Paul, Minn.—State Board of Corrections and Charities: 2d Biennial Report.
State Historical Society: Biennial Report, 1887.

Salem, Mass.—American Association for the Advancement of Science: Proceedings, Vol. XXXV, 1886.

San Francisco, Cal.—Academy of Sciences: Bulletin, Vol. II, Nos. 6 and 7.
California State Mining Bureau: 6th Annual Report of State Mineralogist, Pts. I and II.

Savannah, Ga.—Georgia Historical Society: Maj. Gen. Samuel Elbert.
Topeka, Kan.—Washburn College, Laboratory of Natural History: Bulletin, Vol I, No. 7.
Trenton, N. J.—Natural History Society: Journal, Vol. I, No. 2.
Washington, D. C.—Interior Dept., Bureau of Education: Statistics of Public Libraries in U. S., 1884-5.
Census Office: Vol. XVIII of Final Reports of 10th Census—Social Statistics of Cities, Pt. I; Vol. XV. of 10th Census—Mining Industries.
Patent Office: Official Gazette, Vol's 38, 39, 40 and 41; Lists and Index to Vols. 35, 36, 37, 38 and 39; 6th Annual Report for 1886.
Smithsonian Institution: 4th Annual Report of Bureau of Ethnology, 1882-3.
U. S. Geological Survey: Bulletins 30-33; Mineral resources of U. S. Monographs: X. Dinocerata, an ExtinctOrder of Gigantic Mammals, by O. C. Marsh; XI. Geological History of Lake Lahoutan, a Quaternary Lake of N. W. Nevada, by I. C. Russell; and XII. Geology and Mining Industry of Leadville, Colo., with Atlas, by S. F. Emmons.

FOREIGN.

Cairo, Egypt.—L'Institut Egyptien: Bulletin, 2d Series, No. 7, 1886.
Calcutta, India.—Royal Asiatic Society: Records, Vol. XX, Pts. 1, 2 and 3; Catalogues of Sirralik Vertebrata, and of Pleistocene and Prehistoric Vertebrata; Paleontologia Indica: Series I, Vol. I, Pt. 1; Ser. XII, Vol. I; and Ser. XII, Vol. IV, Pt. 2; Contents of Vol. I.
Cassel, Germany.—Verein fur Naturkunde: Reports 32 and 33, 1884-6.
Christiania, Norway.—Videnskabs Selskabet: Proceedings, 1886.
Cordoba, Argentine Rep.—Academia Nacional de Ciencias Exactes: Bulletin, Vol. IX, Nos. 1-4; Records, Vol. V, Pt. 3.
Bombay, India.—Royal Asiatic Society, Bombay Branch: Journal, Vol. XVIII, No. 45; Index to Transactions, Vol's I-III, and to Journal, Vol's I-XVII.
Brussels, Belgium.—Societe Malacologique de Belgique: Proceedings, Vol. XV, 1886, pp. 1-144; Vol. XVI, pp. 1-80; Statutes of Society.
Florence, Italy.—Biblioteca Nazionale: Bollettino, 1886, Nos. 20-24; 1887, 25-48; Indices Bollettino, 1886; Index to Works, pp. 49-155; Larola Sinnottica.
Georgetown, Brit. Guiana.—Royal Agricultural and Commercial Society: "Limehri"—Journal of the Society, Vol. V, Pt. 2.
Glasgow, Scotland.—Geological Society: Transactions, Vol. VIII, Pt. 1.
Haarlem, Netherlands.—Musee Teyler: Archives, Series II, Vol. III, Pt. 1. Catalogue of Library, Vol's V and VI.
Hamburg, Ger.—Naturwissenschaftlicher Verein: Transactions, Vol. IX, Pts. 1 and 2.
Liverpool, Eng.—Geological Society: Proceedings, Vol V, Pt. 3.
Montreal, Can.—Natural History Society: Record of Science, Vol. II, Nos. 6-8.
Moscow, Russia.—Societe Imperiale des Naturalistes: Bulletin, Vol. LXII, Nos. 2, 3 and 4, with Supplement. 1888, Pts. 1, 2 and 3.
Mexico, Mex.—Sociedad Mexicana da Geografia y Estadistica: Island of "Cayo Arenas;" Bulletin, Vol. VI, Nos. 4-9.

Munster, Prussia.—Provenzial Verein fur Wissenschaft und Kunst: 14th and 15th Annual Reports.

Ottawa, Can.—Geological and Natural History Survey: Descriptive Catalogue of Minerals of Canada; Geological and Topographical Map of Lake of the Woods and vicinity.

Paris, France.—Library of M. Gautier-Villars: Explanation of the Sun Spots, by M. Delauney.

St. John, N. B.—Natural History Society: Bulletin, 1887, No. VI.

Toronto, Can.—Canadian Institute: Proceedings, Vol. IV, No. 2; Vol. V, No. 1.

Rome, Italy.—Biblioteca Nazionale Vittorio Emanuele: Bollettino, 1886, Nos. 5 and 6. Vol. II, Nos. 1-3. Index to Vol. I.

Sydney, N. S. Wales.—Royal Society: Journal and Proceedings, Vol. XIX, 1885.

Shanghai, China.—Royal Asiatic Society, China Branch: Journal, Vol. XX; Vol. XXI, Pts. 1-6.

Turin, Italy.—Musei di Zoologia ed Anatomia Camparata R. University: Bollettino, Vol. I, Nos. 16-18; Vol. II, Nos. 19-26.

Winnipeg, Man.—Historical and Scientific Society: Annual Report for 1885-6. Transactions, Nos. 19-21.

The election of officers for the ensuing year resulted in the choice of

President, - - - -	A. F. Elliot.
Vice-President, - - - -	J. A. Dodge.
Recording Secretary, - -	C. W. Hall.
Treasurer, - - - - -	Franklin Benner.
Corresponding Sec'y,	Miss Gertrude J. Leonard.
Trustees for three years, -	T. B. Walker. T. S. Roberts.

The following persons were elected members: Conway G. MacMillan, John A. Schlener, Dr. H. H. Kimball, Dr. Chas. Simpson, Rev. Timothy Corbett.

February 7, 1888.

Ten persons present.

A piece of pottery was presented, by communication, from Mrs. A. H. Linton. It was obtained from the Navajoes Indians and believed to be over 200 years old. The squaw from whom it was secured was said to be 106 years of age; she stated the piece came to her from her parents and to them from her grandfather.

The following were elected members:

Edw. C. Gale, Prof. H. F. Nachtrieb, C. H. Pettit, C. J. Bartleson, Uly. S. Grant, A. H. Brackett, E. C. Donnell.

Judge Hemiup then read a paper entitled "the star Sirius and its satellites."

The paper gave a resume of what was known at the present time of this interesting star, and an account of the discovery of its satellite by Alvin Clarke about four years ago while testing the objective of the telescope he was then making for the Chicago observatory.

Prof. J. A. Dodge presented a sample of coal of which he had made an analysis for the Canadian Pacific Coal Company, Mr. A. Pugh of St. Paul, general manager. The analysis showed the coal to be an anthracite of good quality. The locality of the bed is the basin of the Bow river, Northwest Territory.

March 6, 1888.

Twenty-one persons present.

The section of botany gave the programe of the evening.

Dr. Thos. S. Roberts presented a paper describing some of the different methods of plants for scattering their seeds. A number of charts illustrated the paper and dried specimens were exhibited of plants from our own flora showing peculiar adaptations for this work.

[ABSTRACT.]

Dr. Roberts spoke briefly from notes upon the subject, "how plants sow their seeds," illustrating by crayon drawings a number of the principal natural devices by means of which the seeds of plants are scattered to a distance from the parent stem.

The advantage to a plant of a wide dissemination of its seeds is that it accomplishes the extensive dispersion of the individuals and contributes to their better development, thus aiding in the perpetuation and advancement of the species. Atmospheric currents, ocean, lake and wind currents, fruit and seed-eating animals, animals with woolly coats, and forces variously generated by the plants themselves, all operate in conjunction with more or less specially developed structures of seed, seed-covering or entire plant to accomplish the dispersal and planting of the ripened seeds. The great class of pappus bearing seeds, winged seeds, wooly seeds, those provided with some parachute-like appendage as is the seed cluster of our common linden, tiny seeds and germs of dust-like lightness and many others are wafted far and wide by the winds; other seeds, seed pods and in some cases the entire plant (as for example *Galium*) are provided with prickles, arms, teeth, barbs or stiff woolly covering by means of which they cling to the rough coats of passing animals and are thus conveyed from place to place; the hard and almost imperishable coats of many seeds insure a safe passage through the digestive tract of birds or other animals and they are dropped it may be miles from where they were devoured with the germ unharmed; or they may be washed hither and thither for days by the river current or ocean wave until at last they find a proper resting place to germinate and establish a new center of distribution. Not a few plants have developed in the course of the great struggle for supremacy special mechanical contrivances by means of which they themselves propel their seeds to a safe distance. Many of these adaptations are truly marvelous. Among them may be mentioned the remarkable "catapult" of the witch hazel (*Hamamelis*), the well-known bursting pod of the balsam or jewel-weed (*Impatiens*,) the common *Oxalis*, the elastic siliques of many *Cruciferæ* and the strange squirting cucumber (*Momordica*) of northern Europe. The common tumble-weed (*Amarantus albus*) and the *Psoralea* (especially *argophylla*) of our western prairies are illustrations of a singular mode of seed distribution where the whole plant is of globular growth and separating at maturity at the surface of the earth, rolls to and fro before every wind, thus serving as a most excellent "seeder." If enough has been said to suggest the instructive field of study that here lies within easy reach of every student of botany or evolution the purpose in view will have been attained.

Conway MacMillan then discussed "Heliotropism."

A brief discussion of the movements of the aerial plant-organs under the influence of unequal lateral illumination, with explanations, according to the various investigators (De Candolle, Frank, Pfeffer, etc.,) of the intimate molecular changes upon which such movements are probably conditioned.

(This paper was published in full in the *Popular Science Monthly* for September, 1888.)

Dr. A. F. Elliot presented some cones and leaves of the Soldad pine of California.

Dr. J. H. Sandberg was elected a member.

April 3, 1888.

Fifteen persons present.

A. S. Dimond was elected a member.

Professor Dodge, of the section of Chemistry, continued the subject presented one year ago, in a discussion of "the purification of water for domestic purposes, particularly filtration."

First were considered the sources of contamination—cesspools, wells, impure ice, etc. Citations of recorded cases were made to show the risks run in using unpurified water.

Secondly, several different modes of filtration were described, and suggestions offered for filter making. The construction and points of advantage of the following filters were pointed out: Pasteur's; the powdered coke filter; the Hyatt filter.

May 8, 1888.

Fifteen persons present.

Chas. S. Fellows was elected a member.

Professor H. F. Nachtrieb read a paper prepared for the Academy by F. L. Washburn "on the structure of the hen's egg and the development of the embryo chick."

Mr. Benner presented a series of "notes on the arrival and nesting of some species of birds in this vicinity for the spring of 1887." (See paper X.)

Professor L. W. Chaney by means of blackboard drawings and glass models illustrated an interesting talk on "the Embryology of the Sea Urchin and Starfish."

June 11, 1888.

Jacob Sitze, Bruno Bierbauer and Will. D. Willard were elected members.

Uly. S. Grant read a paper prepared for the Academy by W. J. McGee, U. S. Geologist, entitled: "The Field of Geology and its Promise for the future." (See paper Y.)

A paper by C. W. Hall then presented "a review of the theories of the origin of the granitic rocks and the crystalline schists."

The paper was the introduction to an investigation by the author into the rise and development of this, one of the earliest problems with which geologists have had to deal. Nothing which could be called a theory, that is, nothing beyond a vague guess or bold assumption had existed before some conception had been reached of the relations of the great crystalline formations to the fossiliferous and other stratified beds. Of these relations Hutton had observed something; but it was Smith who in 1815 in his table of British formations placed the granite, syenite and gneiss as the 34th and lowest in his series of rocks below the London clay. The theories of several geologists following Smith were outlined, and the growth of the leading views of the present day was rapidly traced.

October 2, 1888.

Seven persons present.

Bruno Bierbauer presented a paper which was "a check-list of Paleozoic fossils for the Northwestern states, comprising Wisconsin, Minnesota, Iowa, Nebraska and Dakota. (See paper Z.)

C. W. Hall then gave an account of "the Minneopa well," sunk during the present season by parties in search of gas. (See paper AA.)

Dr. A. F. Elliot gave an account of a gas well he had recently visited in the vicinity of Big Stone lake.

The well had been flowing for months. For some time the flow was an intermittent one, but now it was steady. The gas has a slight odor, and is not inflammable.

November 13, 1888.

Six persons present.

O. W. Oestlund was elected a member.

Conway MacMillan presented "Notes on the Physiology and Morphology of the Carrion-Plant—*Ithyphallus impudicus* (*L.*) *Fries.*

Specimens of this plant were secured at Big island, Lake Minnetonka. It is a fungus which gives off an odor approaching that of decayed flesh, thus deluding flies into making it a receptacle for their eggs. While ovipositing the flies become covered with spores from the fungus, and the plant thus secures propagation. The special morphological and remarkable developmental adaptations to attain the end of sure and speedy scattering of the spores were noted in detail.

C. W. Hall gave an account of a geological trip recently made by him through the Wisconsin river valley from Rhinelander to Stevens Point, with some views on the stratigraphy of the rocks of this, the central river valley of Wisconsin. (See paper BB.)

December 4, 1888.

Twenty-four persons present.

Dr. E. H. Angle and Dr. L. D. Leonard were elected members.

Dr. C. N. Hewitt chairman of the section of sanitary science, presented this topic: "Imperfect sanitary work, in which boards of health and health officers ask the co-operation of all thoughtful people, particularly mothers, fathers, the clergy and teachers." (See paper CC.)

Some of the points urged by the speaker related to infectious diseases; these were illustrated by cultures prepared and presented under the microscope. Quite a discussion arose through the questions of several interested listeners after the reading of the paper, and during the examination of the slides.

January 8, 1889.

Eight persons present.

Dr. N. L. Gardner, of Kioto, Japan, presented the Academy with a collection of the ferns of Japan. The collection consisted of 43 species.

Secretary Hall announced to the Academy that a fine collection of minerals had arrived from the California State Mining Bureau, for which an exchange had been arranged by Mr. S. P. Channell.

The thanks of the Academy were voted to Mr. Channell and Dr. Gardner.

The recording secretary reported the following financial statement.

Amount brought over from last year..............	$ 59 66
Amount collected during the year..........................	495 00
Total..................	$554 66
Rent and gas bills and various incidental sums paid during the year..	$431 17
Amount on hand at date........	$123 49

The corresponding secretary reported the following books and pamphlets received during the year 1888:

THE UNITED STATES.

Baltimore, Md.—Johns Hopkins University: Circulars, Vol. VII, Nos. 62-68.

Brooklyn, N. Y.—Long Island Historical Society: Campaign of 1776; Dutch and Iroquois; Proceedings of 20th Annual Meeting; Proceedings In Memoriam.

Boston, Mass.—American Academy of Arts and Sciences: Proceedings, Vol. XXIII, Pt. 1.

Mass. Horticultural Society: Schedule of Prizes, 1888; Transactions, 1887, Pts. 1 and 2.

Buffalo, N. Y.—Buffalo Historical Society: Annual Report, Jan. 10th, 1888.

Cambridge, Mass.—Harvard College Observatory: Henry Draper Memorial; Second Annual Report.

Museum of Comparative Zoology: Bulletins, Vol. XIII, Nos. 6, 7, 8, 9 and 10; Vol. XVI, Nos. 1 and 2; Vols. XIV and XV; Vol. XVII, Nos. 1 and 2; Annual Report of Curator, 1887-8.

Champaign, Ill.—State Laboratory of Natural History: Bulletin, Vol. II, Art. VII, Vol. III, Art. IV and Nos. 2, 3 and 8.

Chapel Hill, N. C.—Elisha Mitchell Scientific Society: Journal, Vol. IV, Pt. 2; Vol. V, Pts. 1 and 2.

Charleston, S. C.—Elliott Society of Science and Art: Proceedings, Vol. II, pp. 121-200.

Chicago, Ill.—Academy of Sciences: Constitution and By-Laws; Bulletin, Vol. I, Nos. 1-10.

Cincinnati, O.—Society of Natural History: Journal, Vol. X, No. 4; Vol. XI, Nos. 1, 2 and 3.

Denver, Colo.—Scientific Society: Proceedings, Vol. II, Pt. 3.

Iowa City, Ia.—State Historical Society: 16th Biennial Report; Historical Record, Vol. IV, Nos. 1, 2, 3 and 4.

Lansing, Mich.—Michigan Agricultural College—State Board of Agriculture: Bulletins, 32-42.

Lincoln, Neb.—University of Nebraska: University Studies, Vol. I, No. 1.

Madison, Wis.—State Historical Society: Collections, Vols. X and XI; 34th Annual Report.

Milwaukee, Wis.—Public Museum: 6th Annual Report of Trustees.

Minneapolis, Minn.—Minnesota State Horticultural Society: Annual Report, 1883.

State University, Agricultural Department: 4th Biennial Report of Agricultural Department; Bulletin, Nos. 1, 2, 3 and 4.

State University, Geological and Natural History Survey: 15th Annual Report; Bulletins 2, 3 and 4.

Newark, N. J.—New Jersey Historical Society: Proceedings, Vols. I to IX; Collections, Vols. I, II, IV, V, VI with Supplement, and VII.

New Haven, Conn.—Conn. Academy of Arts and Sciences: Transactions, Vol. VII, Pt. 2.

New Orleans, La.—Academy of Sciences: Papers, Vol. I, No. 1.

New York, N. Y.—American Museum of Natural History: Annual Report, of Trustees, 1887-8.

N. Y. Microscopical Society: Journal, Vol. IV, Nos. 1, 2, 3, and 4.

Torrey Botanical Club: Bulletin, Vol. XIV, No. 2; Vol. XV, Nos. 1-5 and 7-12.

Dr. T. F. Allen: The Characeæ of America.

New York Academy of Sciences: Transactions, Vol. VI; and Vol. VII, Nos. 1-8.

American Geographical Society: Bulletins, Vol. XIX, No. 4 and Supplement; Vol. XX, Nos. 1, 2, 3 and 4.

Philadelphia, Pa.—Philadelphia Academy of Natural Sciences: Proceedings, 1887, Pt. III; 1888, Pts. I and II.

Second Geological Survey of Pennsylvania: Annual Report for 1886 Pts. II, III, IV, with 2 Atlases, 1886.

Report: C7, Pt. II. Atlas to accompany Report C7.

Atlas: AA, Pt. II. Northern Anthracite Coal Field.

AA, Pt. II. Eastern Middle Anthracite Coal Field.

Zoological Society: 16th Annual Report,

Providence, R. I.—Rhode Island Historical Society: Proceedings, 1887-8: Life and Services of R. G. Hazard.

Salem, Mass.—American Association for the Advancement of Science: Proceedings, Vol. XXXVI.

San Francisco, Cal.—San Francisco Academy of Science: Bulletin, Vol. II No. 8.

California State Mining Bureau: 7th Annual Report of State Mineralogist.

San Diego, Cal.—C. R. Orcutt: West American Scientist, Vol. III, Dec. '87; Vol. IV, Nos. 35, 37, 38; Vol. V, No. 2.

St. Paul, Minn.—State Historical Society: Catalogue, Vols. I and II, 1888.

St. Peter, Minn.—Minnesota Insane Hospital; 1st and 3d Biennial Reports.

Savannah, Ga.—Georgia Historical Society: Sketch of Life of Sidney Lanier.

Topeka, Kan.—Academy of Science: Transactions, Vols. VIII and X, 1885-6.

Trenton. N. J.—Natural History Society: Journal, Vol. I, No. 3.

Washington, D. C.—Bureau of Education: Report of Commissioner, 1885-6.
Census Office: Tenth Census, Vol. XII, Mortality and Vital Statistics, Pt. 2, Plates and Diagrams; Report on Cotton Production of Mississippi; Vol. XVII, Water Power, Pt. II; Vol. XIX, Vital Statistics of Cities, Pt. II; Vol. XXI, Defective, Dependent and Delinquent Classes; Vol. XXII, Power and Machinery employed in Manufactures and the Ice Industry.
Congressional Library: Message and Documents, 1886-7; Memorials of John A. Logan, Abraham Dowdney, Michael Hahn, Austin F. Pike, Wm. T. Price, John Arnot, Jr., and John F. Miller.
Dept. of Agriculture: 3d Annual Report of Bureau of Animal Industry, 1886; Report of Commissioner, 1887; Report on Grape Vine.
Patent Office: Official Gazette, Lists and Indices of Vols. 40, 41, 42 43, 44 and 45; Annual Report of Commissioner, for 1887, Vol. 46, No. 1.
Smithsonian Institution, Bureau of Ethnology: Bibliography of Eskino Language; Bibliography Sionan Language; Use of Gold and Other Metals; Perforated Stones of California; Work in Mound Explorations.
U. S. Fish Commission: The Fishery Industries of U. S., Sect. II, Geog. Review.
U. S. Geological Survey: Mineral resources of U. S., 1886: Atlas, Geology and Mining Industry of Leadville.
Treasury Dept. Wool and Manufactures of Wool; Statistical Abstract of U. S., 1887, 10th No.: Internal Commerce of U. S., 1887.

FOREIGN.

Berlin, Germany.—R. Friedlauder & Sohn: Naturae Novitates, 1887, 1888, Nos. 1-21 and 23.

Bombay, India.—Royal Asiatic Society, Bombay Branch: Journal, Vol. XVII, No. 46.

Bremen, Gərmany.—A. R. Grote: North American Lepidoptera, Chapter on Butterflies and Moths.

Brussels, Belgium.—Societe Malacologique de Belgique: Proceedings, 1887, pp., 81-142.

Cairo, Egypt.—L'Institut Egyptien: Bulletin, 2d Series, No. 8, 1887.

Calcutta, India.—Geological Survey: Paleontological Indica: Series X, Vol. IV, Pt. 3; and Ser. XIII, Vol. I, Pt. 7; Manual of Geology of India, Pt. IV; Memoirs, Vol. XXIV, Pt. 1; Records, Vol. XX, Pt. 4, Vol. XXI, Pts. 2 and 3.

Cordoba, Argentine Rep.—Academia Nacional de Ciencias Exactes: Boletin, Vol. X, Pts. 1 and 2; Vol. XI, Pts. 1 and 2, 1888.

Demarara, Brit. Guiana.—Royal Agricultural and Commercial Society: "Timehri"—Journal of Society, Vol. II, Pt. 1, New Series.

Florence, Italy.—Bibliotica Nazionale: Bollettino, 1888, Nos. 48 51, 53-57, 59-60, 62-64, 66-71: Index, pp. 1-64 and 81-65.

Haarlem, Netherlands.—Musee Teyler: Archives, Series II, Vol. III, Pt. Deuxienne; Catalogue de Bibliotheque.

Halifax, Nova Scotia.—Institute of Natural Science: Proceedings and Transactions, Vol. VII, Pt. II.

Halle, Ger.—K. Leopoldinisch-Carolinische D. Academia der Naturforscher: Nora Acta, Vols. XXXIX, No. 5, LII, No. 2, and LIII, No. 1; "Leopoldina," Nos. 22 and 23.

Hamburg, Ger.—Naturwissenschaftlicher Verein: Transactions, Vol. X.

Kier, Russia.—Societe des Naturalistes: Memoirs, Vol. IX, Pts. 1 and 2.

Liverpool, Eng.—Geological Society: Proceedings, Vol V, Pt. 4.

Melbourne, Victoria.—Public Library, Museums, etc.: Prodromus of Zoology of Victoria, Decades I-XIV.

Mexico, Mex.—Sociedad Mexicana da Geografia y Estadistica: Bulletin, 4th Series, Vol. I, Nos. 1 and 2.

Montreal, Can.—Natural History Society: Record of Science, Vol. III, Nos. 1-4.

Moscow, Russia.—Societe Imperiale des Naturalistes: Bulletin, 1887, No. 4 with Supplement, 1888. Nos. 1 and 2, with Meterologische Beobachtungen, Beilage, Vol. I, 2d Series.

Ottawa, Canada.—Geological Survey: List of Publications; Catalgue of Canadian Plants, Pt. III and Pt. IV, Endogens; Annual Report, Vol. II.

Paris, France.—E. L. Ragouot: Diagnoses of North American Phycitidae and Galleriidae.

Rio de Janeiro, Brazil.—Instituto Historico, Geographico y Ethnographico: Rivista Trimensal, Vol. I, Pts. 3 and 4, 1887.

Musen Nacional: Archives, Vol. VII, Nos. 1, 2, 3 and 4.

Rome, Italy.—Biblioteca Nazionale Vittorio Emanuele: Bollettino, Nos. 2-6; Index to Vol. 2 of Bollettino.

Toronto, Canada.—Canadian Institute: Annual Report for 1886-7; Proceedings, Vol. III, No. 2, and Whole No., Vol. XXIV, No. 50.

Turin, Italy.—Musei di Zoologia ed Anatomia Comparata, R. Universita: Bollettino, Vol. II, Nos. 33 and 34; Vol. III, 35-43; Index to Vol. II.

Saint John, N. B.—Natural History Society: Bulletin, Vol. VII.

Shanghai, China.—Royal Asiatic Society, China Branch: Journal, Vol. XXII, Nos. 1-4.

Sydney, N. S. Wales.—Department of Mines: Annual Report, for 1887; Mineral Products of N. S. W.

Royal Society: Journal and Proceedings, Vols. XX and XXI, 1887.

The following officers were elected for the year:

President, - - - -	A. F. Elliot.
Vice-President, - - - -	J. A. Dodge.
Recording Secretary, - -	C. W. Hall.
Treasurer, - - - -	Edw. C. Gale.
Corresponding Sec'y, - -	C. S Fellows.
Trustees for three years, -	S. P. Channell. J. McGolrick.

February 5, 1889.

Five persons present.

The section of astronomy, N. H. Hemiup, chairman, had a program ready to present, but owing to the small number—a bare quorum—in attendance, it was not carried out.

March 12, 1889.

Seventeen persons present.

A. D. Meeds was elected a member.

Mr. C. G. MacMillan presented a paper on "Artificial Cells and Osmotic Action." The paper consisted of a discussion of the different varieties of artificial cells, particularly that of Pfeffer, and notes on some experiments made by the author at the Harvard laboratories of Physiological Botany.

Mr. Herbert G. Smith then read a paper on "The Jumpers," a peculiar nervous disease occurring of late in northern Wisconsin.

[ABSTRACT.]

In northern Wisconsin, at Hayward and Mason, were observed several acute cases of "Jumpers" analogous to those of Maine, described by Dr. Beard* some time since. The subjects here are chiefly of French blood—two Swedes being reported, although I cannot positively confirm this. These cases are among working classes, chiefly lumbermen. The characteristic nervous discharges are the occasion of the most extreme physical and mental excitability, which, however, decreases with repetitions of the same cause consecutively applied. In one case a trumpet, when sounded, produced an acute excitation and explosive sounds. Imperative commands, i. e., to strike, to jump, to clap the hands, to "let it drop," &c., &c., are involuntarily obeyed. It is reported upon good authority that one case leaped from a bridge upon which he was working a distance of twenty feet to water; another threw a basket of crockery from his shoulder to the ground, both from these causes. The effect decreases with successive excitations. Absence of excitability largely improves the condition of these cases, while aggravation and frequent "shocks" intensify it, and in all cases produce great bodily and mental distress.

One family includes five cases of Jumpers, but I am uncertain whether this and other similar indications point to a hereditary tendency in the complaint, or more to a general disposition among close companions, especially the young, to imitate a new peculiarity.

April 2, 1889.

Thirteen persons present.

John B. Hawley was elected a member.

Professor J. A. Dodge gave two "analyses of water used in a boiler employed for heating a public building in St. Peter, Minn. (See paper DD.)

Professor C. F. Sidener then discussed the reported decomposition of cobalt and nickel, and, incidentally, the grouping of the chemical elements on the basis of their physical relations. The paper awakened some discussion, participated in by the reader of the paper, Professor Dodge and Mr. Hawley.

*American Neurological Society, N. Y. 1880.

A. D. Meeds then read a paper describing "a deep well at Stillwater, Minnesota." A series of borings from this well was presented to the Academy by Mr. Meeds. (See paper EE.)

May 7, 1889.

Twelve persons present.

Mr. O. W. Oestlund read a paper on "Insect wings: their origin, structure and venation."

A review of "A comparative study of the venation of Insect wings," by Josef Redtenbacher: Annalen des K. K. naturhistorischen Hofmuseums, Wien, Vol I, No. 3.

Profesor L. W. Chaney described from notes "the histology of the Earthworm."

June 4, 1889.

Seven persons present.

Mr. M. A. Morey gave an informal talk on "the geological formations lying north of the Yellowstone National Park."

The speaker had been engaged in exploratory work in this region during the past year. He regarded the rocks among which his work had been carried on as of Cretaceous age, basing his opinion on the fossils which were abundant in certain strata; but quite profound local changes were described, brought about, in the speaker's opinion, by the influence of the enormous outflows of volcanic rocks. Attention was called to several phases of the problems of metamorphism and mineralization to which his investigations had led him, and for which he had thus far reached no method of solution. A series of specimens from the district was exhibited.

Secretary Hall read a paper by Warren Upham on "the limits of species of plants in the Red River valley.

Mr. Upham's paper is withheld at this time to be incorporated as a part of a series of papers in Bulletin 3.

In the discussion of this paper which followed the reading, N. H. Winchell remarked:

That he was glad to observe from Mr. Upham's paper, some change in Mr. Upham's views as to the cause of the prairies since he was associated with the Minnesota survey. He formerly attributed the prairies to climatic causes, chiefly the lack of that precipitation which prevails further east. This difference of opinion between Mr. Upham and himself had induced him to make careful and quite extended observations at numerous places in Minnesota over that belt which covers the outrunning of the timber and the oncoming of the prairie, with the view to ascertain if possible what features of surface or soil accompany the change. These observations will be published in another volume of the final report of the geological and natural history survey of Minnesota, in a discussion of the origin of the prairies.

Prof. Winchell enumerated several theories that had been advanced for the existence of the prairies, and stated that he believed the chief cause is the extensive fires that rage annually or semi-annually over the prairie region. There are facts that disprove every other assumed cause. It is objected by Mr. Upham, that fires do not, in the eastern and central states, produce such treeless tracts, and that they prevail annually with great violence. Yet the eastern fires do not have such extensive level areas to spread over, and to be carried by the wind with such speed. While fire is the prime cause, this has to be supplemented by favoring topography and absence of lakes, and perhaps by some diminution of rain-fall to produce the effects seen in the western states and territories. Notwithstanding all other assumed causes, fire is the only cause which, if repressed, allows the gradual spread of forest trees over the prairies, as has been observed and attested in many cases.

October 8, 1889.

The following were elected members: Prof. F. S. Jones, A. L. Crocker, John Byers, G. H. Warren, R. J. Anderson, Dr. E. A. Hutchins, Peter Christianson, Horace V. Winchell, of Minneapolis; Prof. Otto Lugger and Prof. D. N. Harper, St. Anthony Park; Hiram W. Slack, Henry S. Baker, St. Paul; Prof. L. H. Batchelder, Prof. H. L. Osborn, Hamline; Edward O. Ulrich, Newport, Ky.: Prof. S. Calvin, Iowa City; Chas. R. Keyes, Baltimore, Md.

Secretary Hall gave notice that at the next meeting he should move the following amendment to the by-laws, Article VII, Section 1, viz: That the words "resident in the state" be stricken out, thus making the section read: "Any person may be elected to membership," etc.

A paper was read by N. H. Winchell, entitled "The so-called Huronian rocks in the vicinity of Sudbury, Ontario," of which the following is the

(ABSTRACT.)

The paper gave an account of a joint excursion of the members of the Geological Society of America and of the American Association for the advancement of Science from the Toronto meetings in August into the Huronian region, northeast of lake Huron. As it was illustrated by specimens which have the serial numbers of the State Geological Survey, and is therefore inseparable from them without damage, it has been published in the eighteenth annual report of the survey (pp 47-58) with references to the corresponding rock samples.

The paper rehearsed briefly the progress of opinion in respect to the age of the crystalline rocks of the Northwest, calling particular attention to recent re-examinations of the typical Huronian region, and to the opinions of Irving and Lawson, and the establishment of names for rocks older than the

typical Huronian but more recent than the Laurentian. It then gave the results of some observations at North Bay, Wahnapitae, the copper mines at Sudbury, Algoma and Serpent river, and the inferences arrived at are to the effect that two formations have been confounded under one name (Huronian) as follows:

[*Summary of these Observations.*]

It appears, therefore, that both northwest from Sudbury and eastward from Algoma there are two formations. The slate and the slate conglomerate in both sections constitute the upper formation. In the region northwest from Sudbury the underlying rocks are largely felsitic, but are also micaceous, and of the Stobie mines become hornblendic. These changes are identical with changes that are known to occur in the Keewatin in Minnesota. In the section eastward from Algoma the underlying formation seems to be the Missasaugui quartzite with interbeding of green fissile schist, in part, and a mica schist, varying to hornblendic schist, in part, the latter being the furthest east.

There seems to be some irregularity in the order of succession in the section eastward from Algoma, bringing in several outcrops of strata that belong higher up in the series. If this be not illusory, and due rather to the winding of the railroad from north to south to avoid the hills, it may be accounted for by such faulting and upheaval as have been described in Minnesota, such as have produced the sudden, but indistinct, unconformities and transitions from the Huronian to the Keewatin, that have been described there. Further, the quartzite which has been alluded to as the Missasaugui quartzite, and supposed to be Logan's lowest gray quartzite, is probably not his lowest gray quartzite, but it is a rather a constituent part of the Keewatin. It is allied in all its lithology no less than its persistent verticality, to the Keewatin, and seems to have been formed in the Keewatin ocean in the same manner as the jaspilite beds of that horizon—i. e. by chemical precipitation, the green schist layers showing such advent of basic eruptions or volcanic ash as could form chloritic schists, in the same way as in northeastern Minnesota. The "lower gray quartzite," (No. 5a) of the orignal Huronian, according to Logan's map of 1863, appears a few miles east of Thessalon at the lake shore, and there produces an unconformable contact on the gneiss of the Laurentian. This contact has been examined by Prof. Irving and more lately by Dr. A. C. Lawson, and they concur in the statement that the conglomerate is a pudding-stone of rounded masses, having a quartzite matrix. There can be but little doubt that it is the same seen in the vicinity of Thessalon, and hence that is the Thessalon quartzite, and *overlies* the slates and slate conglomerates, being near the top rather than near the bottom of the original Huronian. This mistake is apparently the same as that made in eastern New York and in Vermont, where the granular quartz and the Potsdam (or red sandrock) seem to overlap and hide from sight the formation immediately older, and lie in unconformity on a still older terrane—on the east on the gneiss of the Green mountains, and on the west on the gneiss of the Adirondacks. It caused the early geologists to question the existence of any such formation as the Taconic—that great series in which has been brought to light latterly a wonderful fauna of primordial life, and which extends from the Atlantic slopes to the western basis of the Rocky mountains. This overlap unconformity implies a sinking of the pre-existing land, and of the ocean's bed, bringing the later formed strata over the beach-limit that existed before.

We may conclude therefore that the observations that were made on the recent excursions conform, at least do not contravene, the views lately set forth by Irving, Bonney and Lawson, and the conclusions published by the reports of the Minnesota survey, to the effect that the Huronian system as now defined and understood by the Canadian geological reports, really embraces two or three formations; that one of these is the true Huronian, as at first discribed and mapped by Murray, another is the Keewatin of Dr. A. C. Lawson, containing the iron ores at Tower, Minnesota, and another is the series of crystalline schists which we have styled Vermillion series. In other places these three formations have been fully treated.* They are distinctly separate by lithology and by unconformities that have been noted from Vermont to Minnesota, and should no longer be included under a single term, at least not under the term Huronian, which at first had a correct and adequate definition embracing but one of them.

Horace V. Winchell read a paper on "The Iron-ore bearing rocks of Minnesota." [See paper FF.]

L. W. Chaney, Jr., presented "some notes on the *Cryptozoon Minnesotense* Winchell of the Cambrian rocks of Minnesota, particularly those in the vicinity of Northfield." [See paper GG.]

Warren Upham read a paper describing a recent visit to Lake Itasca. [See paper HH.]

December 3, 1889.

Ten persons present.

The following persons were elected members: Jos. R. Hofflin, Henry Howling, Minneapolis; W. H. Scofield, Cannon Falls.

The amendment to the by-laws proposed at the October meeting, to-wit: to change Article VII, Section 1, by striking out the words "resident in the state," was presented and carried.†

C. W. Hall gave an account of "a vacation trip into the Black Hills of South Dakota."

[ABSTRACT.]

The excursion was made in company with Professor Van Hise of the U. S. Geological Survey, who was making a summer's reconnaissance through certain Archaean areas of the western half of the United States. The Professor's object in visiting the Black Hills of South Dakota was to determine

*See the seventeenth annual report, Minnesota survey.

†For the constitution and by-laws of the Academy see Bulletins, Vol. II, pp. 1 to 6, incl.

the stratigraphy and structure of the Archaean rocks of that region, and to get at the genesis of the crystalline schists there exposed.* Only the most salient points on the geology of the Hills were noted.

1. The physical characters of the region were briefly outlined, and the area examined during the visit was pointed out. Specimens of the rocks constituting the central core of this great uplift were exhibited and their field relations to each other were stated, viz: the rocks beneath the Cambrian sandstones and conglomerates which apparently entirely surround the central, Pre-Cambrian, core consist of coarse sandstones and conglomerates which, toward the north and the south, in the neighborhood of eruptive rocks, become genuine crystalline schists, the northerly ones somewhat sericitic.

2. Therefore the crystalline schists of the southwestern portion of the Hills are doubtless the same formations which in the northern Hills are conglomeratic and sericitic with some ferruginous bands, the change from conglomerates to crystalline schists being brought about by the heat, pressure, displacement and lesser movements contemporaneous with the outflow of the granites. This view naturally removes the necessity of regarding these rocks as separable "into a western series or group of schists and an eastern series or group of schists."†

3. So far as the speaker's observations went there occur no true Laurentian granites in the Black Hills. The granites occurring in such enormous quantities in the Southern Hills are of eruptive origin. The strike and dip phenomena so conspicuous around the borders of the Harney Peak core of granite, that are respectively parallel to and away from the borders of the granitic mass, could not well be explained in any other way than by assuming the eruptive origin of the core.

4. The tin ore, cassiterite, of the granitic area will probably never be found to occur in paying quantities save in occasional *placers* into which the ore of removed areas of granite has been collected, or in occasional lumps of granite (pegmatites) having a larger quantity of the ore than the average of the granitic mass—this fact, of the non-existance of the cassiterite in paying quantities, being due to the igneous origin of these rocks and the consequent non-segregated condition of the ore in vast masses of the carrying rock.‡

*Bulletin Geol. Soc. Am., Vol. I, pp. 203-244, contains an admirable paper by Professor Van Hise, entitled "The Pre-Cambrian Rocks of the Black Hills," read December 28, 1889.

†See Newton and Jenney, "Report on the Geology and Resources of the Black Hills of Dakota," p. 50.

‡Compare in this connection a paragraph by Professor Van Hise, on p. 211, of the paper already cited.

On Monday, December 16th, 1889, from four until ten o'clock, the Library Board of the city of Minneapolis received the people of Minneapolis and many of the leading citizens of Minnesota in the new Public Library Building.

In this fire-proof building erected at a cost, including the ground, of $334,150.65, and on this occasion formally opened for the use of the citizens of the city, THE MINNESOTA ACADEMY OF NATURAL SCIENCES has been assigned rooms. On the third floor the Academy has an elegant room for its meetings and spacious and equally elegant rooms for the display of its collections which will be daily open to the public.

The Library Board had generously furnished sufficient cases for the display of the collections of the Academy and the secretary and several members had devoted their time for many evenings to cataloguing and arranging the material so that on the occasion of the opening the extent and condition of the museum were very fairly presented to the public.

The rooms thus placed at the disposal of the Academy of Sciences answer present needs and are a realization of the desires of its members expressed in 1880, repeated in 1884, and felt in every subsequent year; they enable the organization to devote its energies more directly to the publication of its Bulletins and to the creation of a museum of natural history and material resources for the great Northwest.

[*Paper X.*]

NOTES ON THE ARRIVAL AND NESTING OF BIRDS IN THE VICINITY OF MINNEAPOLIS FOR THE SPRING OF 1887.—*Franklin Benner.*

My notes for the past year were limited by the short time I was able to devote to looking up the birds. I was only able to make weekly trips, and, living in town, the arrival and departure of the birds was not noted as quickly as they otherwise would have been. My notes begin April third when I saw the first robin.

On the 8th they were followed by our social friends, the blue-birds. April 10th, while driving out Third avenue south towards Richfield, I found a nest and three young of the shore lark. They appeared to be about a week old. This, I think was very early, although on March 24, '81, I found a nest just begun on Lowry's hill and within fifteen feet of a bank of snow two feet deep. The eggs were laid by April 2nd, and although I left them until the 5th, two more were deposited. I think rarely more than three are laid in the first brood.

April 18th, I noted the chipping sparrow; April 25th, the golden crowned wren.

May 2nd, I found in the lake Harriet woods, a nest of three eggs of the Cooper's hawk. The birds were evidently young as they exhibited no fear of me and perched in the neighboring tree. I have visited the same nest this season (1888) and found only one of the birds, but climbing the tree found I was too early for the eggs. Vegetation was much further advanced than it is this year. That same day I found five pewee's nests in course of construction. They seemed to like the porches of the deserted houses around lake Harriet where they can raise their little families before campers make it too uncomfortable for them. One had even gone through a broken window and built its nest on the top of a window casing in a second story room.

May 5th, I made my way to lake Johanna, to a tamarack swamp there, which is very fruitful for the ornithologist. First, I found a crow's nest, but did not disturb it, then a Cooper's hawk's with four comparatively fresh eggs, and not far from that, in an old hawk's nest, five eggs of long eared owl, partially incubated. The bird flew off as I climbed the tree and kept hovering around and flying from tree to tree, snapping her bill while the eggs were being taken. Both birds, in fact, were there, but I only secured the female.

This same day I found robins breeding, four eggs in nest. Quite a number of wild flowers were in blossom, among those most common, was the yellow cowslip.

May 15th, I went out again and got a full set of five eggs of the pewee perfectly fresh. A prairie chicken's nest was observed at Hardley's farm with six eggs, the nest deserted.

May 25th, I went to Grassy lake, beyond Richfield. Here the black tern, gallinules, yellow-headed blackbird and grebes were breeding in very limited numbers. Nest of brown thrush with half-fledged young. Found nest of young musk rats, nine in all, their eyes were closed, yet they could swim.

June 2nd, I found two fresh eggs of the night hawk at Kenwood.

June 5th. My excursion to-day led me out on the Minnetonka road. I found first of all the nest of cree bird with two eggs, red eyed vired building. One of the most interesting discoveries to me was the finding on this day of six nests of the clay colored sparrow (*Spizella palida*). I have been looking for this nest ever since I have been in Minnesota but never found it until this year. On May 29th, I found by the road side a nest of this species in a small bush two feet from the ground and containing two fresh eggs. On this date two more had been added and incubation begun. Three hundred rods further on I saw a patch of hazel bush about a hundred feet square and one of these birds flying near, so I went in to see what was to be found. There were two nests with with fresh eggs. Three nests just finished and one nest with five young, just hatched.

I saw part of the eggs from the first two nests were on the ground and broken and the nests out of place. This, with the large number of nests for such a small space, set me to thinking and my conclusions are, that the bushes being in a cow pasture the cows had upset the nests in going through and thus kept these birds busy building new nests or repairing the old ones. A mile further on I found another nest of this same bird on the ground, containing four young almost fully fledged. Here in a short time were found all the extremes of incubation, fresh eggs, young just hatched and young about fully fledged. The first nests, please note, were all raised about two or three feet from the ground, while the last was right on the ground. This habit of nesting seems to be very common with this bird. Other nests and eggs found this day, were, cat bird, nest and four eggs; yellow warbler nest and five eggs, fresh; rose-breasted grosbeak nest and young about half grown, nest and four eggs partially incubated. The female was very fearless and I had my hand within a few inches over her before she would leave the nest. Found also a grebe's nest with six eggs; grebe's nest, eight eggs; rail's nest, one egg; red-winged blackbird. nine nests, seven with young all the way from just hatched to just ready to leave the nest; one nest, four eggs; one nest, three eggs, fresh. Pond lillies were just in bloom.

On the way home found a small nest by the roadside three feet from the ground, which I found on later investigation to be another clay colored sparrow. The four eggs had been laid, but when found the nest was on its side and the eggs on the ground. I also found the nest of long thrush, one young, a week old.

June 8th, I found nest and five fresh eggs of the black-throated bunting in a small oak tree. The nest was placed four feet, six inches from the ground. The female was shot for identification. June 9, I discovered another nest of this same bird, but on the 13th the four eggs had been laid, three feet ten inches from the ground. This was located the same as the former. Most observers of this bird say that it nests on the ground, and others that the nests are not placed more than eight or ten inches above it in tall grass, but here are two instances of nests forty-six inches from the ground in oak trees which is quite unusual.

This bird is very variable in its coming. Some years they are very common, and again very few are seen. This was so in the years 1879 and 1880. In 1879 there was the greatest abundance of them, but the following year there were hardly any to be seen. Last year they were very common indeed.

June 10th, the two eggs of the cree bird found on the 5th, were just hatched. I visited a marsh out on Portland avenue and found a few fresh eggs of the yellow-headed blackbird. These had evidently been robbed before, for although there were a great many birds, there were very few nests with eggs. There were also some coots' nests but no eggs. I shot a very pretty specimen of the local bittern but could not find the nest.

June 15th, I found a yellow warbler and four eggs; some cow birds. This was evidently the second nest of the birds whose nest I took on the fifth, as it was found only a short distance from where the first one was taken. They built a new nest and layed four eggs in ten days. I found a grass finch, nest building. My record closes for this day by the finding of nest and nine eggs of carolina rail; scarlet tanager nest and two eggs, and about twenty eggs of the cliff swallow, taken from the flour mill at Minnetonka Mills.

Let me mention here the finding of the *Nyctale acadia* in this city on May 9, 1881. With the bird were four young and three eggs; the female was shot. This nest was in an old decayed stub about fifteen inches in diameter and located twelve feet from the ground in an old woodpecker's hole. On rapping on the stub with my gun the bird pushed out its head. The young were of all sizes, showing that the eggs had been incubated from the first laying. The eggs contained large embryos.

May 8, 1888.

[*Paper Y.*]

THE FIELD OF GEOLOGY AND ITS PROMISE FOR THE FUTURE.—*W. J. McGee.*

I.

The legitimate field of Geology is now fairly defined, and so fully occupied that it is possible to scan its expanse and discern the tracts yet untrodden by the pioneer. From a survey of the field it appears that many of these lacunae are interesting, and that one is especially noteworthy.

The primitive geologic classification is based immediately upon phenomena—upon those products of the forces operating naturally upon the earth with which it is the province of the science to deal; but in most cases the processes may be readily inferred from the products, and the phenomena may thus be classified as well by the agencies they represent as by their individual characteristics. So the empiric or formal laws expressing the external relations of the phenomena give place to natural or physical laws expressing their essential relations in terms of the operations by which they are produced; and the ultimate geologic classification thus becomes genetic, or a classification by processes rather than products.

Now the various processes with which the geologist has to deal fall naturally into two principal and antagonistic categories, which are supplemented and modified by five subordinate categories; and these categories of processes clearly define the province of geology.

The initial geologic movements (so far as may be inferred from the present condition of the rocks of the earth) were distortion or displacement of the solid or solidifying terrestrial crust in such manner as to produce irregularities in the surface of the globe. These are the movements involved in mountain growth and in the development of continents; they have been in operation from the earliest eons recognized by the geologist to the present time; and their tendency is ever to deform the geoid and produce irregularity of the terrestrial surface. Such movements have been collectively designated displacement or diastrophism; but in the present connection at least they may be grouped as *deformation*, and the quality of the movement may be characterized as *diastatic*. The movements are partly vertical (though there is always a horizontal element) and are most easily measured from a fixed datum plane, such as sea level, and they are therefore commonly separated into *elevation* and *depression*.

The second great category of movements comprises the various processes of aqueous erosion and deposition initiated by the primary deformation of the terrestrial surface. By these processes mountains and continents are degraded, and sea and lakes are filled with their debris; these processes, too, have been in active operation from the dawn of geologic history to the present; and they ever tend to restore the geoid by obliterating the irregularities of the terrestrial surface produced by diastatic movement. The processes may be collectively called *gradation*; and the antagonistic operations comprehended under the term are designated respectively *degradation* and *deposition*.

A subordinate class of processes by which the rocks of the earth are formed or affected is the extravasation of lavas and other volcanic matter from beneath the surface, and the outflow of subterranean waters containing minerals in solution, together with the consequent collapse of cavities and other movements within the crust of the earth. These processes have been in operation throughout geologic time, though perhaps with diminishing activity; they have added materially to the superficial strata of the earth; and they have modified the geoid not only by addition without but by commensurate loss within and consequent deformation or structural alteration. The operations are commonly comprehended under the name *extravasation*; and, like the other primary categories, this comprises two subordinate classes of processes of antagonistic tendency, which, simply for the purpose of fixing their relations, may be called *efflux* and *collapse*. The vibratory movements of *seismism* probably result from both deformation and vulcanism under certain conditions.

The second subordinate category of processes by which the rocks themselves and the operations of the second great category of geologic processes are modified, comprises the chemic and chemico-mechanical alterations in constitution and structure of the earth's strata brought about by the action of percolating water, air and other gases, the rise of the isogeotherms beneath areas of deposition, the heat of deformation, etc. These processes have affected the rocks ever since the solidification of the planet, but probably with progressively diminishing intensity; by them the rocks exposed to degradation are disintegrated, decomposed and softened, and degradation is thereby accelerated; by them the soft sediments are first lithified and then (sometimes) subsequently metamorphosed; and by them the chemic complexity and structural heterogeneity of the terrestrial crust have been largely produced. The various processes are processes of *alteration*; and they comprehend *lithifaction* and its antithesis (*decomposition* and *disintegration* combined) in its various phases, or rock formation and rock destruction.

There is another subordinate category of processes which are intimately allied to the second great category, viz: *glaciation*. Only two clearly defined periods of extensive glaciation (both late Tertiary or Quaternary) have been recognized, though others have been suggested; in general the tendency is to obliterate surface irregularity both by grinding down elevations and filling up depressions, and thus to perfect the geoid; but glaciation may also accentuate pre-existing irregularities of surface, certainly by moraine-building and probably by basin-cutting, and must therefore be set apart as a unique agency in the modification of the external configuration of the globe. The general process comprises *glacial construction* and *glacial destruction*.

The fourth subordinate category includes the effects of aerial circulation directly upon the land and indirectly through wave and current action. The processes have been in operation throughout geologic time, but so indolently that little traces of their products are found save on the present surface; in general the tendency is to reduce elevations and fill depressions, and thus to merge into gradation; but there is also a tendency to build dunes, beaches and banks, and thus to produce certain minor irregularities of the earth's surface as well as to perpetuate others. The general process may be called *eolation*; and its subordinate processes are, like those of the other categories, antagonistic.

There is a final category which is in part allied to alteration, but is in part unique, viz: the chemic, mechanical and dynamic action of organic life. Ever since the terrestrial crust became so stable as to retain a definite record of the successive stages of world-growth, life has existed, and by its traces has furnished the accepted geologic chronology; at first the organisms were simple and lowly and affected the rocks chemically through the processes of growth and decay as do the lower plants and animals of the present; later, certain organisms came also to contribute largely of their own bodily substance to the growing strata; and still later the highest organisms, with man at their head, have come to interfere with gradation, alteration and eolation by dynamic action, and thus directly or indirectly to modify the various inter-related geologic processes—indeed it is probable that in populous plains, at least, the several natural processes combined are less potent factors in geologic development than human action alone. The vital forces are too varied in action to be conveniently grouped and comprehensively named.

This simple classification of processes appears to traverse the entire domain of geologic science, whether empiric or philosophic, and sets forth the various parts in true relation. It is summarized in the accompanying table.

CLASSIFICATION OF GEOLOGIC PROCESSES.

Principal Categories.	1. Deformation,	Elevation. Depression.
	2. Gradation,	Deposition. Degradation.
Subordinate Categories.	1. Extravasation,	Efflux. Collapse.
	2. Alteration,	Lithifaction. Delithifaction.
	3. Glaciation.	Glacial construction. Glacial destruction.
	4. Eolation,	Eolic construction. Eolic destruction.
	5. Vital action.	Various constructive and destructive processes.

It is interesting to note in passing that the first subordinate category is intimately connected with the first principal category of movements, and that both tend to produce departures from the simple geoidal form, or *heteromorphism.* Play is thus given to the operations of the second principal and the last four subordinate categories, which are also intimately related and combined and tend to produce *heterogeneity* in the external shell of the earth. The joint result is *differentiation* of the earth's exterior—the antithesis of those processes of *concentration* and *segregation* by which the planet was originally formed. The passage from the stage of segregation to that of differentiation represents the senescence of the planet; these stages define the provinces of the astronomer and geologist respectively; and the latter defines in like manner that portion of the field of knowledge within which the inductive method of reasoning is alone applicable, by reason of the ever increasing complexity of the phenomena.

The domain of geology being thus outlined, it remains to indicate those fields which have been well covered by investigation and those which yet remain untrodden; and the first principal category, which defines the least-known field, may be passed for the present.

Geology found birth with the study of the sedimentary rocks and their contained fossils; the extravasated rocks soon after received attention, and at a comparatively early period the metamorphic strata and other rocks produced by the alteration of sediments and extravasated materials, etc., came under investigation; and so the lines of pioneer research were directed toward the genetic classification of rocks. Great progress has been made along these lines, and most of the rocks of the explored earth have been classified with a greater or less degree of refinement. The sedimentary strata are generally classified either by their own sequence or by the degree of biotic development of their contained fossils, or chronologically; some of the extravasated rocks and many of those produced by alteration are simply classified by their extrinsic characters, or petrographically; while certain other rocks of both kinds are classified by their constituents, or mineralogically. The clastic rocks—the products of deposition—especially have received careful scrutiny; out of their study has grown the greater part of geologic literature; surveys and commissions have been endowed for the purpose of investigating them; national and international conventions have been established to discuss them; and their relation to the arts and to the welfare of the race have been pointed out repeatedly. This field of geology has been carefully covered; and though its economic importance is such that it cannot be abandoned and must even be tilled more deeply than ever as the years go on, it may be questioned whether it is not exhausted to comparative barrenness unless new and more fruitful methods are devised.

The phenomena of degradation were brought into prominence by Lyell, and have ever since maintained an important place in geologic literature. Within the last decade, however, a novel and important cognate idea has been developed: it is now perceived that the processes of degradation are governed by definite laws and leave a legible record of their operation in the configuration of the surfaces upon which they have acted, and consequently that geologic history can be interpreted from the hills produced by degradation as well as from the strata produced by deposition in contiguous areas. This discovery, simple as it seems, marks an era in the progress of geologic science, if not indeed the birth of a new science. Already the subject of "geomorphology" as it is called by the director of the national geologic survey, or "systematic geography," as the physical geographer of Harvard proposes to term it, has attracted much attention among the foremost students of this country, and nearly as much abroad. Thus this field, although long worked, is to-day one of the most promising in the entire domain of geology.

Those phenomena of extravasation which trench upon stratigraphy, petrography, and mineralogy have been carefully studied and their significance and formal relations set forth as clearly as present classifications permit; but while the still more interesting physical relations have long been under investigation in various parts of the earth by a score of vulcanologists, the great problems of vulcanism and seismism remain in large part unsolved. These problems cannot, however, be separated from those of deformation, and this field of research is thus narrowed, though it promises rich reward to profound workers.

By reason of the impetus given by early studies, petrography and mineralogy have been carried well forward, and great progress has been made in ascertaining the genesis and relations of the elements of the terrestrial crust. Various rocks and minerals have been discovered in nearly all portions of the earth, their relations to each other and to the arts have been comprehensively studied, and elaborate systems of classification have been devised for them; the ores have been tested and applied to the uses of man in all countries; and most of the mines of the world have been extensively exploited. Yet the progress in this field of rock formation has thus far been chiefly in the direction of differentiation and endless multiplication of details; and the need of the hour is for concentration and for the development of a philosophic idea by which the complex subject may be simplified as the even more complex subject of biology was simplified by the idea of natural selection. This field of geology is promising both to the daily drudge who digs for base metal and to the inspired searcher who delves more deeply for the golden grains of knowledge.

It is remarkable that the class of geologic processes and agencies most intimately related to the leading industry of the world, and even with all the higher forms of life upon the globe, i. e., the decomposition of rocks, the formation of subsoils and soils, etc., should have received so little attention. The entire field of agricultural geology remains practically untrodden, and no man dreams whither its unexplored paths may lead.

Although the glacial deposits of the world, and particularly those of America, have been elaborately studied, and although this study has contributed more than one important chapter to the history of the earth's development, the field remains fertile and yields rich returns for labor expended upon it. But little is yet known of the destructive action of ice; for the glacial mill is veiled from curious eyes, save perhaps its outer portals, and the areas of greatest grinding are unexplored or inaccessible; the fact that the question as to the glacial excavation of the Great Lakes is still mooted and so far from settlement that no conservative geologist speaks upon it with confidence, well illustrates the paucity of knowledge concerning the primary process of glaciation; and so this field is one of the most promising within the domain of the science to the intrepid explorer. Equally promising however, is the general field of inquiry concerning the causes and conditions of glacial climate, where the physicist and astronomer meet the geologist on common ground, and where more than one sturdy pioneer has already gone down beneath the gloom of uncertainty into the treacherous morass of ill-founded speculation.

The direct action of the winds has never been an important process in geology, save, perhaps, in limited areas, and the subject promises little to the investigator; the indirect action of the winds through the waves and currents of inland seas has just been studied by American geologists so exhaustively as apparently to leave little for their successors in this field; but the indirect effects of aerial circulation upon geologic phenomena produced through climate, oceanic currents, etc., affords a fit field for further study.

Science never lifted the veil of the unknown upon more enchanting vision than when she vivified the fossils entombed in the rocks and thus opened a vivid panorama of the earth's life stages, stretching from the present back through unreckoned ages to the infancy of the organic world; and though paleontology has revolutionized cosmology within two generations, its field is fertile as ever and responds abundantly to intelligent cultivation. The influence of physical environment upon the organism has been carefully examined, and an essential factor in the development of life has thereby been brought to light; but, although the coals, limestones, hydrocarbons, etc., have been separately studied, the general reciprocal influence of the organism upon the physical environment, and thus upon the general process of differentiation of the external shell of the earth, has never been comprehensively investigated. This will eventually prove one of the most fruitful fields of geologic research.

Recurring now to the first principal category of processes, viz., deformation, the most interesting and one of the most extensive of the partially explored fields of geologic research is found. The structure of mountains has long been attentively regarded, and many profound speculations concerning their origin have been indulged in; and the origin of continents and ocean basins has been considered by every student of the general geologic history of the globe. Here the domain of the physicist and astronomer on the one hand and that of the geologist on the other, overlap; and the ablest minds of the generation have sought to solve the problems presented by the phenomena. Here the physicist contributes principles and makes deductions of great suggestiveness and often of high value to the geologist; and here the geologist is an agnostic, assails the deductions of the physicist, and, too frequently for the good repute of physical science as applied to geologic research, breaks them down. But the geologist is equally an agnostic with respect to his own conclusions of higher rank than mere generalizations; and he assails every inference of his fellows, and unless he be rash indeed, guards his own course at every step and feels his way cautiously through the tangled maze of ambiguous testimony recorded in the crumpled strata of the mountains. Yet substantial progress is made during each decade in the subjugation of this refractory territory.

Within about a decade an inference of the highest moment has been made by American geologists concerning diastatic movement, viz: that certain orogenic movements are consequent upon gradational transfer of matter; that the earth is in a condition of isostacy, and that as the rains bear detritus from the mountains into the seas, the unloaded mountains rise and the loaded sea bottoms sink; and thus that a part of the deformation of the outer shell of the earth is consequent upon the processes of gradation. At first blush it might appear that the great problem of earth movement is solved by this discovery; but consideration shows that these consequent diastatic movements are but the indirect result of antecedent diastatic movements for which no adequate cause has yet been assigned. It is evident that if diastatic movement were dependent solely upon transfer of sediments it would progressively diminish with lapse of time, that the mechanism of mountain building and continent growth would soon be clogged by increasing friction, and that the terrestrial surface would be quickly graded so completely that further movement would cease; but the rocks record diastatic activity throughout geologic time, now increasing, now diminishing, but on the average probably increasing rather than diminishing, and perhaps as potent to-day as during any past time. So deformation is separable into two classes of movements, that depending upon transfer of sediments, which may be designated *consequent*; and that for which cause has not yet been assigned (unless the "contraction" theory be accepted), which may be called *antecedent*. Discriminated upon a different basis they fall into two classes approximately but not exactly coinciding with these, namely, *orogenic*, or mountain making movements, and *epeirogenic*,* or continent building movements.

The first of these classes of diastatic movement may be set aside as at least partially explained, though many details remain to be elaborated; and this part of the field is yet promising to the student. But it is the remaining portion of the field of geology defined by deformation which, above all others, appears to afford promise for the future, and especially to the systematic student who seeks to dig deeper than his fellows;

*A term proposed by Gilbert.

and here the most profound of the remaining mysteries of geology is found.

II.

It is only within a decade that diastatic movements of the consequent class have been separated from the primary class; even yet there are geologists who do not recognize the distinction; and so most of the hypotheses thus far framed to explain the deformation of the terrestrial shell rest on the implicit or explicit assumption that all diastatic movements belong to the class here called antecedent.

The primitive hypothesis ascribed the corrugations of the terrestrial crust to more rapid contraction of the interior of the earth than the exterior shell, accompanying secular cooling. The common conception as to the mechanism of this process was familiarly illustrated by likening the corrugated globe to a withered apple—the inequalities of the terrestrial surface corresponding to the wrinkles on the apple's skin; and to the surprise of a majority of geologists this hypothesis has been prominently advocated within a year or two. It appears, however, quite untenable: Fisher and others have shown that the postulated cause is far from commensurate with the observed effect—that even upon the most liberal estimates of radial contraction due to secular cooling, the concomitant tangential contraction would not produce a tithe of the observed corrugation of the terrestrial crust; Dutton maintains that equitable contraction of a spheroidal segment would not produce corrugations such as those characterizing the earth's skin; Taylor, Alexander Winchell and others have pointed out that any corrugations resulting from secular contraction of the terrestrial crust in combination with stresses resulting from precession, nutation, retardation of axial rotation, etc., would tend to assume certain definite directions, and that these directions do not coincide with those of the mountain ranges actually existing nearly enough to give countenance to the hypothesis; Reade and others have recently discovered that tangential contraction due to secular cooling must have been confined to a limited shell (even thinner than the strata actually known to be corrugated); and it might be shown that the concentration of montanic corrugation along certain lines, leaving vast intervening areas quite undisturbed, does not agree with the hypothesis and could not occur in accordance with it under any conditions of rigidity and internal friction of the rocks which it is reasonable to assume—the arches are too long and rest too heavily upon the terrestrial nucleus to convey crushing strains to their extremities without greater compression about their keystones. The "contraction hypothesis" must therefore be rejected, at least as a quantitatively adequate cause of terrestrial deformation.

There is an alternative hypothesis. A dozen geologists have shown that lines of mountain growth commonly coincide with zones of rapid deposition during former times, and that in these zones the deposition was accompanied by depression (thus foreshadowing the later conception of consequent diastatic movement); they have shown further that in consequence of the combined sinking and thickening of the crust the surfaces of equal temperature within the earth—the isogeotherms—unquestionably rose through the sediments until strata formed at the temperature of the sea bottom were heated to hypogeal temperatures; and they inferred that the consequent expansion of the sediments developed stresses whereby further heat was generated, and that the rocks were thus corrugated, flexed and sometimes metamorphosed. This hypothesis has had currency for a generation. It has been commonly questioned, however, whether the assumed cause is commensurate with the observed effect, whether the expansion of sedimentary beds by local rise of isogeotherms from time to time and from place to place is sufficient to explain the extensive and profound corrugation observed in the mountains of the earth, the shortening of the Alpine arc by 120,000 metres as measured by Heim, and the shortening of the Appalachian arc by 60 miles as estimated by Claypole. Quite recently, however, Reade has pointed out what the early advocates of the hypothesis had overlooked, viz: that since the strata are confined in two directions, any expansion due to rise of temperature must take place all in one direction, and that a given rise of temperature would produce thrice the elevation and perhaps thrice the corrugation inferred by the older geologists; and the hypothesis has thus been rendered more acceptable.

Singularly, Reade and all of his predecessors, save J. Herschel, practically neglect the most important factor in the series of movements contemplated in the hypothesis; and even Herschel's case is hardly the general one: lines of sedimentation are the margins of continents; in each case the sediments are laid down not upon a horizontal surface but upon a seawardly sloping bottom; moreover the sediments do not form a horizontal surface, but take a certain seaward slope determined by bottom slope, marine currents, wave action, etc. Thus the mass of sediments is collectively in the condition of the mass of snow upon a roof or upon a mountain side, i. e., in a condition of potential instability or *inequipotentiality*. If the mass is stable in either case, it is because the friction among the particles exceeds the attraction of gravitation upon the particles; and it is obvious that if particle friction were reduced by augmentation of temperature or by alteration of constitution, or if the efficiency of gravitation were increased by addition to the mass. the point of stability might be passed, when the mass would move in the direction of slope. It is equally obvious that if an inequipotential mass expand, the resulting movement will not take place equally in all directions but in the direction of least resistance, which is that of the slope. Now every deposit of sediments fringing the continents is in a condition of inequipotentiality, and any movement due to rise of isogeotherms must take place in a single direction; and the movement will not be limited to that due to expansion, since other factors co-operate. But under the classification tabulated above, any such movements fall into the consequent class, and hence the hypothesis utterly fails as an explanation of the obscure antecedent deformation by which active geologic processes were initiated early in the history of the earth, and by which these processes have ever since been maintained. It cannot be too strongly emphasized that without continents zones of deposition could not be formed, and that continents could not have come into being without antecedent deformation. The case is simple. Either (1) the primeval earth was highly rugose and gradation and consequent deformation have always been employed in reducing the rugosity, or else (2) a general deforming force of unknown value has always been in operation—either the earth is a clock once wound up and ever since running down, or else it is a prime motor whose mechanism may be obscure but whose energy is ever renewed within itself. To the working geologist, constrained by the inexorable logic of facts, there is but one choice between these alternatives—the primeval earth was less rugose than the present, and diastatic movement has not declined with the ages; and the grander earth movements are in progress to-day and apparently as active as at any time in the past.

Thus it appears (1) that while the problem of consequent diastatic movement has been at least partially solved, no attempt has been made to explain antecedent deformation except by the untenable "contraction hypothesis;" and (2) that the antecedent movements are now and ever have been important factors in developing continents and mountains and initiating the various geologic processes whose products represent the material phenomena of the terrestrial crust. The source of these mysterious movements may be sought; and to this end the quagmire of speculation must be skirted.

Pratt and others have shown that a plumb-line suspended over the sea-shore is generally deflected seaward, despite the less density of water than land, thus indicating much greater density of the submarine portion of the earth than of its subaerial portion; and Fisher and others have shown that when the plumb-line is suspended at the base of a mountain range it may be deflected away from it despite the great density of the superficial mountain rocks, proving the mean density of the mountain range to be less than that of the adjacent plain. The discovery of this relation and the American induction of consequent deformation led to the development of Dutton's doctrine of isostacy, according to which the entire terrestrial shell is in a state of hydrostatic equilibrium—the continents floating higher than the sea bottoms because lighter, and the mountain ranges overlooking the adjacent plains, like icebergs the ocean, because their roots are less dense than the medium they penetrate.

A qualitatively adequate cause for the relation is not far to seek, and has indeed been suggested by Faye: Deep sea soundings have shown that the deeper waters of the ocean are cold, the mean temperature of the ocean bottom being much lower than that of the surface either of water or land. Now, water is a good conductor and also a ready conveyor of heat; and it is evident that the ocean bottoms are subjected to more rapid refrigeration than the land, that the terrestrial shell is chilled to the greater depth beneath the sea, and that the cooler suboceanic rocks are, *ceteris paribus*, denser than those forming the continents. And this explanation of the observed inequality in density of the earth's shell is at the same time an explanation of antecedent deformation; for it is evident that with the progress of secular refrigeration there is a constant tendency to depress and condense the ocean floor and to relatively uplift and lighten the continents.

It is true that the existing difference in temperature appears inadequate alone to explain either the difference in density or the inequality in altitude between ocean bottom and land surface, and that the difference in rate of secular cooling similarly appears inadequate alone to explain the aggregate of epeirogenic movement; and herein lies the supposed weakness of Faye's hypothesis. Be it noted, however, that the cause has not only been in operation throughout geologic time, but has produced cumulative and thereby greatly multiplied effects. The direct and indirect consequences of an initial inequality in temperature of the earth's crust are complex and far-reaching, though none the less obvious. If a slight irregularity in a shoal sea bottom, sufficient to deepen the waters on the one hand and expose the rocks on the other hand, be given, it is evident (1) that the sea bottom will be chilled and the exposed rocks warmed, producing (2) contractional shortening of the sea bottom radius and deepening of the basin, together with expansional elongation of the land radius and elevation of the nascent land, and at the same time (3) condensation of the sea bottom strata and lightening of the land strata accompanied by further sinking of the former and rise of the latter in isostatic adjustment. It is equally evident that these movements will be followed by (4) desiccation, oxidation, disintegration, and relief from pressure, and thus further lightening, of the land strata; and eventually by (5) erosion of the exposed rocks and deposition of their detritus in less compact condition about the land periphery, thereby farther diminishing the mean density of the growing land, and consequently (6) still further elevation of the land and relative depression of the sea basin. It is evident also (7) that each of these consequent movements must co-operate with the initial one in deforming the earth's shell, (8) that each additional deformation must (within certain distant limits) increase the difference in rate of refrigeration both directly and through differentiation and consequent levitation of the nascent land, to be followed in turn by (9) renewed deformation. Whether these cumulative tendencies are quantitavely adequate to produce the observed difference in density and altitude of ocean basins and continents and the sum of the antecedent deformation of the earth cannot be determined at least until the researches of Woodward upon the rates and effects of secular of cooling of the earth have borne fruit; but certainly there is here a veritable, and as viewed from the standpoint of the geologist apparently a sufficient cause of antecedent diastatic movement.

If the cause be adequate, world-history becomes simple and intelligible. While yet the planet was young and its surface approximately homomorphic and homogeneous, slight warping of the primeval surface occurred, and low islands emerged, either synchronously or independently, to form the continental nuclei; for under the hypothesis this slight initial cause sufficed to set the entire process of earth-differentiation in operation. The sun beat upon the low islands and checked the chilling of the rocks, which thus rose higher and higher, while the neighboring seas grew deeper and deeper; anon the rain fell upon the rocks, triturated them, and carried their debris to the perimeters of the infant continents which they absolutely depressed though always less than their own thickness by reason of their relative lightness, and as the sediment-choked sea shoaled, the continents grew; then the isogeotherms rose under the continental margins, and the sediments were still further lifted by consequent deformation; with the heating from below the strata expanded laterally as well as horizontally, and so slipped seaward on the sloping bottoms and crumpled their perimeters which thus rose still further above sea level and formed mountain ranges overlooking the sea on the one hand and the original continental nuclei on the other; and thus the continents expanded and the derived rocks being ever lighter than the original, they have maintained approximately their original positions, while the continent-building movement has never ceased to operate. With increase in area, the continents were separated into tracts within which the geologic processes varied in activity, some of the nuclei merged and the land masses became asymmetric; some were temporarily submerged, and others may have become lost; the shores were shifted through long distances with the successive oscillations of the growing land; and as the land area increased, isostatic stresses were developed which affected the entire globe and perhaps gave birth to new continents or brought death to old. At the same time great mountain ranges were upheaved and great valleys excavated, particularly about the continental margin, and consequent diastatic movement supervened; in the interior of the continents the primitive rocks were slowly degraded, modified in density and conductivity, and here, too, consequent deformation progressed; and various subordinate movements occurred, which need not be considered here. But in general the continents grew peripherally, their margins were the zones of activity while their centers were more stable, and the general process was one of differentiation and levitation; while the ocean floor simultaneously shrunk and sank, the general tendency was toward condensation and conservation of the primitive terrestrial shell.

The details of world growth cannot be set forth in a page. It is enough to here portray, in few and simple lines, a hypothetic conception of the general process, chiefly to show that while the unequal cooling of land and sea bottom may be altogether inadequate to produce directly the grand inequalities of the earth's surface, the cause has operated cumulatively and in conjunction with the most potent agencies of geology throughout the whole of geologic time, and may be amply adequate to produce indirectly the obscure antecedent stresses (for which adequate cause has not hitherto been assigned) by which the terrestrial motor has ever been kept in motion and to initiate the consequent movements by which the mountains and the lesser valleys have been developed. Thus may a mite be contributed toward the elucidation of the great remaining mystery of geology.

June 11, 1888.

[*Paper Z.*]

A CHECK-LIST OF THE PALAEOZOIC FOSSILS OF WISCONSIN, MINNESOTA, IOWA, DAKOTA AND NEBRASKA.—*Bruno Bierbauer.*

It is the object of the following list to enumerate as far as possible all the described fossils of the Palaeozoic formations of Minnesota, Wisconsin, Iowa, Nebraska and the Dakotas. In none of the states named, with the exception of Wisconsin, has a complete list been made of the known fossils within its borders. The descriptions of the forms enumerated in this list are scattered through the publications of various scientific societies throughout the world, the reports of many scientific surveys, home and foreign periodicals, etc., so the work of collating was a very tedious one. In the preparation of the list the compiler received valuable aid from Messrs. E. O. Ulrich, Charles R. Keyes, W. H. Scofield and Professor C. W. Hall, and to the first named of these gentlemen are especial thanks due for access to manuscript lists and compilations not elsewhere obtainable.

In the classification it will be seen that no one authority has been followed. The general outline is that of Nicholson and Lyddeker; special groups are arranged according to the plan of some one especially eminent in their study. The Crinoidea are classed closely after Wachsmuth and Springer's revision, the Blastoidea after Etheridge and Carpenter, the Cystids after Zittel, and the Bryozoa after Ulrich. The list is designed to be what it is named, *a check-list.*

ABBREVIATIONS:—NAMES OF AUTHORS.

(These are used only when abbreviations are necessary.)

Barr	Barrande
Bill	Billings
v. B	von Buch
Con	Conrad
Con. & Ph	Conybeare & Phillips
Dal	Dalman
D'Arch	D'Archiac
D'Orb	D'Orbigny
Ed. & H	Edwards & Haime
Eichw	Eichwald
Fisch	Fischer
Gein	Geinitz
Goldf	Goldfuss
Guett	Guettard
H	Hall
H. & Whitf	Hall & Whitfield
K	Keyes
Keys	Keyserling
Kg	King
Lam	Lamarck
Linn	Linne or Linnaeus
McC	McCoy
McCh	McChesney
Mart	Martin
M. & Hay	Meek & Hayden
M. & Wn	Meek & Worthen
Mich	Michel n
Montf	Montfort
Mort	Morton
Mun	Munster
Murch	Murchison
Newb. & Wn	Newberry & Worthen
Nich	Nicholson
Nich. & Hs	Nicholson & Hinds
Nor. & Prat	Norwood & Pratten
Ow. & Shum	Owen & Shumard
Ph. or Phill	Phillips
Portl	Portlock
Roem	Roemer
Rom	Rominger
Sal	Salber
v. Sch	von Schauroth
Schl	Schlotheim
Shum	Shumard
Sow	Sowerby
Swal	Swallow
S. & Hay	Swallow & Hayden
Ul	Ulrich
Vanux	Vanuxem
de Vern	de Verneuil
Wachs	Wachsmuth
Wachs.& Spr.	Wachsmuth & Springer
Wahl	Wahlenberg
Whitf	Whitfield
Wh. & St. J	White & St. John
Wh. & Whitf	White & Whitfield
Win	Winchell, A.
Win., N. H	Winchell, N. H.
Yar. & Shum	Yardell & Shumard

NAMES OF GEOLOGICAL FORMATIONS IN DESCENDING ORDER.

Perm. or Pe	Permian or Dyas
Carb or Ca	Carboniferous
Coal or Cl	Coal Measures
U. Cl	Upper Coal Measures
M. Cl	Middle Coal Measures
L. Cl	Lower Coal Measures
Kask or Ka	Kaskaskia
Ches. or Ch	Chester
War. or W	Warsaw
St L. or S	St. Louis
Keok. or Ke	Keokuk
Burl. or B.	Burlington
Kind. or Ki	Kinderhook
Dev. or D	Devonian
Chem. or Cg	Chemung
Ham. or Ha	Hamilton
U. Hl	Upper Helderburg
L Hl	Lower Helderburg
Niag. or N	Niagara
Guel. or Gu	Guelph
H. R. or H	Hudson River
Gal. or Ga	Galena
Tr. or T	Trenton
L. Mag. or L	Lower Magnesian
P	Potsdam

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.*
SUBKINGDOM PROTOZOA.					
Fusilina cylindrica Fischer............	......	......	Coal	Carb.	......
" depressus Fischer............	......	......	......	Carb.	......
SUBKINGDOM PORIFERA.					
Anthaspidella sp. undet.................	Tr.	......	......	......	......
Astraeospongia hamiltonensis M. & Wn.	......	......	Ham.	......	......
Astylospongia sp. undet...............	T. Ga.	Niag	......	......	......
Camarocladia sp. undet..........	......	T. Ga.	......	......	......
Cerronites dactyoloides Owen.	......	......	Niag.	......	......
Cylindricoelia minnesotensis Ulrich.....	......	Tr.	......	......	......
Heterospongia subramosa Ulrich........	......	H. R.	......	......	......
Hindia parva Ulrich......	......	Tr.	......	......	......
" spheroidalis Duncan............	......	Niag.	......	......	......
Hyalostelia solidaga Ulrich............	......	H. N.	......	......	......
Rauffella filosa Ulrich	......	Tr.	......	......	......
" palmipes Ulrich.	......	Tr.	......	......	......
†Receptaculites globularis Hall........	Gal.	......	......	......	......
" hemisphaericus Hall....	Niag.	......	......	......	......
" infundibuliformis Hall..	Niag.	......	......	......	......
" iowensis Owen.........	Gal.	H. R.	H. R.	......	......
" occidentalis Salter......	......	H. R.	......	......	......
" oweni Hall.............	Gal.	Ham.	Tr.	......	......
" reticulata Owen........	......	......	Niag.	......	......
Zittrella sp. undet	Tr.	......	......	......	......
SUBKINGDOM COELENTERATA.					
Class Hydrozoa.					
Bythograptus laxus Hall...............	Tr.	......	......	......	......
Cannapora planulata Hall	......	......	Chem.	......	......
Climacograptus typicalis Hall..........	Gal.	......	......	......	......
" sp. undet	Ga. H.	......	......	......	......
Dendrograptus hallanus Prout	P.	......	......	......	......
Dictyonema neenah Hall	Tr.	......	......	......	......
Diplograptus peosta Hall.......	Tr.	......	......	......	......
Graptolitic bodies sp. & gen. undet	H. Ga.	......	......	......	......
‡Lamellopora infundibularia Owen.....	......	......	Niag.	......	......
Oldhamia sp. undet....................	Tr.	......	......	......	......
Stromatopora concentrica Goldfuss......	......	......	Niag.	......	......
" expansa Hall & Whitfield..	......	......	Ham.	......	......
" incrustans Hall & Whitfield	......	......	Ham.	......	......
" solidula Hall & Whitfield..	......	......	Ham.	......	......
Class Actinozoa.					
GROUP ZOANTHARIA.					
Acervularia inequalis Hall.............	......	......	Chem.	......	......
Alveolites irregularis Whitfield.........	H. R.	......	......	......	......

*This list, prepared before the territory of Dakota had been divided into South Dakota and North Dakota, represents the Palaeozoic of both the states.

†Rauff (in Zeisschr. d. Deutschen Geol. Gesellchaft XL) regards the systemic position of this group still entirely unsettled.

‡This genus is either synonymous with Stromatopora or very closely allied.—*S. A. Miller.*

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Alveolites rockfordensis Hall & Whitfield			Chem.		
" sp. undet	H. R.				
Amplexus annulatus Whitfield	Guel.				
" fenestratus Whitfield	Niag.				
" fragilis White & St. John			Keok.		
" shumardi Edwards & Haime	Niag.				
" sp. undet	N. Gu.				
*Anthophyllum expansum Owen			Niag.		
*Astrala ananas Owen			U.Hl.		
†Astrocerium constrictum Hall	Niag				
† " venustum Hall	N. Gu				
Aulacophyllum sp. undet	Niag.				
Axophyllum rude White & St. John			U.Cl.		
‡Calceola sp. undet	Tr.				
Campophyllum nanum Hall & Whitfield			Chem.		
" torquium Owen			Carb.	Carb.	
Chonophyllum ellipticum H. & Whitf			Chem.		
" magnificum Billings	Guel.				
" niagarense Hall	Niag.				
" sp. undet	N. Gu.				
Cladopora dichotoma Hall	U.Hl.				
" magna Hall & Whitfield	U.Hl.				
" palmata Hall	U.Hl.				
" prolifica Hall	U.Hl.				
" reticulata Hall	Niag.				
" " with finer cells	Niag.				
" robusta Rominger			U.Hl.Ha.		
" sp. undet	Guel.				
Coenites lunatus Nicholson & Hinds	Niag.				
Columnaria alveolata Goldfuss	Tr.				
" sp. undet	Tr.				
Cyathophyllum calyculare Owen			Niag.		
" corinthium Owen			Niag.		
" dianthus Goldfuss			U.Hl.		
" fungites Owen & Shumard			L. Cl.		
" undulatum et multiplicatum Ow.			Niag.		
§Cyathaxonia cornu Michelin				Perm.	
" profunda Ed. & H.				Carb.	
" prolifera McChesney			Coal		
" wisconsensis Whitfield	Niag.				
Cystiphyllum mundulum Hall			Chem.		
" niagarense Hall	Niag.				
" vesiculosum Goldfuss			Chem.		
" " var (?)	Guel.				
Cystostylus infundibulus Whitfield	Niag.				
" typicus Whitfield	Niag.				
Diphiphyllum caespitosum Hall	N. Gu.				
" sp. undet	Guel.				
Eridophyllum sp. undet	Niag.				
Favosites favosus Goldfuss	Niag.	Drift			
" gothlandicus Lamarck	Niag.				

*Not a Palaeozoic genus.—*Miller.*
†See Favosites.—*Miller.*
‡Not likely to occur in Lower Silurian deposits.—*Ulrich.*
§Not American.—*Ulrich.*

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa.	Neb.	Dak.
Favosites gothlandicus var basalticus Goldfuss	......	......	Niag.	......	......
" niagarensis Hall	N. Gu.	......	......	......	......
" occidens Whitfield	Guel.	......	......	......	......
* " spongilla Rominger	......	......	Niag.	......	......
" sp. undet	Tr. N.	......	......	......	......
Heliophyllum halli Edwards & Haime	......	Drift.	Niag.	......	......
Lithostrotion mammillare Ed. & H.	......	......	St. L.	......	......
" proliferum Hall	......	......	St. L.	......	......
" subcylindriformis Owen	......	......	Coal	......	......
†Lopophyllum calceolum M & Worth	......	......	Chem.	......	......
" proliferum McChesney	......	......	Coal	......	......
Omphyma stokesi Edwards & Haime	Niag.	......	......	......	......
Phillipsastrea gigas Owen	......	......	Ham.	......	......
" johanna Hall & Whitfield	......	......	Chem.	......	......
‡ " mammillaris Owen	......	......	Ham.	......	......
" multiradiata Hall	......	......	Chem.	......	......
Rhombopora lepidodendroides Meek	......	......	L.Cl.	......	......
§Sarcinula (porites?) glabra Owen	......	......	Ham.	......	......
Streptelasma calyculus Hall	Niag.	......	......	......	......
" corniculum Hall	T. Ga.	Tr.	......	......	......
" multilamellosum Hall	Gal.	......	......	......	......
" profundum Conrad	Tr.	......	......	......	......
" sp. undet	H T Ga N	......	......	......	......
Striatopora carbonaria White	......	......	Burl.	......	......
" iowensis Owen	......	......	Ham.	......	......
" rugosa Hall	......	......	Ham.	......	......
Strombodes (=Arachusphyllum) mammillaris Owen	......	......	Ham.	......	......
Strombodes pentagonus Goldfuss	N. Gu.	......	Niag.	Carb.	......
" sp. undet	Niag.	......	......	......	......
Syringopora compacta Billings	Niag.	......	......	......	......
" dalmani Billings	Niag.	......	......	......	......
" harveyi White	......	......	B. Ki.	......	......
" multattenuata McChesney	......	......	......	Carb.	......
" rectiformis Billings	Niag.	......	......	......	......
" reticulata Goldfuss	......	......	Dev.	......	......
" verticillata Goldfuss	Niag.	......	......	......	......
Thecia major Rominger	Niag.	......	......	......	......
" minor Rominger	Niag.	......	......	......	......
Zaphrentis acutus White & Whitfield	......	......	Chem.	......	......
" calceola White & Whitfield	......	......	Chem.	......	......
" elliptica White	......	......	Burl.	......	......
" gigantea Le Sueur	U.Hl.	......	......	......	......
" glans White	......	......	Burl.	......	......
" racinensis Whitfield	Niag.	......	......	......	......
" rustica Billings	......	H. R.	......	......	......
" solida Hall	......	......	Chem.	......	......
" turbinata Hall	Niag.	......	......	......	......
" sp. undet	T Ga Gu N	......	......	......	......

*Syn. for F. spinigerus Hall, 28th N. Y. Report.
†See Zaphrentis calceola White & Whitfield.
‡See Strombodes mammillaris Owen.
§Not an American Palaeozoic genus.—*Miller.*

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
GROUP ALCYONARIA.					
Aulopora arachnoidea Hall.............	......	......	Ham.	......	......
" iowensis Hall & Whitfield.....	......	......	Chem.	......	......
" saxivadua Hall & Whitfield...	......	......	Chem.	......	......
" serpens Goldfuss..............	......	......	Chem.	......	......
Chaetetes (vide Polyzoa).					
Halysites agglomeratus Hall............	Niag.	......	......	......	......
" catenulatus Linn..............	N. Gu.	......	......	......	......
" " var labyrinthicus Goldf.	N. Gu.	......	......	......	......
" micropora Whitfield...........	N. Gu.	......	......	......	......
Heliolites macrostylus Hall.............	Niag.	......	......	......	......
" pyriformis Gnettard..........	Niag.	......	......	......	.....
" spiniporus Hall..............	Niag.	......	......	......	......
SUBKINGDOM ECHINODERMATA.					
Class Echinoidea.					
Archaeocidaris agassizi Hall............	......	......	Burl.	......	......
" edgarensis Worthen & Miller	......	......	L.Cl.	......	......
" triserratus Meek.........	......	......	......	Carb.	......
Echinocystites nodosus Hall.............	Niag.	......	......	......	......
Eocidaris hallianus Geinitz.............	......	......	......	Perm.	......
" rossicus von Buch............	......	......	......	Carb.	......
" (?) squamosus M. & Wn	......	......	Burl.	......	......
Palaechinus burlingtonensis M. & Wn...	......	......	Burl.	......	......
" gracilis Meek & Worthen...	......	......	Burl.	......	......
Class Asteroidea.					
Palaeaster sp. nov. Ulrich...............	......	Tr	......	......	......
" " " "	......	Tr.	......	......	......
Schoenaster wachsmuthi M. & Wn......	......	......	Kind.	.....	......
Class Crinoidea.					
[*Palaeocrinoidea—Wachsmuth & Springer*]					
Actinocrinus asperrimus M. & Wn......	......	......	Burl.	......	......
" brontes Hall...............	......	.....	Keok.	......	......
" clarus Hall................	......	......	Burl.	......	......
" coelatus Hall..............	......	......	Burl.	......	......
" ectypus Meek & Worthen..	......	......	Burl.	......	......
" excerptus Hall............	......	......	Burl.	......	......
" fosteri McChesney.........	......	......	Burl.	......	......
" glans Hall.................	......	......	Burl.	......	......
" hurdianus McChesney......	......	......	Burl.	......	......
" infrequens Hall...........	......	......	Burl.	......	......
" jugosus Hall..............	......	......	Keok.	......	......
" limabracheatus Hall	......	......	Burl.	......	......
" longus Meek & Worthen...	......	......	Burl.	......	......
" lowei Hall................	......	......	Keok.	......	......
" lucina Hall...............	......	......	Burl.	......	......

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Actinocrinus multibrachiatus Hall.......	......	......	Burl.	......	......
" multiradiatus Shumard.....	......	......	Burl.	......	......
" opusculus Hall............	......	......	Burl.	......	......
" ovatus Hall...............	......	......	Burl.	......	......
" penicillus Meek & Worthen	......	......	Burl.	......	......
" pernodosus Hall...........	......	......	Keok.	......	......
" proboscidialis Hall.........	......	......	Burl.	......	......
" reticulatus Hall.	......	.....	Burl.	......	......
" scitulus Meek & Worthen..	......	......	Burl.	......	......
" sexarmatus Hall...........	......	......	Burl.	......	......
" spinotentaculus Hall	......	......	Burl.	......	......
" tenuisculptus McChesney..	......	......	Burl.	......	......
" thalia Hall	......	......	Burl.	......	......
" unicarinatus Hall..........	......	......	B. Ke.	......	......
" verrucosus Hall...........	......	......	Burl.	......	......
Agaricocrinus americanus Roemer......	......	......	B. Ke.	......	......
" brevis Hall..............	......	.....	Burl.	......	......
" convexus Hall............	......	......	Burl.	......	......
" fiscellus Hall............	......	......	Burl.	......	......
" gracilis Meek & Worthen	......	......	Burl.	......	......
" inflatus Hall............	......	......	Burl.	......	......
" ornotrema Hall.........	......	......	Burl.	......	......
" pentagonus Hall..........	......	......	Burl.	......	......
" planoconvexus Hall......	......	......	Burl.	......	......
" pyramidatus Hall........	......	......	Burl.	......	......
" stellatus Hall...........	......	......	Burl.	......	......
" whitfieldi Hall...........	......	......	Keok.	......	......
" wortheni Hall...........	......	......	Keok.	......	......
Amphoracrinus divergens Hall.........	......	......	Burl.	......	......
" spinobrachiatus Hall ...	......	......	Burl.	......	......
Atelestocrinus delicatus Wachs. & Spr..	......	.....	Burl.	......	......
" robustus	......	......	Ke. B	......	......
Barycrenus bullatus Hall...............	......	......	Keok	......	......
" cornutus Owen & Shumard..	......	......	Burl.	......	......
" magister Hall	......	......	Keok.	......	......
" rhombiferus Ow. & Shum ..	......	......	Burl.	......	......
" sculptilis Hall	......	......	Burl.	......	......
" solidus Hall...............	......	......	Burl.	......	......
" spurius Hall...............	......	......	Keok.	......	......
" stellatus Hall..............	......	......	Keok.	......	......
" turmidus Hall.............	......	......	Keok.	......	......
" wachsmuthi M. & Wn......	......	......	Burl.	......	......
Batocrinus aequibrachiatus McChesney..	......	.....	Burl.	......	......
" equalis Hall................	......	......	Burl,	......	......
" andrewsianus McChesney....	......	......	Burl.	....	......
" biturbinatus Hall............	......	......	Keok.	......	......
" cassedayanus M. & Wn......	......	......	Burl.	......	......
" christyi Shumard............	......	......	Burl.	......	......
" clypeatus Hall.............	......	......	Burl.	......	......
" discoideus Hall.............	......	......	Burl.	......	......
" dodecadactylus M. & Wn....	......	......	Burl.	......	......
" hageri McChesney.	......	......	Burl.	......	......
" lagunculus Hall............	......	......	Ke.*	......	......
" laura Hall..................	......	......	Burl.	......	......

*Referred by S. A. Miller to the Warsaw group.

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Batocrinus lepidus Hall................	......	......	Burl.	......	......
" longirostris Hall............	......	......	Burl.	......	......
" lovei Wachsmuth & Spr.....	......	......	Burl.	......	......
" mundulus Hall..............	......	......	Ke.*	......	......
" nashvillae Troost	......	......	Keok.	......	......
" " var subtractus Wh.	......	......	Bu.†	......	......
" pistillus Meek & Worthen...	......	......	Burl.	......	......
" planodiscus Hall............	......	......	Ke B†	......	......
" pyriformis Shumard.........	......	......	Burl.	......	......
" quasillus Meek & Worthen..	......	......	Burl.	......	......
" rotundus Yardell & Shumard	......	......	Burl.	......	......
" similis Hall................	......	......	Keok.	......	......
" sinuosus Hall...............	......	......	Burl.	......	......
" steropes Hall...............	......	......	Keok.	......	......
" trochiscus Meek & Worthen.	......	......	Ke. B.	......	......
" turbinatus Hall............	......	......	Burl.	......	......
" " var elegans Hall..	......	......	Burl.	......	......
Belemnocrinus florifer Wachs. & Spr....	......	......	Burl.	......	......
" pourtalesi Wachs & Spr..	......	......	Burl.	......	......
" typus White............	.....	......	Burl.	......	......
" whitei Meek & Worthen	......	......	Burl.	......	......
Bursacrinus confirmatus White	......	......	Burl.	......	......
" wachsmuthi M. & Wn......	......	......	Kind.	......	......
Calceocrinus barrisi Worthen..........	......	......	Ham.	......	......
" tunicatus Hall............	Niag.	......	Keok.	......	......
" ventricosus Hall	......	......	Burl.	......	......
Catillocrinus wachsmuthi M. & Wn.....	......	......	Burl.	......	......
Ceriocrinus craigii Worthen............	......	......	Coal.	......	......
" hemisphericus Shumard.....	......	......	......	Carb.	......
" inflexus Geinitz............	......	......	......	Coal	......
Coelioc inus dilatatus Hall.............	......	......	Burl.	......	......
"r lyra Meek & Worthen.....	......	......	Burl.	......	......
" subspinosus White.........	......	......	Burl.	......	......
" ventricosus Hall..........	......	......	Burl.	......	......
Cyathocrinus barrisi Hall...............	......	......	Burl.	......	......
" barydactylus Wachs. & Spr.	......	......	Burl.	......	......
" cora Hall.................	Niag.	......	......	......	......
" enormis Meek & Worthen.	......	......	Burl.	......	......
" fragilis Meek & Worthen..	......	......	Burl.	......	......
" gilesi Wachs. & Spr.......	......	......	Burl.	......	......
" incipiens Hall............	......	......	Burl.	......	......
" iowensis Owen & Shumard	......	......	Burl.	......	......
" lamellosis White	......	......	Burl.	......	......
" marschallensis Worthen...	......	......	Kind.	......	......
" parvibrachistus Hall.......	......	......	Keok.	......	......
" rigidus White	......	......	Burl.	......	......
" rotundatus Hall...........	......	......	Burl.	......	......
" tenuidactylus M. & Wn...	......	......	Burl.	......	......
" waukoma Hall...........	Niag.	......	......	......	......
Decadocrinus fiscellus Meek & Worthen	......	......	Burl.	......	......
" halli Hall................	......	......	Burl.	......	......
" juvenis Meek & Worthen..	......	......	Burl.	......	......
" scalaris Meek & Worthen..	......	......	Burl	......	......

*Referred by S. A. Miller to the Keokuk group.
† " " " Warsaw group.

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Dichocrinus angustus White			Burl.		
“ conus Meek & Worthen			Burl.		
“ crassitestus White			Burl.		
“ lachrymosus Hall			Burl.		
“ larvis Hall			Burl.		
“ lineatus Meek & Worthen			Burl.		
“ liratus Hall			Burl.		
“ ovatus Owen & Shumard			Burl.		
“ pisum Meek & Worthen			Burl.		
“ plicatus Hall			Burl.		
“ pocillum Hall			Burl.		
“ scitulus Hall			Burl.		
“ striatus Owen & Shumard			Burl.		
Dorycrinus canoliculatus M. & Wn.			Burl.		
“ concavus Meek & Worthen			Burl.		
“ cornigerus Hall			Burl.		
“ decornis Hall			Burl.		
“ gouldi Meek & Worthen			Keok.		
“ kelloggi Worthen			Keok.		
“ mississippiensis Roemer			Keok.		
“ missouriensis Shumard			Burl.		
“ parvus Shumard			Burl.		
“ quinquelobus var intermedius Meek & Worthen			Bu.Ke		
“ roemeri Meek & Worthen			Burl.		
“ subaculeatus Hall			Burl.		
“ unicornis Owen & Shumard			Burl.		
“ unispinus Hall			Burl.		
Eretmocrinus attenuatus Hall			Burl.		
“ calyculoides Hall			Burl.		
“ carica Hall			Burl.		
“ clio Hall			Burl.		
“ cloelia Hall			Burl.		
“ corbulis Hall			Burl.		
“ coronatus Hall			Burl.		
“ gemmiformis Hall			Burl.		
“ konincki Shumard			Burl.		
“ leucosia Hall			Burl.		
“ matuta Hall			Burl.		
“ neglectus M. & Wn.			Burl.		
“ ramulosus Hall			B. Ke.		
“ remibrachiatus Hall			Burl.		
“ verneuilanus Shumard			Burl.		
Erisocrinus antiquus Meek & Worthen			Burl.		
“ typus Meek & Worthen				Carb.	
“ whitei Meek & Worthen			Burl.		
Eucalyptocrinus cornutus Hall	Niag.				
“ cornutus var excavatus Hall	Niag.				
“ crassus Hall	Niag.				
“ obconicus Hall	Niag.				
“ ornatus Hall	N. Gu.				
Eucladocrinus millebrachiatus W. & S.			Ke. B.		
“ pleuroviminus White			Burl.		
Eupachycrinus orbicularis Hall			Keok.		
“ tuberculatus M. & Wn.			U.Cl.		

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Eupachycrinus verrucosus Wh. & St. J.	......	......	U.Cl.	Carb.	......
" sp. undet..	......	......	L.Cl.	......	......
Forbesiocrinus agassizi Hall	......	......	Burl.	......	......
" wortheni Hall	......	......	Keok.	......	......
Glyptaster occidentalis Hall	Niag.	......	......	......	......
" (?) pentangularis Hall	Niag.	......	......	......	......
Glyptocrinus nobilis Hall	Niag.	......	......	......	......
Glyptocrinus armosus McChesney	Niag.	......	......	......	......
Graphiocrinus rudis Meek & Worthen..	......	......	Burl.	......	......
" simplex Hall	......	......	Burl.	......	......
" spinobrachiatus Hall	......	......	Burl.	......	......
" striatus Meek & Worthen	......	......	Burl.	......	......
" tortuosus Hall	......	......	Burl.	......	......
" Wachsmuthi M. & Wn...	......	......	Burl.	......	......
Ichthyocrinus burlingtonensis Hall	......	......	Burl.	......	......
" nobilis Wachs. & Spr.	......	......	Kind.	......	......
Lampterocrinus inflatus Hall	Niag.	......	......	......	......
Macrostylocrinus striatus Hall	Niag.	......	......	......	......
Megistocrinus brevicornis Hall	......	......	Burl.	......	......
" crassus White	......	......	Burl.	......	......
" evansi Owen & Shumard	......	......	Burl.	......	......
" farnsworthi White	......	......	Ham.	......	......
Megistocrinus latus Hall	......	......	Ham.	......	......
" nodosus Barris	......	......	U. Hl.	......	......
Melocrinus nodosus Hall	......	......	Niag.	......	......
" (?) verneuili Troost	Niag.	......	......	......	......
Mespilocrinus konincki Hall	......	.....	Burl.	......	......
" scitulus Hall	......	......	Burl.	......	......
Nipterocrinus arboreus Worthen	......	......	Burl.	......	......
" wachsmuthi M. & Wn.	......	......	Burl.	......	......
Ollacrinus fiscellus Meek & Worthen	.....	......	Burl.	......	......
" obovatus Meek & Worthen...	......	......	Burl.	......	......
" reticulatus Hall	......	......	Burl.	......	......
" robustus Hall	......	......	Keok.	......	......
" tenuiradiatus M. & Wn	......	......	Burl.	......	......
" tuberculosus Hall	......	......	Burl.	......	......
" typus Hall	......	......	Burl.	......	......
Onychocrinus asteriformis Hall	......	......	Burl.	......	......
" diversus Meek & Worthen	......	......	Burl.	......	......
Parisocrinus perplexus Meek & Worthen	......	......	Burl.	......	......
" solignoideus White	......	......	Burl.	......	......
" tenuibrachiatus M. & Wn...	......	......	Burl.	......	......
Pereiochocrinus amplus Meek & Worthen	......	......	Burl.	......	......
" christyi Hall	Niag.	......	......	......	......
" semiradiatus Hall	Niag.	......	......	......	......
" tenuidiscus Hall	......	......	Burl.	......	.....
" whitei Hall	......	......	Burl.	......	......
Physetocrinus asper Meek & Worthen..	......	......	Burl.	......	......
" dilatatus Meek & Worthen	......	......	Burl.	......	......
" ornatus Hall	......	......	Burl.	......	......
" ventricosus Hall	......	......	Burl.	......	......
Platycrinus aequalis Hall	......	......	Burl.	......	......
" americanus Ow. & Shum.	......	......	Burl.	......	......
" asper Meek & Worthen	......	......	Burl.	......	......
" brevinodus Hall	......	......	Keok.	......	......

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Platycrinus burlingtonensis Ow. & Shum.	......	......	Burl.	......	......
" calyculus Hall	......	......	Burl.	......	......
" canaliculatus Hall	......	......	Burl.	......	......
" cavus Hall	......	......	Burl.	......	......
" corrugatus Owen & Shumard	......	......	Burl.	......	......
" descoideus Owen & Shumard	......	.....	Burl.	......	......
" elegans Hall	......	......	Burl.	......	......
" eminulus Hall	......	......	Burl.	......	......
" glyptus Hall	......	......	Burl.	......	......
" halli Shumard	......	......	Burl.	......	......
" haydeni Meek	......	......	......	Subca	......
" hemisphericus M. & Wn.	......	......	Ke. B.	......	......
" incomptus White	......	......	Burl.	......	......
" nodulosus Hall	......	......	Burl.	......	......
" nodobrachiatus Hall	......	......	Burl.	......	......
" nucleiformis	......	......	Burl.	......	......
" ornigranulus McChesney	......	......	Burl.	......	......
" parvinodus Hall	......	......	Burl.	......	......
" perasper Shumard	......	......	Burl.	......	......
" pileiformis Hall	......	......	Burl.	......	......
" planus Owen & Shumard	......	......	Burl.	......	......
" pocilliformis Hall	......	......	Burl.	......	......
" praenuntius Wachs. & Spr.	......	......	Burl.	......	......
" pratteni Worthen	......	......	Burl.	......	......
" quinquenodus White	......	......	Burl.	......	......
" regalis Hall	......	......	Burl.	......	......
" saffordi Hall	......	......	Keok.	......	......
" scobina Meek & Worthen	......	......	Burl.	......	......
" sculptus Hall	......	......	Burl.	......	......
" shumardianus Hall	......	......	Burl.	......	......
" subspinosus Hall	......	......	Burl.	......	......
" subspinulosus Hall	......	......	Burl.	......	......
" tenuibrachiatus M. & Wn.	......	......	Burl.	......	......
" truncatulus Hall	......	......	Burl.	......	......
" tuberosus Hall	......	......	Burl.	......	......
" wortheni Hall	......	......	Burl.	......	......
" yandelli Owen & Shumard	......	......	Burl.	......	......
Poteriocrinus (?) calyculus (?)	......	......	Burl.	......	......
" doris Hall	......	......	Burl.	......	......
" (?) lepidus	......	......	Burl.	......	......
" notabilis Meek & Worthen	......	......	Burl.	......	......
" obuncus White	......	......	Burl.	......	......
" whitei Hall	......	......	Burl.	......	......
Rhodocrinus barrisi Hall	......	......	Burl.	......	......
" nanus Meek & Worthen	......	......	Burl.	......	......
" wachsmuthi Hall	......	......	Burl.	......	......
" whitei Hall	......	......	Burl.	......	......
" " var burlingtonensis H.	......	......	Burl.	......	......
" wortheni Hall	......	......	Burl.	......	......
Scaphiocrinus arqualis	......	......	Burl.	......	......
" briareus	......	......	Keok.	......	......
" Carenatus Hall.	......	......	Burl.	......	......
" clio Meek & Worthen	......	......	Burl.	......	......
" coxanus Worthen	......	......	Keok.	......	......
" cutidactylus Hall	......	......	Burl.	......	......

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Scaphiocrinus delicatus Meek & Worthen	......	......	Burl.	......	......
" dechotomus Hall..........	......	......	Burl.	......	......
" extensus Wachs. & Spr....	......	......	Keok.	......	......
" keokuk Hall..............	......	......	Keok.	......	......
" nanus Meek & Worthen ..	......	......	Burl.	......	......
" obscurus Wachs. & Spr....	......	......	Keok.	......	......
" penicillus M. & Wn......	......	......	Burl.	......	......
" orestes Worthen..........	......	......	Keok.	......	......
" rambulosus Hall...........	......	......	Burl.	......	......
" rusticullus White..........	......	.....	Burl.	......	......
" swallovi Meek & Worthen.	......	......	Burl.	......	......
" subempressus M. & Wn...	......	......	Burl.	......	......
" thetys Meek & Worthen...	......	......	Burl.	......	......
Scytalocrinus macrodactylus M. & Wn...	......	......	Burl.	......	......
Steganocrinus aranrolus Meek & Worthen	......	......	Burl.	.....	......
" concinnus Shumard........	......	......	Burl.	......	......
" pentagonus Hall............	......	......	Burl.	......	......
" sculptus Hall.............	......	......	Burl.	......	......
Stereocrinus triangulatus Barris.	......	......	Burl.	......	......
" " var liratus Barris	......	......	Burl.	......	......
Strotocrinus glyptus Hall...............	......	......	Burl.	......	......
" perumbrosus Hall..........	......	......	Burl.	......	......
" regalis Hall.................	......	......	Burl.	......	......
Synbathocrinus brevis Meek & Worthen.	......	......	Burl.	......	......
" dentatus Ow. & Shum...	......	......	Burl.	......	......
" instutinis Hall..........	......	......	Ham.	.....	......
" papillatus Hall..........	......	......	Burl.	......	......
" wachsmuthi M. & Wn...	......	......	Burl.	......	......
" wortheni Hall	......	......	Burl.	......	......
Taxocrinus fletcheri Worthen...	......	......	Kind.	......	......
" giddingri Hall..............	......	......	Keok.	......	......
" interscapularis Hall.........	......	......	Ham.	......	......
" juvenis Hall................	......	......	Burl.	......	......
" meeki Hall	......	......	Keok.	......	......
" ramulosus Hall.............	......	......	Burl.	......	......
" thiemii Hall...............	......	......	Burl.	......	......
Teleiocrinus aegilops Hall...............	......	......	Burl.	......	......
" althea Hall..................	......	......	Burl.	......	......
" clivosus Hall...............	......	......	Burl.	......	......
" erodus Hall	......	......	Burl.	......	......
" insculptus Hall.............	......	......	Burl.	......	......
" liratus Hall.................	......	......	Burl.	......	......
" rudis Hall..................	......	.....	Burl.	......	......
" tenuiradiatus Hall..........	......	......	Burl.	......	......
" umbrosus Hall...............	......	......	Burl.	......	......
Vasocrinus macropleurus Hall..........	......	......	Burl.	......	......
Woodocrinus asper Meek & Worthen...	......	......	Burl.	......	......
" asperatus Worthen........	......	......	Keok.	......	......
" bursarformis White........	......	......	Burl.	......	......
" elegans Hall..............	......	......	Burl.	......	......
" ramosus Hall..............	......	......	Burl.	......	......
" scobina Meek & Worthen..	......	......	Burl.	......	......
" serratus Meek & Worthen.	......	......	Burl.	......	......
" tentaculatus Worthen	......	......	Keok.	......	......
" troostanus M. & Wn......	......	......	Burl.	......	......

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Class Cystoidea.					
Agelacrinites sp. nov. Ulrich	......	Tr.	......	......	......
Amygdalocystis florealis Billings	Gal.	......	......	......	......
Apiocystites imago Hall	Niag.	......	......	......	......
“ sp.?	Gal.	......	......	......	......
Caryocrinus ornatus Say	Niag.	......	......	......	......
Crinocystites chrysalis Hall	Niag.	......	......	......	......
“ ornatus Hall	Niag.	......	......	......	......
“ sp. (?)	Niag.	......	......	......	......
*Echinocystites nodosus Hall	Niag.	......	......	......	......
Echino-encrinitus anatiformis Hall	......	......	Tr.	......	......
Glyptocystites logani Billings	Gal.	......	......	......	......
Gomphocystites clavus Hall	Niag.	......	......	......	......
“ glans Hall	Niag.	......	......	......	......
Hemicosmites subglobosus Hall	Niag.	......	......	......	......
Holocystites abnormis Hall	Niag.	......	......	......	......
“ alternatus Hall	Niag.	......	......	......	......
“ cylindricus Hall	Niag.	......	......	......	......
“ ovatus Hall	Niag.	......	......	......	......
“ scutellatus Hall	Niag.	......	......	......	......
“ winchelli Hall	Niag.	......	......	......	......
†Lichenocrinus sp.?	H. R.	Tr.	......	......	......
Pleurocystites squamosus Billings	Gal.	......	......	......	......
†Strobelocystites calvini White	......	......	Ham.	......	......
Cystidean nov. gen. et sp. Ulrich	......	Tr.	......	......	......
Class Blastoidea.					
Cryptoblastus melo Owen & Shumard	......	......	Burl.	......	......
“ “ var projectus M.&Wn.	......	......	Burl.	......	......
“ pisum Meek & Worthen.	......	......	Burl.	......	......
?Codaster subtruncatus Hall	......	......	Ham.	......	......
“ whitei Hall	......	......	Ham.	......	......
Codonites gracilis Meek & Worthen	......	......	Burl.	......	......
‡Elaeacrinus meloniformis Barris	......	......	Ham.	......	......
“ obovatus Barris	......	......	Ham.	......	......
“ verneuili Troost	......	......	Ham.	......	......
Granatocrinus melo Meek & Worthen	......	......	Burl.	......	......
“ melon ides M. & Wn	......	......	Burl.	......	......
“ neglectus M. & Wn	......	......	Burl.	......	......
“ norwoodi Owen & Shumard	......	......	Kind.	......	......
“ “ var fimbriatus M. & Wn.	......	......	Burl.	......	......
“ pisum Meek & Worthen	......	......	Burl.	......	......
“ projectus Meek & Worthen	......	......	Kind.	......	......
“ shumardi Meek & Worthen	......	......	Kind.	......	......
Metablastus lineatus Shumard	......	......	Burl.	......	......
“ wortheni Hall	......	......	Keok.	......	......
§Orophocrinus campanulatus Hambach.	......	......	Burl.	......	......
“ gracilis Meek & Worthen	......	......	Burl.	......	......
“ stelliformis Ow. & Shum.	......	......	Burl.	......	......

*Is classed under Echinoidea by Nicholson & Lyddeker.
†Regarded by Zittel as a doubtful cystidean.
‡Syn. for Nucleocrinus.—*Miller.*
§Etheridge & Carpenter think O. Campanulates of Hambach is only a variety of O. Stelliformis, Owen & Shumard.

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn	Iowa	Neb.	Dak.
Schizoblastus melonoides M. & Wn.	......	......	Burl.	......	......
" neglectus Meek & Worthen	......	......	Burl.	......	......
" sayi Shumard	......	......	Burl.	......	......
Tricoelocrinus wortheni Hall	......	......	Keok.	......	......
Troostocrinus bipyramidalis Hall	......	......	Keok.	......	......
" burlingtonensis M. & Wn.	......	......	Burl.	......	......
" conoideus Hall	......	......	War.	......	......
" koninckianus Hall	......	......	War.	......	......
" laterniformis Ow. & Shum.	......	......	Ches.	......	......
" potteri Hambach	......	......	Burl.	......	......
" subtruncatus Hall	......	......	Ham.	......	......
SUBKINGDOM ANNULOSA.					
DIVISION ANARTHROPODA.					
Class Polychaeta.					
Arenicolites (scolithus) woodi Whitf	P.	......	......	......	......
" sp. undet	......	......	......	......	P.
Conchicolites sp. nov. Ulrich	......	H. R.	......	......	......
" flexuosus Hall	......	Tr.	......	......	......
" sp. undet	......	Tr.	......	......	......
Ortonia sp. undet	Niag.	......	......	......	......
Palaeochorda, vide Plantae.					
Palaeopychus, " "					
Serpula planorbites Meek	......	......	......	Perm.	......
Serpulites murchisoni Hall	P.	......	......	......	......
" sp. undet	......	Tr.	......	......	......
Spirorbis arkonensis Nicholson	......	......	Ham.	......	......
" omphalodes Goldfuss	......	......	Ham.	......	......
Worm-like tubes	L. Tr.	......	......	......	......
DIVISION ARTHROPODA.					
Class Crustacea.					
ORDER TRILOBITA.					
Acidaspis danai Hall	Niag.	......	......	......	......
Aglaspis barrandi Hall	P.....	......	......	......	......
" eatoni Whitfield	P.	......	......	......	......
Agnostus disparilis Hall	P.	......	......	......	......
" josepha Hall	P.	......	......	......	......
" paralis Hall	P.	......	......	......	......
Agraulus (conocephalus)	P.	......	......	......	......
" anatinus Hall	P.	......	......	......	......
" (bathyurus) woosteri Whitfield.	P.	......	......	......	......
Arionellus bipunctatus Shumard	P.	......	......	......	......
" convexus Whitfield	P.	......	......	......	......
" (conocephalus) dorsalis Hall	P.	......	......	......	......
" sp. undet	P.	......	......	......	......

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Asaphus barrandi Hall	Tr.	......	......	......	......
" gigas D'Kay	Tr.	Tr.	Tr.	......	......
" homalonotoides Walcott	Tr.	......	......	......	......
" iowensis Owen	Tr.	......	Tr.	......	......
" romingeri Walcott	Tr.	......	......	......	......
" susae Calvin	Tr.	......	Tr.	......	......
" wisconsensis Hall	Tr.	......	......	......	......
" sp. undet	Tr.	......	......	......	......
Bathyurus longispinus Hall	P.	......	......	......	......
" stonemani Vogdes	......	Tr.	......	......	......
Bronteus acamas Hall	N. Gu.	......	......	......	......
" laphami Whitfield	Niag.	......	......	......	......
Bumastus barriensis Murchison	......	Tr.	Tr.	......	......
Calymene callicephala Green	......	......	Tr.	......	......
" clintoni Vanuxem	Niag.	......	......	......	......
" crassimarginata Hall	......	......	Ham.	......	......
" niagarensis Conrad	Niag.	......	......	......	......
" senaria Conrad	T. Ga. H.	Gal.	H. R.	......	......
" sp. undet	......	......	Ham.	......	......
Ceraurus insignis Hall	Niag.	......	......	......	......
" niagarense Hall	Niag.	......	......	......	......
" pleurexanthus Green	Tr.	Tr.	......	......	......
" sp. undet	Tr. N.	......	......	......	......
Chariocephalus whitfieldi Hall	P.	......	......	......	......
Conocephalites (agraulos) anatinus Hall	P.	......	......	......	......
" amodosus Hall	P.	......	......	......	......
" calymenoides Whitfield	P.	......	......	......	......
" diadematus Hall	P.	......	......	......	......
" (Arionellus) dorsalis Hall	P.	......	......	......	......
" eos Hall	P.	......	......	......	......
" (Ptychaspis) explanatus Whitf.	P.	......	......	......	......
" hamulus Owen	P.	P.	......	......	......
" iowensis Owen	P.	......	......	......	......
" minor Shumard	P.	......	......	......	......
" nasutus Hall	P.	......	......	......	......
" optatus Hall	P.	......	......	......	......
" patersoni Hall	P.	......	......	......	......
" perseus Hall	P.	......	......	......	......
" (?) quadratus Whitfield	P.	......	......	......	......
" shumardi Hall	P.	......	......	......	......
" winona Hall	P.	......	......	......	......
" wisconsensis Owen	P.	......	......	......	......
Crepicephalus centralis Whitfield	......	......	......	......	P.
" (?) gibbesi Whitfield	P.	......	......	......	......
" miniscensis Owen	......	P.	......	......	......
" onustus Whitfield	P.	......	......	......	......
" planus Whitfield	......	......	......	......	P.
" wisconsensis Owen	P.	P.	......	......	......
Cythere cyclas Geinitz	......	......	......	Perm.	......
" nebrascensis Keyserling	......	......	Coal	Perm.	......
" simplex White & St. John	......	......	L. Ca.	......	......
" sp. undet	......	......	Carb.	Carb.	......
Dalmanites callicephalus Hall	T., Ga.	T. Ga.	......	......	......
" nicta Hall	Tr.	......	......	......	......
" vigilans Hall	Niag.	......	......	......	......

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Dalmanites sp. undet.	......	Tr.	......	......	......
Dikellocephalus barabuensis Whitfield	L Mag	......	......	......	......
" eatoni Whitfield	L Mag	......	......	......	......
" grannlosus Owen	......	P.	......	......	......
" lodensis Whitfield	P.	......	......	......	......
" (?) iowensis Owen	......	P.	P.	......	......
" minnesotensis Owen	P.	P.	......	......	......
" " var limbatus H.	P.	......	......	......	......
" miniscensis Owen	P.	P.	......	......	......
" misa Hall	P.	......	......	......	......
Dikellocephalus osceola Hall	P.	......	......	......	......
" pepinensis Hall	P.	P.	......	......	......
" spiniger Hall	P.	......	......	......	......
Ellipsocephalus curtus Whitfield	P.	......	......	......	......
Encrinurus nereus Hall	Niag.	......	......	......	......
" ornatus Hall & Whitfield	Niag.	......	......	......	......
" sp. undet.	Tr. N.	......	......	......	......
Harpes sp. undet.	Gal.	Gal.	......	......	......
Illaenurus convexus Whitfield	L.	Tr.	......	......	......
" quadratus Hall	P.	......	......	......	......
Illaenus armatus Hall	Niag.	......	......	......	......
" crassicaudus Wahl	Tr.	Tr.	......	......	......
" cuniculus Hall	Niag.	......	......	......	......
" daytonensis Hall & Whitfield	Niag.	......	......	......	......
" herricki Foerste	......	Tr.	......	......	......
" imperator Hall	Niag.	......	......	......	......
" insignis Hall	Niag.	......	......	......	......
" iowensis Owen	Gal.	......	......	......	......
" madisonanus Whitfield	Niag.	......	......	......	......
" (Nileus) minnesotensis Foerste	......	Tr.	......	......	......
" ovatus Conrad	Tr.	......	Tr.	......	......
" pterocephalus Whitfield	Niag.	......	......	......	......
" taurus Hall	T. Ga.	Tr.	......	......	......
" sp. undet.	T. Ga. H. N.	T. Ga. H.	......	......	......
Lichas breviceps Hall	Niag.	......	......	......	......
" phlyctonodes Green	Niag.	......	......	......	......
" sp. undet.	......	Tr.	......	......	......
Menocephalus minnesotensis Owen	......	P.	......	......	......
Pemphigaspis bullatus Hall	P.	......	......	......	......
Phacops macrophthalma Owen	......	......	Ham.	......	......
" rana Green	Ham.	......	Ham.	......	......
" sp. undet.	Niag.	......	Tr.	......	......
Phillipsia granulifera Owen	......	......	Coal	......	......
" major Shumard	......	......	......	Carb.	......
" pustulata Owen	......	......	Coal	......	......
" scitula Meek & Worthen	......	......	......	Carb.	......
" sp. undet.	......	......	Coal	Carb.	......
Proteus davenportensis Barris	......	......	Chem.	......	......
" sp. undet.	Gal.	......	......	......	......
Ptychaspis barabuensis Winchell, A.	P.	......	......	......	......
" (Conocephalites) explanatus Whitf.	P.	......	......	......	......
" granulosus Owen	P.	......	......	......	......
" miniscensis Owen	P.	......	......	......	......
" minuta Whitfield	P.	......	......	......	......

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Ptychaspis striata Whitfield	P.				
" sp. undet	P.				
Sphaerocephalus sp. undet	Gal.				
Sphaerexochus mirus Beyrich	Niag.				
" romingeri Hall	Niag.				
Triarthella auroralis Hall	P.				
ORDER OSTRACODA.*					
Beyrichia foetoidea White & St. John			U. Cl.		
Beyrichia petrifactor White & St. John			L. Cl.		
" " var velata Wh. & St. J.			L. Cl.		
" sp. undet	Tr. H.				
Eurychilina formosa Ulrich		Tr.			
Leperditia alta Conrad	Tr.				
" fabulites Conrad	Niag.	Tr.			
" fonticola Hall.	Niag.				
DIVISION MOLLUSCOIDEA.					
Class Polyzoa (Bryozoa).					
Acanthocladia americana Swallow				Perm.	
Actinotrypa peculiaris Rominger			Keok.		
Amplexopora Winchelli Ulrich		Tr.			
Anolotichia impolita Ulrich		Tr.			
Archimedes negligens Ulrich			Keok.		
" oweniana Hall			Keok.		
Arthroclema armatum Ulrich		Tr.			
" cornutum Ulrich		Tr.			
Arthropora simplex Ulrich		Tr.			
Arthrostylus conjunctus Ulrich		Tr.			
" obliqua Ulrich		Tr.			
Asidopora parasitica Ulrich		Tr.			
Atactoporella ortoni Nicholson	H. R.				
† " pavonia D'Orbigny	H. R.				
" punctata Whitfield	H. R.				
" sp. undet	H. R.				
Batostoma fertilis Ulrich		Tr.			
" irrosa Ulrich		Tr.			
Berenicea minnesotensis Ulrich		Tr.			
Bythopora herricki Ulrich		Tr.			
Callopora incontroversa Ulrich		Tr.			
‡ " ramosa D'Orbigny	H. R.				
‡ " rugosa Edwards & Haime	H. R.				
" undulata Ulrich		Tr.			
Calloporella lens Whitfield	H. R.				
Chartetes ? fusiformis Whitfield	H. R.				

*"I have at least 25 new species of Ostracoda from the Trenton and Galena of Minnesota, belonging to the genera: Aparchites, Bythocypris, Eurychilina, Ctenobalbina (Ulrich, M. S.), Ceraditia (Ulrich, M. S.), Jonesella (Ulrich, M. S.), Premitia and Leperditia."—*E. O. Ulrich.*

†Whitfield, no doubt had Peronopora decip'ens Rominger in view, but W. is in error; the species does not occur in Wis.

‡Do not occur in Wisconsin.—*Ulrich.*

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Chartetes lycoperdon Say	T. Ga. H.	Tr.	Tr.		
Clathopora flabellata Hall.	Niag.				
Constellaria polystomella Nicholson	H. R.				
Coscinium latum Ulrich			Burl.		
Cyclopora expatriata Ulrich			Keok.		
" fungia Prout			Keok.		
Cycloporella perversa Ulrich			Keok.		
" spirifera Ulrich			Keok.		
Cystodictya americana Ulrich			Keok.		
" hamiltonensis Ulrich			Ham.		
" lineata Ulrich			Keok.		
" nitida Ulrich			Keok.		
" pustulosa Ulrich			Keok.		
" simulans Ulrich			B. Ke		
Dekayella ulrichi? Nicholson		Tr.			
" sp. undet		Tr.			
Dekayia aspera Edwards and Haime	H. R.				
" trentonensis Ulrich			Tr.		
" sp. undet			Tr.		
Diastoporina flabellata Ulrich			Tr.		
Dichotrypa foliata Ulrich			Ham.		
Dicranopora fragilis Billings	H. R.				
Diplotrypa infida Ulrich		Tr.			
Euspilopora? barrisi Ulrich			Ham.		
" serrata Ulrich			Ham.		
Evactinopora grandis Meek & Worthen			Kind.		
" quinqueradiata Ulrich			Burl.		
" sexradiata M. & Worth			Burl.		
Fenestella burlingtonensis Ulrich			Burl.		
" cingulata Ulrich			Keok.		
" dilata Prout			Ham.		
" elegans Hall					Niag.
" elegantissima Eichwald				Carb.	
" filistriata Ulrich			Burl.		
" funicula Ulrich			Keok.		
" granulosa Whitfield	H. R.				
" milleri Owen & Shumard			Ham.		
" multispinosa Ulrich			Keok.		
" nodosa Prout			Ham.		
" plebeja, McCoy				Carb.	
" perelegans Meek				U Cl.	
" (Lyropora) retrorsa M. & Worth.			Kind.		
" rudis Ulrich			Keok.		
" shumardi Prout				Carb.	
" vera Ulrich.			Ham.		
" virgosa Eichwald				Carb.	
Fenestropora occidentalis Ulrich			Ham.		
Fistulipora astricta Ulrich			Ham.		
" collina			Ham.		
" communis			Ham.		
" compressa Rominger			Keok.		
" concentrica Hall.	Niag.				
" foordi Ulrich			Ham.		
" laxata Ulrich		Tr.			
" monticulata Ulrich			Ham.		

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Fistulipora nodulifera Meek	......	......	......	Carb.	......
Glyptopora keyserlingi Prout	......	......	Keok.	......	......
" megastoma Ulrich	......	......	Keok.	......	......
" pinnata Ulrich	......	......	Burl.	......	......
Helopora alternata Ulrich	......	Tr.	......	......	......
" divaricata Ulrich	......	Tr.	......	......	......
" mucronata Ulrich	......	Tr.	......	......	......
Hemitrypa aspera Ulrich	......	......	Keok.	......	......
" nodosa Ulrich	......	......	Keok.	......	......
" pateriformis Ulrich	......	......	Keok.	......	......
" perstriata Ulrich	......	......	Keok.	......	......
" plumosa Prout	......	......	Keok.	......	......
" proutana Ulrich	......	......	Ke.W.	......	......
" " var nodulosa Ul	......	......	Keok.	......	......
" tenera Ulrich	......	......	Ham.	......	......
Homotrypa exiles Ulrich	......	Tr.	......	......	......
" insignis Ulrich	......	Tr.	......	......	......
" minnesotensis Ulrich	......	Tr.	......	......	......
" multituberculata Whitf	H. R.	......	......	......	......
" subramosa Ulrich	......	Tr.	......	......	......
Homotrypella instabilis Ulrich	......	Tr.	......	......	......
Leioclema gracillimum Ulrich	......	......	Keok.	......	......
" minutissimum Nicholson	......	......	Ham.	......	......
" occidens Owen & Shumard	......	......	Chem.	......	......
" punctatum Hall	......	......	Ke.W.	......	......
? " rugosa Whitfield	H. R.	......	......	......	......
? " ?solidissima Whitfield	H. R.	......	......	......	......
" subglobosum Ulrich	......	......	Kind.	......	......
" wachsmuthi Ulrich	......	......	Kind.	......	......
" sp. undet	H. R.	......	Carb.	Carb.	......
Leptotrypa hexagonalis Ulrich	......	Tr.	......	......	......
Lyropera retrorsa Meek & Worthen	......	......	Burl.	......	......
Mitoclema? mundulum Ulrich	......	Tr.	......	......	......
Monotrypella multitabulata Ulrich	......	Tr.	......	......	......
" quadrata Rominger	H. R.	H. R.	......	......	......
" rectangularis Whitfield	H. R.	......	......	......	......
*Monticulipora grandis Ulrich	......	Tr.	......	......	......
* " mammulata D'Orbigny	H. R.	......	......	......	......
Nematopora conferta Ulrich	......	Tr.	......	......	......
" granosa Ulrich	......	Tr.	......	......	......
" ovalis Ulrich	......	Tr.	......	......	......
Nicholsonella ponderosa Ulrich	Tr.	......	......	......	......
Pachydictia conciliatrix Ulrich	......	Tr.	......	......	......
" fimbriata Ulrich	......	Tr.	......	......	......
" foliata Ulrich	......	Tr.	......	......	......
" occidentalis Ulrich	......	Tr.	......	......	......
" pumila Ulrich	......	Tr.	......	......	......
Palaeschara sp. undet	H. R.	......	......	......	......
Petalotrypa compressa Ulrich	......	......	Ham.	......	......
" delicata Ulrich	......	......	Ham.	......	......
Phyllodictya frondosa? Ulrich	......	Tr.	......	......	......
Phylloporina corticosa Ulrich	......	Tr.	......	......	......
" halli Ulrich	......	Tr.	......	......	......

*Classed by Nicholson & Lyddeker (1889) under Actinozoa.

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Phylloporina sublaxa Ulrich............	......	Tr.	......	......	......
Pinnatopora conferta Ulrich...........	......	.....	Keok.	......	......
" striata Ulrich..............	......	......	Keok.	......	......
" trilineata Meek............	......	......	......	Carb.	......
" vinii Ulrich	......	.....	Keok.	......	......
" youngi Ulrich.............	......	.....	Keok.	......	......
Polypora burlingtonensis Ulrich.........	......	......	Burl.	......	......
" gracilis Prout........	......	.....	Keok.	.....	......
" hallana Prout................	......	......	Keok.	.... .	......
" hamiltonensis Prout..........	......	......	Ham.	......	......
" incepta Hall..................	Niag.	......	......	......	......
" maccoyana Ulrich.............	......	......	Keok.	......	......
" papillata McCoy..............	......	......	....	Carb.	......
" radialis Ulrich...............	......	......	Keok.	......	.....
" retrorsa Ulrich.	......	.....	Keok.	......	......
" simulatrix Ulrich.............	......	......	Keok.	......	......
" submarginata Meek..........	......	......	Coal	Carb.	......
" sp. undet......	......	.....	Carb.	Carb.	......
Praesopora conoidea Ulrich............	......	Tr.	......	......	......
" contigua Ulrich............	......	Tr.	......	......	......
" lycoperdon Say............	......	Tr.	......	......	......
Proutella discoidea Prout...............	......	......	Keok.	......	......
Ptilodictya nodosa Hall................	......	Tr.	......	......	......
" ramosa Ulrich...............	......	Tr.	.... .	......	......
" recta Hall..................	T. Ga.	.....	.. ..	......	......
" subrecta Ulrich.............	......	Tr.	......	......	......
" sp. undet....................	T. Ga.	......	.....	......	......
Ptilopora acuta Ulrich..................	......	......	Ke. B.	......	......
" cylindracea Ulrich...........	......	......	Keok.	......	......
" valida Ulrich................	......	......	Keok	....	......
Rhinidictya exigua Ulrich..............	......	Tr.	......	......	......
" fidelis Ulrich	......	Tr.	.....	......	......
" humilis Ulrich.............	......	Tr	.... .	......	.....
" minima Ulrich	......	Tr.	......	......	......
" mutabilis Ulrich...........	......	Tr.	......	......	......
" " var major Ulrich	......	Tr.	......	......	......
" " var minor Ulrich	......	Tr.	......	......	......
" paupera Ulrich.............	......	Tr.	......	......	......
" sp.?........................	T.Ga.H.	......	......	......	......
Rhombopora (?) asperrima Ulrich.......	......	......	Keok.	......	......
" craasa Ulrich...............	......	......	Keok.	......	......
" dichotoma Ulrich...........	......	......	Burl.	......	......
" exigua Ulrich	......	......	Burl.	......	......
" gracilis Ulrich.............	......	......	Burl.	.. ..	......
" lepidodendroidea Meek	......	......	Coal	Coal	......
" subannulata Ulrich.........	......	......	Ham.	......	......
" sulcifera Ulrich	......	......	Ham.	......	......
" varia Ulrich................	......	......	Keok.	......	......
Saganella membranacea Hall...........	Niag.	......	......	......	......
" sp. undet.........	Niag.	......	...	......	......
Semicoscinium rhombicum Ulrich......	......	......	Ham.	......	......
Septopora biserialis Swallow...........	......	......	Coal	Carb.	......
Stenopora americana Ulrich............	......	......	Keok.	......	......
" angularis Ulrich..............	......	......	Keok.	......	......
" emaciata Ulrich	......	......	Keok.	......	......

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Stenopora carbonaria Worthen	......	......	Coal	......	......
Stictopora elegantula Hall	T. Ga. H.	......	......	......	......
Stictoporella angularis Ulrich	......	Tr.	......	......	......
" cribrosa Ulrich	......	Tr.	......	......	......
" frondifera Ulrich	......	Tr.	......	......	......
" rigida Ulrich	......	Tr.	......	......	......
Stomatopora inflata Hall	......	Tr.	......	......	......
" pertenuis Ulrich	......	Tr.	.....	.....	......
Streblotrypa major Ulrich	......	......	Keok.	......	......
" radialis Ulrich	......	......	Keok.	......	......
Strotopora dermata Ulrich	......	......	Keok.	......	......
" faveolata Ulrich	......	......	Keok.	......	......
Taeniodictya frondosa Ulrich	......	......	Keok	......	......
" ramulosa Ulrich	......	......	Keok.	......	......
" " var burlingtonensis Ul.	......	......	Keok.	......	.....
Taeniopora occidentalis Ulrich	......	.....	Ham.	......	......
Thamniscus octonarius Ulrich	......	.....	......	Coal	......
Trematopora annulifera Whitfield	H. R.	......	.....	......	......
" granulata Whitfield	H. R.	......	......	......	......
" ornata Ulrich	......	Tr.	......	......	......
" primagenia Ulrich	......	Tr.	......	......	......
" sp. undet	{T. Ga. {N. H.	......	......	......	......
Worthenopora spinosa Ulrich	.....	......	W.Ke.	......	......
Vinella repens Ulrich	......	Tr.	......	......	......
CLASS BRACHIOPODA.					
Acambonia prima White	......	......	Burl.	......	......
Ambocoelia (Spirifer?) minuta White	......	......	Chem.	......	......
" umbonata Conrad	......	......	Chem.	.....	......
Anastrophia interplicata Hall	Niag.	.....	.....	......	......
Athyris incrassata Hall	......	......	Burl.	......	......
" planosulcata Phillips	......	......	.....	Carb.	......
" roissyi Owen	......	......	L.Cl.	......	......
" subtilita Hall	......	......	Carb.	Carb.	......
" (?) trisinuata McChesney	Niag.	......	......	......	......
" vittata Hall	....	.....	Ham.	.....	......
Atrypa aspera var occidentalis Hall	....	......	Ham.	......	......
" capax (see Rhynchonella capax) Con.	......	......	Tr. (?)	......	......
" comis Owen	......	......	U.Hl.	.....	......
" concentrica Eaton	......	......	Ham.	.....	......
" concinna Owen & Shumard	......	......	Ham.	......	......
" hemiplicata (see Camerella h.) H.	......	Tr.	Tr.	......	......
" hystrix Hall	Ham.	......	Chem.	......	......
" modesta (see Zygospira modesta) Say	.....	......	Tr.	....	......
" nodostriata Hall	Niag.	......	......	......	......
" reticularis Linne	Ha. N.	Dev.	Ham.	......	......
" spinosa Hall	Ham.	......	......	......	......
" sp. undet	Guel.	......	......	......	......
Aulosteges spondyliformis Wh. & St, J.	Guel.	......	.....	......	......
*Camarophoria globulina Phillips	.....	......	......	Perm	......
" subtrigona M. & Worth.	.....	......	Keok.	......	......
Camerella hemiplicata Hall	T. Ga.	Tr.	Tr.	......	......
" ops Billings	Tr.	......	......	......	......

*As identified by Geinitz is Phynchonella uba Marcom.—*Ulrich.*

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Camerella several undet. sp.	......	T. Ga.	......	......	......
Chonetes coronata Conrad	Ham	......	......	......	......
" crenulata Owen	......	......	L.Cl.	......	......
" deflecta Conrad	Ham.	......	......	......	......
" fischeri Norwood & Pratten	......	......	Chem.	......	......
" flemingi Norwood & Pratten	......	......	......	Carb.	......
" geniculata White	......	......	Chem.	......	......
" glabra Geinitz	......	......	Carb.	Perm.	......
" granulifera Owen	......	......	L.Cl.	Carb.	......
" illinoisensis Worthen	......	......	Kind.	......	......
" iowensis Owen	......	......	Carb.	......	......
" laevis Keyes	......	......	Coal	......	......
" laquessiana Owen (?)	......	......	Ham.	......	......
" logani Norwood & Pratten	......	......	Burl.	......	......
" " var aurora Hall	......	......	Ham.	......	......
" mesoloba Norwood & Pratten	......	......	Coal	......	......
" mucronata Meek & Worthen	......	......	......	Carb.	......
" nana Hall (?)	......	......	Ham.	......	......
" semiovalis Hall (?)	......	......	Ham.	......	......
" verneuilana Norwood & Pratten	......	......	Coal	Carb.	......
" sp. undet.	......	......	Ha.Cl.	......	......
Crania antiqua Hall	H. R.	......	......	......	......
" famelica Hall	......	......	Chem.	......	......
" granulosa Winchell (?)	......	Tr.	......	......	......
" modesta White & St. John	......	......	U.Cl.	......	......
" reposita White	......	......	Ham.	......	......
" scabiosa Hall	Gal.	......	......	......	......
" sheldoni White	......	......	Ham.	......	......
" trentonensis Hall	......	Tr.	......	......	......
Cryptonella calvini Hall	......	......	Chem.		......
" (Terebratula) eudora Hall	......	......	Chem.		......
Cyrtina aspera Hall	Ham.	......	......	......	......
" curvilineata (?) White	......	......	Burl.	......	......
" hamiltonensis Hall	Ham.	......	......	......	......
" triquetra Hall	......	......	Ham.	......	......
" umbonata Hall	......	......	Ham.	......	......
Dinobolus conradi Hall	Niag.	......	......	......	......
Discina capax White	......	......	Chem.	......	......
" inutilis Hall	Niag.	......	......	......	......
" marginalis Whitfield	Ham.	......	......	......	......
" nitida Phillips	......	......	Coal	......	......
" pelopea Billings	......	Tr.	......	......	......
" sp. undet.	......	H. R.	......	......	......
Eichwaldia reticulata Hall	Niag.	......	......	......	......
Gypidula larviuscula Hall	......	......	Ham.	......	......
" multicostata Hall	N. Gu.	......	......	......	......
" occidentalis Hall	N. Gu.	......	Chem.	......	......
*Hemiphronites americana Whitfield	Gal.	Gal.	......	......	......
Leiorhynchus iris Hall	......	......	Chem.	......	......
" kelloggi Hall	Ham.	......	......	......	......
†Leptaena alternata Conrad	......	......	Tr. H.	......	......
" barabuensis Winchell	P. L.	......	......	......	......
‡ " deflecta Conrad	......	......	Tr.	......	......

*See Orthisina americana.
†See Strophomena alternata.
‡See Streptorhynchus deflecta.

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa.	Neb.	Dak.
*Leptarna deltoidea Conrad	......	Tr.	......	......	......
" melita Hall & Whitfield	P.	......	......	......	......
† " planumbona Hall	......	Tr.	Tr.	......	......
‡ " recta Conrad	......	......	Tr.	......	......
" sericea Sowerby	T. Ga. H.	Tr.	Tr.	......	......
" transversalis Dalman	Niag.	......	......	......	......
§ " trilobata Owen	......	Tr.	......	......	......
" sp. undet	......	Tr. N	......	......	......
Leptocoelia planoconvexa Hall	Niag.	......	......	......	......
" plicatula Hall	Niag.	......	......	......	......
Lingula ampla Owen	P.	......	......	......	......
" antiqua Emmons	P.	P.	......	......	......
‖ " attenuata Hall	Tr.	......	......	......	......
" calumet (?) Winchell, N. H.	......	P.(?)	......	......	......
" elderi Whitfield	Tr.	Tr.	......	......	......
" halli White	......	......	Burl.	......	......
" (?)iowensis Owen	......	......	H. R.	......	......
" maquoketa Hall	H. R.	......	......	......	......
" mosia Hall	P.	P.	......	......	......
" obtusa Hall	Tr.	......	......	......	......
" paliformis Hall	H. R.	......	......	......	......
" quadrata Eichwald	T. Ga.	Tr.	......	......	......
¶ " scotica var nebrascensis Meek	......	......	......	Carb.	......
" stoneana Whitfield	P.	......	......	......	......
" umbonata Cox	......	......	Coal	......	......
" winona Hall	P.	......	......	......	......
" sp. undet	P.	Ga. H.	......	......	......
Lingulella aurora Hall	P.	P.	......	......	......
" iowensis Owen	Gal.	Gal.	......	......	......
Lingulepis cuneata Whitfield	......	......	......	......	P.
" dakotensis Meek & Hayden	......	......	......	......	P.
" morsensis Winchell, N. H	......	St. Peter	......	......	......
" perattenuata Whitfield	......	......	......	......	P.
" pinnaeformis Owen	P.	P.	......	......	P.
" prima Conrad	......	P.	......	......	......
Meekella striato-costata Cox	......	......	Carb.	Carb.	......
Meristella hyale Billings	Guel.	......	......	......	......
" nucleolata Vanuxem	L.Hl.	......	......	......	......
Monomorella prisca Billings	Guel.	......	......	......	......
" sp. undet	Gal.	......	......	......	......
Obolella nana Meek & Hayden	......	......	......	......	P.
" polita Hall	P.	......	......	......	P.
Obolus apollinus Owen	P.(?)	......	P.	......	......
" conradi Hall	Niag.	......	Mag.	......	......
" pectinoidea Whitfield	......	......	......	......	P.
**Orbicula prima Owen	......	P.	......	......	......
Orbiculoidea sp. undet	......	......	......	Carb.	......
Orthis acutilirata Conrad	......	Tr.	H. R.	......	......

*See Strophomena deltoidea.
†See Streptorhyncus planumbona.
‡Syn. for Streptorhyncus rectum.
§See Strophomena trilobata.
‖Preoccupied; Billings called it L. daphne.
¶Probably a good species.—*Ulrich.*
**This may be a Crania.—*Ulrich.*

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis	Minn.	Iowa	Neb.	Dak.
Orthis amoena Winchell, N. H..........	......	Ga. H.	......	......	......
" bellarugosa Hall..................	T. Ga.	Gal.	Tr.	......	......
" biloba Linn.....................	Niag.	......	......	......	......
" borealis Billings.................	Tr.	......	......	......	......
" carbonaria Swallow..............	......	......	Carb.	Carb.	......
" charlottae Winchell, N. H........	.....	Tr.	......	......	......
" circularis Winchell, N. H.........	......	Tr.	......	......	......
" conradi Winchell, N. H..........	......	Tr.	......	......	......
" crenistria Phillips................	......	......	L.Cl.	Carb.	......
" desparalis Conrad................	Tr.	Tr.	......	......	......
" elegantula Dalman...............	N. Gu.	......	......	......	......
" " var media Shaler......	......	Tr.	......	......	......
" ella(?) Hall......................	Tr.	......	......	......	......
" emacerata Hall....................	......	Tr.	......	......	......
" equivalvis Conrad	T. Ga.	......	......	......	......
" flabellula Sowerby...............	Niag.	......	......	......	......
" hybrida Dalman	Niag.	......	......	......	......
" impressa Hall....................	Ham.	......	Ham.	......	......
" inequalis Hall....................	......	......	Ham.	......	......
" insculpta Hall....................	......	H.R.	......	......	......
" iowensis Hall....................	......	......	Ham.	......	......
" " var furnarius Hall	......	......	Ham.	......	......
" kankakensis McChesney.........	H R.	......	......	......	......
" kassubae Winchell, N. H.........	......	Tr.	......	......	......
" keokuk Hall	......	......	Keok.	......	......
" lynx, Eichwald..................	T Ga. H.	Gal.	......	......	......
" mcfarlanei Meek	......	......	Ham.	......	......
* " media Winchell..................	......	Tr.	......	......	......
" meeki Miller S. A................	......	H.R.	......	......	......
" michelini L'Eveille..............	......	......	L. Ca.	......	......
" " var burlingtonensis Hall	......	......	Burl.	......	......
" minneapolis Winchell, N. H......	......	Tr.	......	......	......
" oblata Hall......................	L. Hl.	......	......	......	......
" occidentalis Hall................	H.R.	H.R.	H.R.	......	......
" pectinella Conrad................	T. Ga. H.	......	......	......	......
" pecosi Marcon	......	. ....	Carb.	......	......
" pepina Hall	P.	......	.....	......	......
" perveta Conrad..................	T. Ga.	Tr.	Tr.	......	......
" plicatella Hall..................	T. Ga.	Tr.	.....	......	......
" prava Hall..	......	.....	Ham.	......	......
" remnicha Winchell, N. H.......	......	P.	......	......	......
" resupinata Martin...............	......	......	Coal	......	.....
" robusta Hall....................	......	......	L.Cl.	......	......
" sandbergi Winchell, N. H........	......	P.	......	......	......
" sinuata Hall.....................	......	......	H.R.	......	......
" striato-costata Cox..............	......	......	Carb.	......	......
" subcarinata Hall.................	L. Hl.	......	......	......	......
" subelliptica White & Whitfield...	......	......	Chem.	......	......
" subequata Conrad.	Tr.	Tr.	Tr.	......	......
" suborbicularis Hall..............	......	......	Ham.	......	......
" subquadrata Hall	Tr. H.	H.R.	H.R.	......	......
" swallovi Hall....................	......	......	Burl.	......	......
" sweeneyi Winchell, N. H.........	......	Tr.	......	......	......
" testudinaria Dalman	T. Ga. H.	Tr.	.....	......	......

*Name preoccupied by Shaler—see O. elegantula.

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Orthis thiemii White	......	......	Burl.	......	......
" tricenaria Conrad	T. Ga. H.	Tr.	Tr.	......	......
" vanuxem Hall	......	......	Ham.	......	......
" whitfieldi Winchell, N. H.	......	H.R.	......	......	......
" sp. undet	T Ga N H	H.R.	......	......	......
*Orthisina americana Whitfield	Gal.	Gal.	......	......	......
Pentamerella arata Conrad	......	......	Ham.	......	......
" dubia Hall	......	......	Ham.	......	......
" nucula Hall	......	......	Ham.	......	......
" obsolescens Hall	......	......	Ham.	......	......
Pentamerus bisinuatus McChesney	Niag.	......	......	......	......
" fornicatus Hall	Niag.	......	......	......	......
" larvus Owen & Shumard	......	......	Niag.	......	......
" lenticularis Wh. & Whitf.	......	......	Chem.	......	......
" multicostatus Hall	Niag.	......	......	......	......
" oblongus Murchison	N. Gu.	......	Niag.	......	......
" occidentalis Hall	......	......	Ham.	......	......
" pergibbosus H. & Whitf.	N. Gu.	......	......	......	......
" ventricosus Hall	N. Gu.	......	......	......	......
" sp. undet	N Gu L H	......	......	......	......
Phodilops truncata Hall	Gal.	......	......	......	......
Productella Shumardeana Hall	......	......	Ham.	......	......
" spinulicostata Hall	Ham.	......	......	......	......
" truncata Hall	......	Ham.	......	......	......
Productus arcuatus Hall	......	......	Chem.	......	......
" cancrini de Verneuil	......	......	......	Perm.	......
" carbonarius Owen & Shumard	......	......	L.Cl.	......	......
" concentricus Hall	......	......	Chem.	......	......
" cora D'Orbigny	......	......	L.Cl.	Carb.	......
" costatus Sowerby	......	......	Coal	Carb.	......
" dissimilis Hall	......	......	Ham.	......	......
" flemingi Sowerby	......	......	......	Carb.	......
" " var burlingtonensis Hall	......	......	Burl.	......	......
" horrescens de Verneuil	......	......	......	Perm.	......
" horridus Sowerby	......	......	......	Perm.	......
" koninckianus de Verneuil	......	......	......	Perm.	......
" lobatus de Verneuil	......	......	L.Cl.	......	......
" longispinus Sowerby	......	......	Carb.	Carb.	......
" marginalis Owen & Shumard	......	......	L.Cl.	......	......
" mesialis Hall	......	......	Keok.	......	......
" muricatus Norwood & Pratten	......	......	L.Cl.	......	......
" nanus Meek & Worthen	......	......	L.Cl.	......	......
" nebrascensis Owen	......	......	Carb.	Carb.	......
" orbignyanus de Verneuil	......	......	......	Carb.	......
" pertenuis Meek	......	......	......	Carb.	......
" prattenianus Norwood	......	......	Carb.	Carb.	......
" punctatus Martin	......	......	Carb.	Carb.	......
" pustulosus Phillips	......	......	......	Carb.	......
" scabriculus Martin	......	......	......	Carb.	......
" semireticulatus Martin	......	......	Carb.	Carb.	......
" setigerus Hall	......	......	Keok.	......	......
" " var Keok. Hall	......	......	Keok.	......	......
" shumardianus Hall	......	......	Ham.	......	......
" sublatus Hall	......	......	Niag.	......	......

*See Streptorhyncus americanum Whitfield, Geol. Wis., Vol. IV, p. 243, ed.

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Productus symmetricus McChesney.....	......	......	Carb.	Carb.	......
" vineinalis White.............	......	......	Burl.	......	......
" vittatus Hall................	......	......	Keok.	......	......
Rensselaria johanni Hall................	......	......	U.Hl.	......	......
" sp. undet..................	Guel.	......	......	......	......
Retzia (acambona?) altirostris White.....	......	......	Chem.	......	......
" mormoni Marcon................	......	......	Coal	Carb.	......
* " punctulifera Shumard	......	......	Carb.	Carb.	......
" sexplicata White & Whitfield.....	......	......	Chem.	......	......
" sp. undet.......	Guel.	......	......	......	......
Rhynchonella ainslei Winchell, N. H....	......	Tr.	......	......	......
† " angulata Linne...........	.....	......	......	Perm.	......
" anticostensis Billings......	Ha.Ga	......	......	......	......
" capax	H.R.	H.R.	......	......	......
" cuneata‡ Dalman	Guel.	......	......	......	......
" increbescens Conrad	T.Ga.	T.Ga.	......	......	......
" indianensis Hall..........	Niag.	......	......	......	......
" intermedia Barris.........	......	......	Chem.	......	......
" janea Billings	H.R.	......	......	......	......
" neenah Whitfield.........	T. Ga. H.	......	......	......	......
" neglecta Hall.............	N.Gu.	......	......	......	......
" opposita White & Whitfield	......	......	Chem.	.....	......
§ " osagiensis Swallow........	......	......	Carb.	Carb.	......
" ottumwa White...........	......	......	St. L.	......	......
" perlamellosa Whitfield....	H R.	.....	.....	......	......
" pisum Hall & Whitfield...	Guel.	......	......	......	......
" recurvirostra Hall........	......	Tr.	......	......	......
" testudinis White..........	......	......	Chem.	......	......
" uta Marcou..............	......	......	Coal	Coal	......
" venustula Hall...........	......	......	Chem.	......	......
" sp. undet	......	Tr.	......	......	......
Schizocrania filosa Hall	Tr.	......	......	......	......
Siphonotreta sp. nov. Ulrich.............	......	Tr.	......	......	......
Skenidium insignurem Hall.............	Niag.	......	......	......	......
" sp. undesc.................	......	Tr.	......	......	......
Spirifera angusta Hall..................	Ham.	......	......	......	......
" aspera Hall....................	Ham.	......	Ham.	......	......
" attenuata Owen & Shumard....	......	......	Coal	......	......
" atwaterana‖ Miller S. A........	Ham.	......	.....	......	......
" audacula Conrad...............	......	......	Ham.	......	......
" bimesialis Hall................	......	......	Ham.	......	......
" biplicata Hall	......	......	Chem.	......	......
" capax Hall....................	....	......	Chem.	......	......
" camerata Morton..............	......	......	U.Cl.	Carb.	......
" cedarensis	......	......	Ham.	......	......
" clavalula McChesney..........	......	.....	Burl.	......	......
¶ " costata Sowerby..............	......	......	Coal	......	......
" cyrtinaformis Hall............	......	......	Chem.	......	......
" disjuncta Sowerby............	......	......	Chem.	......	......

*Synonym for R. mormoni Marcou.
†As identified by Geinitz is Syntrielasma hemiplicata Hall.—*Ulrich.*
‡See S. A. Miller, N. A. Pal., under R. cuneata, p.368; Ed.
§Syn. for R. uta Marcou.
‖Proposed instead of S. pennata Owen, preoccupied.
¶Species not likely found in America.—*Ulrich.*

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Spirifera eudora Hall	Niag.				
" euruteines Owen			U.Hl.		
" " var fornacula Hall	Ham.				
" extenuata Hall			Kind.		
" fembriata Conrad			Ham.		
" forbesi Norwood & Pratten			Burl.		
" gibbosa Hall	Niag.				
" glabra Martin			Niag		
" glans cerasus White			Ham.		
" granulifera Hall	Ham.				
" grimesi Hall			Burl.		
" hanstrum Owen			Coal		
" hirtus White & Whitefield			Chem.		
" hungerfordi Hall			Ham.		
" imbrex Hall			Burl.		
" incertus Hall			Burl.		
" inequicostata Owen			L Cl.		
" integricosta Owen			L.Cl.		
" inutilis Hall			Ham.		
" iowensis Owen			Ham.		
" keokuk Hall			Keok.		
* " laminosa McCoy				Carb.	
" ligus Owen	Ham.				
" lineata Martin			U.Cl.	Carb.	
" lynx† var biforatus Owen			H.R.		
" macbridei Calvin			Chem.		
" manni Hall			Ham.		
" marionensis‡ Shumard			Chotean		
" meta Hall	Niag.				
" mosquensis§ Fischer				Carb.	
‖ " mucronata Conrad	Ham.				
" neglecta Hall			Keok.		
" nobilis Barr	Niag.				
¶ " opima Hall			Coal		
" orestes Hall			Chem.		
" oweni Hall			U.Hl.		
" parryana Hall			Ham.		
" pennata** Owen	Ham.	Dev.			
" planoconvexa Shumard			Carb.	Carb.	
" plena Hall			Burl.		
" propinqua Hall			Keok.		
" pseudolineata Hall			Keok.		
" Racinensis McChesney	Niag.				
" radiata Sowerby	Niag.				
" rockymontana Marcou			Coal		
" rostellata Hall			Keok.		
" rotundata Owen			L.Cl		
" " var semiovalis Owen			L.Cl		
" striata Martin			Ham.		

*As identified by Geinitz is Speriferina kentuckiensis.
†Is an Orthis—or more properly a Platystrophia.—*Ulrich.*
‡Geol. Iowa, Vol. I, Pt. 1, 1858, p 511, ed.
§This species is not American.
‖Synonym for S. pennata.—*Atwater.*
¶Syn. for S. rockymontana Marcou.—*Ulrich.*
**Preoccupied—see S. atwaterana.

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Spirifera striata var triplicata Marcou...	......	......	L.Cl.	......	......
" subattenuata Hall............	......	......	Ham.	......	......
* " subcuspidata Hall..	......	......	Keok.	......	......
" subcuspidatiformis Miller S. A.	......	......	Keok.	......	......
" submucronata† Hall..........	......	......	Ham.	......	......
" suborbicularis Hall...........	......	......	Keok.	......	......
" subrotundata Hall	......	......	Chem.	......	......
" subvaricosa Hall.............	......	......	Chem	......	......
" tenuicostata Hall	......	......	War.	......	......
" whitneyi Hall................	......	......	Ha.Cg	......	......
" sp. undet	......	......	Keok.	......	......
Spiriferina kentuckiensis Shumard......	......	......	Coal	Carb.	......
" subtexta White.............	......	......	Burl.	......	......
" zigzag Hall	......	......	Ham.	......	......
Stenochisma contractum var saxatile Hall	.....	......	Chem.	......	......
‡Streptorhynchus alternatum Hall	......	Dev.	......	......	......
" americanum§ Whitfield	Gal.	......	......	......	......
" cardinale Whitfield....	H.R.	......	......	......	......
" chemungensis Conrad..	......	......	Chem.	......	......
" crassum M. & Hay	.....	......	Coal	Coal	......
" crenestriatum Phillips.	......	......	Keok.	......	......
" deflectum Conrad......	T. Ga.	T. Ga.	......	......	......
" (?) deltoideum Conrad....	T. Ga.	......	......	......	......
" filitextum Hall........	H.R.	Tr.	......	.....	......
" fluctuosum Billings....	......	H.R.	......	......	......
" inequalis Hall........	......	......	Burl.	......	......
" inflatum Wh. & Whitf.	......	......	Chem.	......	......
" lens White...........	......	......	Chem.	......	......
" planoconvexum Hall...	H.R.	......	......	......	......
" planumbonum Hall....	H.R.	.....	.....	......	......
" rectum Conrad	Tr.	......	......	......	......
" sinuatum Emmons.....	H.R.	......	......	......	......
" subplanum Conrad.....	Niag.	......	......	......	......
" subtentum Hall........	H.R.	......	......	......	......
" thalia Billings	Tr.	.....	......	......	......
" sp. undet.............	Tr. H. N.	Tr.H.	......	......	......
Stricklandinia gaspensis Billings........	Niag.	......	......	......	......
" multilirata Whitfield.....	Guel.	......	......	......	......
Strophalosia horrescens‖ de Verneuil....	......	......	......	Carb.	......
Strophodonta arcuata Hall.............	......	......	Ham.	......	......
" canace Hall..............	......	......	Chem.	......	......
" costata Owen.............	......	......	U.Hl.	......	......
" demissa Conrad...........	Ham.	......	......	......	......
" fragilis¶ Hall..............	......	......	Ham.	......	......
" hybrida Hall.............	......	......	Chem.	......	......
" inequistriata Conrad.......	Ham.	......	Ham.	......	......
" nacrea Hall	.....	......	Ham.	......	......
" perplana Conrad..........	Ham.	......	Ham.	......	......
" " var nervosa Hall..	......	......	Ham.	......	......

*Preoccupied—see S. subcuspidatiformis S. A. Miller.—*Ulrich.*
†Preoccupied—see S. subattenuata Hall.
‡This species does not occur in Minnesota.—*F. W. Sardeson.*
§See Orthisina americana Whitfield.
‖Meek regarded this identification of Geinitz's as founded on Productus nebrascensis Owen.—*Ulrich.*
¶Synonym for S. perplana Conrad.

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Strophodonta plicata Hall			Ham.		
" profunda Hall	Niag.				
" striata Hall	Niag.				
" subdemissa Hall			Chem.		
" variabilis Calvin			Chem.		
" sp. undet	Ha.N.Cg				
Strophomena alternata Conrad	T. Ga. H.	Tr.	Tr. H.		
" (?) antiquata Sowerby	H.R.				
" camerata Conrad	Tr.				
" convexa Owen			Tr.		
" deltoidea Conrad		Tr.			
" incrassata Hall	T. Ga				
" kingi Whitfield	H.R.				
" minnesotensis Win., N. H.					
" nitens Billings	H.R.	Tr.			
" patenta Hall	Tr.				
" profunda Conrad	Niag.				
" rhomboidalis Wahlenberg	Guel.				
" tenuilineata Conrad	Tr.				
" tenuistriata Sowerby	Tr.	Tr.			
" trilobata Owen		Tr.			
" unicostata Meek & Worthen	H.R.	H.R.			
" wisconsensis Whitfield	H.R.				
" sp. undet	T Ga H N	Tr. H.			
Strophonella reversa Hall			Ham.		
Syntrielasma hemiplicatum Hall			Carb.	Carb.	
Terebratula bovidens Morton			Carb.	Carb.	
" elia Hall			U.Hl.		
" jucunda Hall			U.Hl.		
* " lamellosa L'Eveille			L.Cl.		
" navicella Hall			Ham.		
" romingeri			Ham.		
" sacculus Owen			L.Cl.		
" serpentina (?) Owen			L.Cl.		
" sp. undet			N. Hl. Cl.		
Trematis sp. undet	Tr.N.	Tr.			
Trematospira hirsuta Hall	Ham.				
Trimerella grandis Billings	Niag.				
Triplesia primordialis Whitfield	P.				
Tropidoleptus carinatus Hall			Ham.		
" occidens Hall			Ham.		
Waldheimia (?) compacta Wh. & St. J.			U.Cl.		
Zygospira modesta Hall	T. Ga. H.				
" recurvirostris Hall	T. Ga.	Tr.			

SUBKINGDOM MOLLUSCA.

CLASS LAMELLIBRANCHIATA.

	Wis.	Minn.	Iowa	Neb.	Dak.
Allorisma elegans King				Perm.	
" (sedgwickia) geinitzii Meek				Carb.	
" granosum Shumard				Carb.	

*Probably not an American species.

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Allorisma leavenworthense M. & Hay.				Carb.	
" marionense White			Burl.		
" reflexum Meek				Carb.	
" subcuneatum Meek & Hayden			Carb.	Carb.	
" subelegans Meek				Carb.	
Ambonychia acutirostra Hall	N. Gu.				
" aphaea Hall	Niag.				
" attenuata Hall	Tr.	Tr.			
" bellistriata Hall			Tr.		
" casei Meek		H.R.			
" lamellosa Hall	T. Ga.				
" obtusa* Hall			Tr.		
" orbicularis Emmons		Tr.			
" planistriata Hall	Tr.				
" radiata Hall	T. Ga.				
" recta Hall	T. Ga.				
" sp. undet.	Tr.	Tr.			
Amphicoelia leidyi Hall	Niag.				
" neglecta McChesney	Niag.				
Arca striata Schlotheim				Perm.	
Astarte† gibbosa McCoy			Carb.		
" mortonensis Geinitz				Perm.	
" nebrascensis Geinitz				Perm.	
" sp. undet				Perm.	
Astartella vera Hall			Coal		
Aucella hausmanni Goldfuss				Perm.	
Avicula (Pterinea) cancellata Barris			Ham.		
" circulus Shumard.			Chem.		
" emacerata Conrad	Niag.				
" longa Geinitz			Carb.	Carb.	
" pinnaeformis Geinitz				Perm.	
" spelemcaria Schlotheim				Perm.	
" sulcata Geinitz				Carb.	
" sp. undet			Coal		
Aviculopecten americana Meek			Carb.	Carb.	
" burlingtonensis M. & Wn.			Burl.		
" carboniferus Stevens			Carb.	Carb.	
" coxanus Meek & Worthen			Coal	Carb.	
" gradocostus White			Coal		
" koninckii M. & Wn.			L.Cl.		
" limaformis M. & Wn.			Chem.		
" missouriensis Shumard				Carb.	
" nodocostatus Wh. & Whitf.			Chem.		
" occidentalis Shumard			Carb.	Carb.	
" whitei Meek			Crab.	Carb.	
Bakevellia parva Meek & Hayden				Perm.	
Cardiomorphia ovata Hall			Chem.		
" (? Cardiopsis) parvirostris White			Chem.		
" " rhomboidea Hall			Coal		
Cardinia nana Owen			Coal		
Chaenomya cooperi Meek & Hayden				Coal	
" leavenworthensis M. & Hay.			Coal	Coal	
" minnehaha Swallow				Coal	

*See Cypricardites obtusus.
†Astarte is not a palaeozoic genus.—*Ulrich.*

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Clidophorus neglectus Hall	H.R.	......	......	......	......
" ? occidentalis M. & Hay	......	......	......	Perm.	......
" paleasi de Verneuil	......	......	......	Perm.	......
" (Solenopsis) solenoides Geinitz	......	......	......	Perm.	......
Clinopistha radiata Hall	......	......	Coal	......	......
Conocardium altum Keyes	......	......	Ham.	......	......
" pulchellum Wh. & Whitf	......	......	Chem	......	......
Cypricardella quadrata Wh. & Whitf		......	Chem.	......	......
Cypricardinia arata Hall	Niag.	......	......	......	......
" sublamellosa H. & Whitf	......	......	Ham.	......	......
Cypricardites canadensis Billings	Tr.	......	......	......	......
" megambonus Whitfield	Tr.	Tr.	......	......	......
" niota Hall	Tr.	Tr.	......	......	......
" obtusus Hall	......	......	Tr.	......	......
" quadrilatera Hall	Niag.	......	....	......	......
(?) " rigida White & Whitfield	......	......	Chem.	......	......
" rectirostris Hall	Tr.	......	......	......	......
" rotundatus Hall	Tr.	Tr.	......	......	......
" subtruncatus Hall	Tr.	.....	.....	......	......
" ventricosus Hall	Tr.	......	......	......	......
" sp. undet	Tr.	Tr.	......	......	......
Dolabra alpina Hall	......	......	U.Cl.	......	......
Edmondia aspinwallis Meek	......	......	......	Carb.	......
" burlingtonensis Wh. & Whitf.	......	......	Chem	......	......
" calhouni (?) Meek & Hayden	......	......	......	Perm.	......
" glabra Meek	......	......	......	Carb.	......
" nebrascensis Geinitz	......	......	......	Carb.	......
" radiata Hall	......	......	U.Cl.	......	......
" reflexa Meek	......	......	......	......	......
" subtruncata Meek	......	......	......	......	......
Entolium aviculatum Swallow	......	......	Carb.	Carb.	......
Euchondria neglecta Geinitz	......	......	......	Carb.	......
Gervillia longa Geinitz	......	......	......	Perm.	......
" parva Meek & Hayden	......	......	......	Perm.	......
" strigosa White	......	...	......	Chem.	......
" sulcata Geinitz	......	.....	......	Perm.	......
Leda barrisi White & Whitfield	......	......	Chem.	......	......
" bellistriata Stevens	......	......	U.Cl.	......	......
" (Nucula) subscitula Meek & Hayden	......	......	......	Perm.	......
Leptodomus leidyi Hall	Niag.	......	......	......	......
" neglectus McChesney	Niag.	......	......	......	......
" undulatus Whitfield	Niag.	......	......	......	......
Lima retifera (?) Shumard	......	......	....	Perm.	.....
Lyrodesma prostriatum Conrad	......	Tr.	......	......	......
Macrodon parvus White & Whitfield	......	......	Chem.	......	......
" tenuistriata Meek & Worthen	......	......	Carb.	Carb.	......
Megalomus canadensis Hall	Guel.	.....	......	......	......
Modiola (?) subelliptica Meek	......	......	......	Carb.	......
Modiolopsis dictarus Hall	Niag.	......	......	......	......
" faba Hall	Tr.	Tr.	......	......	......
" nilesi Meek & Worthen	Niag.	......	......	......	......
" plana Hall	Tr.	Tr.	......	......	......
" recta Hall	Niag.	......	......	......	......
" subalatus Hall	Niag.	......	......	......	......
" superba Hall	Tr.	......	......	......	......

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Modiolopsis sp. undet	Tr. N.	Ga. H.	......	......	......
Modiomorpha concentrica Conrad	Ham.	......	......	......	......
Myalina keokuk Worthen	......	......	Keok.	......	......
" perattenuata	......	......	......	Carb.	......
" subquadrata Shumard	......	......	......	Perm.	......
" swallovi McChesney	......	......	Coal	Carb.	......
Mytilus concavus (?) Swallow & Hayden	......	......	......	Perm.	......
" fibristriatus White & Whitfield	......	......	Chem.	......	......
" occidentalis White & Whitfield	......	......	Chem.	......	......
Nucula beyrichi von Schauroth	......	......	......	Perm.	......
" iowensis White & Whitfield	......	......	Chem.	......	......
" kankanensis de Verneuil	......	......	......	Perm.	......
" parva McChesney	......	......	Coal	......	......
" subacuta Meek & Hayden	......	......	......	Perm.	......
" ventricosa Hall	......	......	Coal	Carb.	......
Nuculana bellistriata Stevens	......	......	Coal.	......	......
Orthonota parallela? Hall	......	Tr.	......	......	......
" ventricosa Whitfield	......	......	Chem.	......	......
Orthodesma sp. undet	......	H.R.	......	......	......
Palaeoneilo constricta Conrad	Ham.	......	......	......	......
" emarginata Conrad	Ham.	......	......	......	......
" fecunda Hall & Whitfield	Ham.	......	......	......	......
" nuculiformis Stevens	Ham.	......	......	......	......
Paleocardia cordiformis Hall	Niag.	......	......	......	......
Paracyclas sabini White	......	......	Chem.	......	......
Pecten grandarvus Goldfuss	......	......	......	Carb.	......
" hawni (vide Aviculopecten carboniferus) Geinitz	......	......	Carb.	Perm.	......
Pernopecten shumardianus Winchell	......	......	Kind.	......	......
Pinna hinrichsiana White & St. John	......	......	Subca	......	......
" peracuta Shumard	......	......	Carb.	Carb.	......
" subspatula Worthen	......	......	Keok.	......	......
Pleurophorus oblongus Meek	......	......	......	Carb.	......
" (?) occidentalis M. & Hay.	......	......	......	Perm.	......
" (Cardinia) subacuneata M. & Hay.	......	......	......	Perm.	......
Prothyris elegans Meek	......	......	......	Carb.	......
Pseudomonotis hawni Meek & Hayden	......	......	......	Perm.	......
" radialis Phillips	......	......	......	Carb.	......
" sp. undet	......	......	......	Carb.	......
Pterinea aviculoidea Hall	L.Hl.	......	......	......	......
" demissa Hall?	H.R.	......	......	......	......
" striacosta McChesney	Niag.	......	......	......	......
" (?) undulata Meek & Worthen	......	......	Kind.	......	......
Pteronites sp. undet	Ham.	......	......	......	......
Sanguinolaria sp. undet	......	......	Coal	......	......
Schizodus curtus Meek & Hayden	......	......	......	Carb.	......
" obscurus Sowerby	......	......	......	Perm.	......
" rossicus de Verneuil	......	......	......	Perm.	......
" truncatus King	......	......	......	Perm.	......
" sp. undet	Niag.	......	......	......	......
Sedgwickia concava Meek & Hayden	......	......	......	Perm.	......
Solenomya soleniformes Cox	......	......	Coal	......	......
" 2 sp. undet	......	......	......	Carb.	......
Solenopsis solenoides Geinitz	......	......	......	Carb.	......
Tellinomya alta Hall	Tr.	Tr.	......	......	......

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn	Iowa	Neb.	Dak.
Tellinomya hartsvillensis Safford	......	Tr.	......	......	......
" iphigenia Billings	Tr.	......	......	......	......
" levata Hall	Tr.	......	Tr.	......	......
" nasuta Hall	Tr.	......	......	......	......
" ventricosa Hall	Tr.	Tr.	......	......	......
" sp. undet Hall	T. Ga.	T. Ga.	......	......	......
Yoldia subscitula Meek & Worthen	......	......	......	Carb.	......
Class Gasteropoda.					
Aclisina minuta Stevens	......	......	Coal	......	......
" robusta Stevens	......	......	Coal	......	......
" swalloviana Geinitz	......	......	......	Carb.	......
Anomphalus rotulus Meek & Worthen	......	......	Coal	......	......
Bellerophon antiquatus Whitfield	P.	......	......	......	......
" bilabiatus White & Whitfield	......	......	Chem.	......	......
" bilobatus Sowerby	Tr.	Tr.	Tr.	......	......
" hiulcus Sowerby	......	......	L.Cl.	......	......
" interlineatus Portlock	......	......	......	U.Cl.	......
" kaukasensis Swallow	......	......	......	Carb.	......
" marcouianus Wh. & Whitf.	......	......	......	U.Cl.	......
" montfortianus Nor. & Prat.	......	......	......	U.Cl.	......
" nodocarinatus Hall	......	......	Coal	......	......
" panneus White	......	......	Kind.	......	......
" percarinatus Conrad	......	......	Coal	Carb.	......
" perelegans Wh. & Whitf.	......	......	Kind.	......	......
" scrieptiferus White	......	......	Kind.	......	......
" urii Fleming	......	......	Coal	......	......
" vinculatus Wh. & Whitf.	......	......	Kind.	......	......
" wisconsensis Whitfield	Tr.	......	......	......	......
Bucania angustata Hall	Niag.	......	......	......	......
" bidorsata Hall	Tr.	Tr.	......	......	......
" buelli Whitfield	Tr.	......	......	......	......
" expansa Hall	......	Tr.	......	......	......
" punctifrons Hall	Tr.	......	......	......	......
" trigonostoma Hall & Whitfield	Niag.	......	......	......	......
Bulimorpha minuta Stevens?	......	......	Coal	......	......
Callonema lichas Hall & Whitfield	......	......	Dev.	......	......
Capulus cornuformis Winchell	......	......	Kind.	......	......
" coyrtolites McChesney	......	......	Burl.	......	......
" equilaterus Hall	......	......	B. Ke.	......	......
" fissurella Hall	......	......	Keok.	......	......
" formosus Keyes	......	......	Kind.	......	......
" infundibulum Meek & Worthen	......	......	Keok.	......	......
" latus Keyes	......	......	Burl.	......	......
" obliquus Keyes	......	......	Burl.	......	......
" paralius White & Worthen	......	......	Kind.	......	......
" quincygensis McChesney	......	......	Burl.	......	......
" romerius Winchell	......	......	Kind.	......	......
" tribulosus White	......	......	Burl.	......	......
" uncus Meek & Worthen	......	......	Keok.	......	......
Clisospira occidentalis Whitfield	......	......	Coal	......	......
Conchopeltis minnesotensis Walcott	......	Tr.	......	......	......
Cyclonema (?) elevata Hall	Niag.	......	......	......	......
" pauper Hall	Niag.	......	......	......	......

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Cyclonema percarinata Hall	T. Ga.	......	......	......	......
Cyrtolites carinatus Miller, S. A.	......	Gal.	......	......	......
" compressus Conrad	Tr.	Tr.	......	......	......
" dyeri Hall	Gal.	......	U.Cl.	......	......
" gillianus White & St. John	......	......	..	......	......
Dentalium annulostriatum M. & Wn.	......	......	Coal	......	......
" grandaevum Winchell	......	......	Kind.	......	......
" meekianum Geinitz	......	......	Coal	Coal	......
" obsoletum Hall	......	......	Coal	......	......
Eccyliomphalus undulatus	Tr.	......	......	......	......
Eunema (Murchisonia) pagoda Salter	Tr.	......	......	......	......
" (?) trilineata Hall	Niag.	......	......	......	......
Euomphalus ammon White & Whitfield	......	......	Chem.	......	......
" barrisi Winchell	......	......	Kind.	......	......
" latus Hall	......	......	Burl.	.....	......
" macrolineatus Whitfield	Niag.	......	......	......	......
" macromphalus	......	......	Kind.	......	......
" minnesotensis Owen	......	Tr.	......	......	......
" mopsus Hall	Niag.	......	.....	......	......
" obtusus Hall	......	......	Kind.	......	......
" pernodosus M. & Wn.	......	......	Coal	......	......
" pervetus Conrad	......	......	Tr.	......	......
" roberti White	......	......	Burl.	......	......
" rugosus (vide subrugosus) Hall	......	......	Coal	......	......
" strongi Whitfield	L Mag	......	......	......	......
" subrugosus M. & Wn.	......	......	Coal	......	......
" treliratus Conrad	......	......	Tr.	......	......
" vaticinus Hall	P.	......	......	......	......
Fusispira elongata Hall	Gal.	Gal.	......	......	......
" subfusiformis Hall	......	Gal.	......	......	......
" terebriformis Hall	.....	Gal.	......	......	......
" ventricosus Hall	Gal.	Gal.	......	......	......
Helicotoma plamulata Salber	Tr.	Tr.	......	......	......
Holopea conica Winchell	......	......	Kind.	......	......
" elevata Hall	Guel.	......	......	......	......
" guelphensis Billings	Guel.	......	......	......	......
" harmonia (?) Billings	Guel.	......	......	......	......
" magniventra Whitfield	Guel.	......	......	......	......
" obliqua Hall	T. Ga.	......	......	......	......
" pal dinaeformis Hall	T. Ga.	......	......	......	......
" pyrene (?) Billings	Ga. (?)	......	......	......	......
" subconica Winchell	......	......	Kind.	......	......
" sweeti Whitfield	P.	......	......	......	......
" (Pleurotomaria) turgida Hall	L Mag	......	.....	......	......
" ventricosa Hall	......	Tr.	.....	......	......
Holopella mira Winchell	......	......	Kind.	......	......
Inachus pervetus (vide Euomphalus pervetus) Conrad	......	......	Tr.	......	......
Loxonema leda	Niag.	......	......	......	......
" magnum Whitfield	Guel.	......	.....	......	......
" oligospira Winchell	......	......	Kind.	......	......
" pexatum Hall	......	......	Chem.	......	......
Maclurea bigsbyi Hall	Tr.	Tr.	......	......	......
" cuneata Whitfield	Gal.	Gal.	......	......	......
" logani Salber	......	......	Tr.	......	......

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Maclurea magna Le Sueur	......	Tr.	H.R.	......	......
" subrotundata Whitfield	Gal.	......	......	......	......
Metoptoma barabuensis Whitfield	L Mag	......	......	......	......
" montrealensis Billings	......	Tr.	......	......	......
" patelliformis Hall	H.R.	Gal.	......	......	......
" perovalis Whitfield	Tr.	......	......	......	......
" recurva Whitfield	L Mag	......	......	......	......
" retrorsa Whitfield	L Mag	......	......	......	......
" similis Whitfield	L Mag	......	......	......	......
" superba Billings	......	Tr.	......	......	......
" umbella Meek & Worthen	......	......	Burl.	......	......
" undata Winchell	......	......	Kind.	......	......
Murchisonia abbreviata Hall	......	......	Tr.	......	......
" alexandria Billings	Gal.	......	......	......	......
" augustata Hall	......	Tr. H.	......	......	......
" bellicincta Hall	......	Tr. H.	H.R.	......	......
" " var major Hall	T. Ga.	......	......	......	......
" becincta Hall	Tr. H.	Tr. H.	......	......	......
" boydi Hall	Guel.	......	......	......	......
" chamberlini Whitfield	Guel.	......	......	......	......
" conradi Hall	Niag.	......	......	......	......
" gracilis Hall	T. Ga.	Tr.	......	......	......
" helecteres Salber	T. Ga.	Tr.	......	......	......
" hercyna Billings	Guel.	......	......	......	......
" laphami Hall	Niag.	......	......	......	......
" logani Hall	Guel.	......	......	......	......
" longespira Hall	Guel.	......	......	......	......
" macrospira Hall	Guel.	......	......	......	......
" marconiana Geinitz	......	......	......	U.Cl.	......
" milleri Hall	......	Tr.	......	......	......
" mylitta Billings	Guel.	......	......	......	......
" nebrascensis Geinitz	......	......	......	U.Cl.	......
" neglecta Winchell	......	......	Kind.	......	......
" (Eurema) pagoda Salber	Tr.	......	......	......	......
" perangulata Hall	......	Tr.H.	......	......	......
" prolixa White & Whitfield	......	......	K.	......	......
" quadricincta Winchell	......	......	Kind.	......	......
" shumardiana Winchell	......	......	......	......	......
" subfusiformis Hall	......	Tr. H.	H.R.	......	......
" subtarniata Geinitz	......	......	......	U.Cl.	......
" sumnerensis Safford	......	Tr.	......	......	......
" tricarenata Hall	Tr.	Tr.	Tr.	......	......
" turretiformis Hall	Guel.	......	......	......	......
" ventricosa Hall	Tr.	Tr.	......	......	......
Naticopsis depressa Winchell	......	......	Kind.	......	......
" gigantea Hall	......	......	Ham.	......	......
Ophileta (Raphistoma) primordialis Win.	P.	......	......	......	......
" uniangularis Vanuxem	L Mag	......	......	......	......
" sp. undet	L Mag	......	......	......	......
Orthonema conica Meek & Worthen	....	......	Coal	......	......
Palaeomara irvingi Whitfield	L Mag	...	......	......	......
Platyceras biserialis Hall	......	......	Burl.	......	......
" bivalve White & Whitfield	......	......	Chem.	......	......
" capulus (?) Hall	......	......	Burl.	......	......
" niagarensis Hall	Niag.	......	......	......	......

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Platyceras paralium White & Whitfield			Chem.		
" primordialis Hall	P.				
" reversum Hall			Burl.		
" subrectum Hall & Whitfield			Keok.		
" ventricosum Conrad			Ham.		
Platyostoma bivalve White & Whitfield			Kind.		
" lineata Conrad			Ham.		
Platystoma niagarensis Hall	Guel.				
Pleurotomaria alvena Winchell	P.				
" ambigua Hall		Tr.			
" axion Hall	N. Gu.				
" bilix Conrad			H R.		
" brazoensis Shumard			Coal		
" carbonaria Nor. & Prat.			Coal		
" depauperata Hall	Tr.				
" galtensis Billings	Guel.				
" grayvillensis Nor. & Prat.			Coal	U.Cl.	
" halei Hall	N. Gu.				
" haydeniana Geinitz				U. Cl.	
" hoyi Hall	Niag.				
" idia Hall	Niag.				
" inornata Meek				U.Cl.	
" isaacsii Hall			Ham.		
" laphami Whitfield	Niag.				
" lenticularis Emmons		Tr.	H.R.		
" mississippiensis Wh. & Whitf.			Chem.		
" missouriensis Geinitz				U.Cl.	
" modesta Keyes			L.Cl.		
" murialis Owen		L Mag			
" niota Hall	Tr.				
" occidens Hall	Tr.				
" pauper Hall	Niag.				
" perhumerosa Meek				U.Cl.	
" perlata Hall	Niag.				
" racinensis Whitfield	Niag.				
" sphaerulata Conrad			Coal	Carb.	
" subconica Hall	Tr.	Tr.			
" subdecussata Geinitz				U.Cl.	
" tabulata Hall (?)			Coal		
" umbilicata Hall		Tr. H.			
" valvatiformis M. & Wn.			L.Cl.		
Porcellia crassinoda White & Whitfield			Kind.		
" nodosa Hall			Kind.		
" obliquinoda White			Kind.		
" rectinoda Winchell			Kind.		
Raphistoma lapicida Salber		Tr. H.			
" lenticularis Sowerby	T.Ga.	Tr.			
" nasoni Hall	Tr.				
" niagarensis Whitfield	Niag.				
Scaevogyra elongata Whitfield	L Mag				
" obliqua Whitfield	L Mag				
" ornata (?)		Tr			
" swezeyi Whitfield	L Mag				
Soleniscus attenuatus Hall			Coal		
" brevis White			Coal		

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Soleniscus gracilis Cox	......	......	Coal	......	......
" hallianus Geinitz	......	......	......	U.Cl.	......
" humilis Keyes	......	......	Coal	......	......
" medialis Meek & Worthen	......	......	......	Coal	......
" newberryi Stevens	......	......	Coal	......	......
" paludinaeformis Hall	......	......	Coal	......	......
Sphaeradoma medialis M. & Wn	......	......	L.Cl	......	......
" pinguis Winchell	......	......	Kind.	......	......
" ponderosa Swallow	......	......	Coal	......	......
" primagenius Conrad	......	......	Coal	U. Cl.	......
Straparollus catilloides Conrad	......	......	L.Cl.	......	......
" cyclostomus Hall	......	......	Ham.	......	......
" hippolyta Billings	......	......	Guel.	.....	......
" minnesotensis (vide Euomphalus minnesotensis) Owen	......	Tr.	......	......	......
" pernodosus Meek & Worthen	......	......	L.Cl.	......	......
" solanoides Hall	Guel.	......	......	......	......
Streptacis whitfieldi Meek	......	......	Coal	......	......
Subulites elongatus Emmons	T. Ga.	Tr.	Tr.	......	......
" ventricosus Hall	N. Gu.	......	......	......	......
Tremanothus alpheus Hall	Niag.	......	......	......	......
Trochonema ambiguum Hall	Tr.	......	......	......	......
" beachi* Whitfield	Tr.	Tr.	......	......	......
" beloitense Whitfield	Tr.	Tr.	......	......	......
" fatua Hall	N. Gu.	......	......	......	......
" lapicidum Salber	H. R.	......	......	......	......
" umbilicatum (vide T. beachi) H.	T. Ga.	Tr.	......	......	......
Turbo lenticularis Conrad	......	......	Tr.	......	......
Turbonilla swalloviana Geinitz	......	......	......	U.Cl.	......
Zenophora trignostoma Meek	Niag.	......	......	......	......
Order Pteropoda.					
Conularia bylbis White	......	......	Chem.	......	......
" trentonensis Hall	Gal.	Tr.	......	......	......
" victa White	......	......	Chem.	......	......
" sp. undet	......	Tr.	......	......	......
Hyolithes baconi Whitfield	Tr.	......	......	......	......
" primordiales Hall	P.	......	......	......	......
Pterotheca attenuata Hall	Tr.	......	......	......	......
Class Cephalopoda.					
Actinoceras beloitense Whitf	Tr.	......	......	......	......
Cyrtoceras amplicorne Hall	Niag.	......	......	......	......
" annulatum† Hall	Tr.	......	......	......	......
" arcticameratum Hall	Guel.	......	......	......	......
" brevicorne Hall	Niag.	......	......	......	......
" camurum Hall	Tr.	......	......	......	......
" conicum Owen	......	......	L Mag	......	......
" corniculum‡ Hall	Tr.	......	.....	.....	......
" dardanus Hall	Niag.	......	......	......	......
" eugium Hall	Tr.	......	......	......	......

*See T. umbilicatum. Also Geol. Wis., Vol. IV. p. 213.
†C. subannulatum D'Orbigny proposed instead.
‡C. tenuistriatum Hall proposed instead.

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Cyrtoceras hercules Winchell & Marcy..	Niag.	......	......	......	......
" infundibulum Whitfield......	Niag.	......	......	......	......
" laterale Hall................	N. Gu.	......	......	......	......
" loculosum Hall..............	Tr.	......	......	......	......
" lucillus Hall................	Niag.	......	......	......	......
" macrostomum Hall..........	Tr.	Tr.	Tr.	......	......
" marginalis Conrad..........	......	......	Niag.	......	......
" neleus Hall.................	Tr.	......	......	......	......
" opimum Keyes.............	......	......	Ham.	......	......
" planodorsatum Whitfield.....	Tr.	Tr.	......	......	......
" pusillum Hall...............	Niag.	......	......	......	......
" rectum Whitfield............	Guel.	......	......	......	......
" rigidum Hall................	N. Gu.	......	......	......	......
" sp. undet....................	......	T. Ga.	Niag.	......	......
Discites tuberculatus Owen............	......	......	Subca	......	......
Discosorus conoideum Hall............	Niag.	......	......	......	......
Endoceras angusticameratum Hall......	......	Tr.	......	......	......
" annulatum Hall.............	Tr.	......	......	......	......
" cuvieri Owen...............	......	......	H.R.	......	......
" distans Hall................	......	Tr.	......	......	......
" magniventrum Hall.........	......	Tr.	......	......	......
" proteiforme Hall............	Tr.	Tr.	Tr.	......	......
" " var strangulatum Hall	......	Tr.	......	......	......
" rapax Billings..............	......	Tr.	......	......	......
" (Camoceras) subannulatum Whitf.	Tr.	......	......	......	......
" subcentrale Hall.............	......	......	Tr.	......	......
" sp. undet....................	Tr.	Tr.	......	......	......
Gomphoceras fusiforme Whitf..........	Ham.	......	......	......	......
" breviposticum Whitf........	Ham.	......	......	......	......
" scrinum Hall	Niag.	......	......	......	......
" septoris Hall................	Niag.	......	......	......	......
" sp. undet....................	T.N.Gu.	Tr.	......	......	......
Goniatites iowensis Meek & Worthen...	......	......	Coal	......	......
" nolinensis Cox...............	......	......	L.Cl.	......	......
" opimus White & Whitfield....	......	......	Chem.	......	......
Gonioceras anceps Hall	Tr.	......	......	......	......
" occidentalis Hall.............	Tr.	......	......	......	......
Gyroceras burlingtonensis Owen........	......	......	L.Cl.	......	......
" convolvans Hall...............	Tr.	......	......	......	......
" cornutum Owen......	......	......	L Mag	......	......
" duplicostatum Whitfield.......	Tr.	......	......	......	......
" hercules Winchell & Marcy....	Niag.	......	......	......	......
" pratti Barris..................	......	......	Chem.	......	......
" sp. undet.....................	Niag.	......	......	......	......
Huronia annulatum Hall..............	Niag.	......	......	......	......
Lituites Marshii Hall..................	Niag.	......	......	......	......
" multicostatus Whitfield.........	Niag.	......	......	......	......
" occidentalis Hall	Tr.	......	......	......	......
" ortoni Meek....................	Niag.	......	......	......	......
" robertsoni Hall...	H. R.	......	......	......	......
" undatus Emmons...............	......	Tr.	......	......	......
Nautilus biserialis Hall................	......	......	Coal.	......	......
" capax Hall.....................	Niag.	......	......	......	......
" divisus White & St. John......	......	......	U.Cl.	......	......
" lasalliensis Meek & Worthen...	......	......	Coal	......	......

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Nautilus eccentricus Meek & Hayden...	......	......	......	Perm.	......
" occidentalis Swallow..........	N.(?)	......	Coal	......	......
" planorbiformis M. & Wn.......	......	......	Coal	......	......
" (Cryptoceras) springeri Wh. & St. J	......	......	U.Cl.	......	......
" winslovi Meek & Worthen.....	......	......	Coal	......	......
" sp. undet....................	Niag.	Tr. (?)	......	......	......
Oncoceras abruptum Hall...............	Tr.	......	......	......	......
" alceus Hall..................	Tr.	......	......	......	......
" brevicurvatum Hall...........	Tr.	......	......	......	......
" lycus Hall....................	Tr.	......	.....	......	......
" mummiformie Whitfield	Tr.	Tr.	......	......	......
" orcas Hall....................	Niag.	......	......	......	......
" pandion Hall..................	Tr.	......	......	......	......
" plebeium Hall................	Tr.	......	......	......	......
Ormoceras tenuifilum Hall.............	Tr.	Tr.	.....	......	......
" sp. undet...	Tr.N.	......	......	......	......
Orthoceras abnorme Hall...............	Niag.	Tr	......	......	......
" alienum Hall..................	Niag.	......	......	......	......
" amplicameratum Hall.........	Tr.	Tr.	......	......	......
" angulatum Wahlenberg........	Niag.	......	......	......	......
" anellum Conrad...............	Tr.	......	......	......	......
" annulatum Sowerby...........	N.Gu.	......	......	.....	......
" (Actinoceras) Beloitense Whitf	Tr.	......	......	......	......
" bilineatum Hall...............	.....	Tr.	......	......	......
" capitolinum Safford	Tr.	......	......	......	......
" carltonense Whitfield.........	Guel.	......	......	......	......
" columnare Hall...............	N. Gu.	......	......	......	......
" crebescens Hall..............	......	Niag.	......	......	......
" cribrosum Geinitz.............	.....	......	Carb.	Perm.	......
" hoyi McChesney..............	Guel.	......	......	......	......
" iowense Ow. (see O. undulatum)	......	.....	Niag.	......	......
" junceum Hall.................	N. Ga.	Tr.	......	......	......
" laphami McChesney...........	Niag.	......	......	......	......
" laqueatum Hartt..............	......	......	L Mag	......	......
" loxias Hall....................	Niag.	......	......	......	.....
" marginale Owen..............	......	......	L Mag	......	......
" medullare Hall................	Niag.	.....	......	......	......
" multicameratum Hall..........	Tr.	Tr.	Tr.	......	......
" niagarense Hall...............	Niag.	......	......	......	......
" planoconvexum Hall..........	T. Ga.	......	......	......	......
" primogenium Hall............	L Mag	......	......	......	......
" procerum Hall................	......	......	......	......	......
" rushensis McChesney.........	......	......	Coal	......	......
" undulatum* Owen	......	......	Niag.	......	......
" undulostriatum Hall..........	......	......	Tr.	......	......
" vastator Hall.................	......	......	Niag.	......	......
" vertebrale Hall................	Niag.	......	......	......	......
" wauwatosense Whitfield.......	Niag.	.....	......	......	......
" sp. undet......................	T. N. Ha.	Tr.	Coal	......	......
Phragmoceras hoyi Whitfield...........	Niag.	......	......	......	......
" " var compressus Whitf.	Niag.	......	......	......	......
" labiatum Whitfield..........	Niag.	.....	......	......	......
" nestor Hall..................	Niag.	......	......	......	......
Trochoceras bannisteri Winchell & Marcy	Niag.	.....	.....	......	......

*Preoccupied by Sowerby, 1812.—*Miller, S. A., N. A. Pal., p. 452.*

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Trochoceras costatum Hall..............	Niag.	......	......	......	......
" desplainense McChesney.....	Niag.	......	......	......	......
" gebhardi Hall.......	Guel.	......	......	......	......
" notum Hall..................	Niag.	......	......	......	......
Trocholites ammonius Conrad..........	......	Tr.	......	......	......

SUB-KINGDOM VERTEBRATA.

Class Pisces.

NAMES OF FOSSILS.	Wis.	Minn.	Iowa	Neb.	Dak.
Acondylacanthus gracilis St. J. & Wn...	......	......	Kind.	......	......
Agassizodus scitulus St. John & Worthen	......	......	L.Cl.	......	......
" variabilis Newb. & Worthen.	.....	......	U.Cl.	......	......
Anaclitacanthus senucostatus Newb. & W	......	......	Burl.	......	......
Antliodus, sarculus Newb. & Wn.....	......	......	Burl.	......	......
" simplex Newberry & Worthen.	......	......	Burl.	......	......
Asteroptychius bellulus St. J. & Wn.....	......	......	L. Cl.	......	......
" vetustus St. John & Wn......	......	......	Kind.	......	......
Batacanthus baculiformis St. John & Wn	......	......	Keok.	......	......
Bathychilodus macisaacsi St. John & Wn	......	......	Dev.	......	......
Calopodus apicalis St. John & Worthen..	......	......	M.Cl.	......	......
Cholodus inaequalis St. John & Worthen	......	......	U.Cl.	......	......
Chomatodus arcuatus St. John..........	......	......	......	U.Cl.	......
" comptus St. John & Wn.....	......	......	Burl.	......	......
" elegans Newberry & Wn....	......	......	Keok.	......	......
" gracillemus Newb. & Wn....	......	......	Burl.	......	......
" inconstans St. John & Wn....	......	......	St. L.	......	......
" incrassatus St. John & Wn...	......	......	St. L.	......	.....
" multiplicatus Newb. & Wn..	......	......	Burl.	....	......
Cladodus alternatus St. John & Worthen	......	......	Kind.	......	......
" bellifer St. John & Wn........	......	......	Burl.	.....	......
" carinatus St. John & Wn......	......	......	Coal	......	......
" englypheus St. John & Wn....	......	......	St. L.	......	......
" exilis St. John & Worthen.....	......	......	Kind.	.....	......
" exiguus St. John & Worthen...	......	......	Kind.	......	......
" fulleri St. John & Worthen....	......	......	L.Cl.	......	......
" gomphoides St. John & Wn ...	......	......	Burl.	......	......
" intercostatus St. John & Wn...	......	......	Kind.	......	......
" mortifer Newberry & Worthen	......	......	......	U.Cl.	......
" praenuntins St. John & Wn....	......	......	Burl.	......	......
" raricostis St. John & Worthen.	......	......	Keok.	......	......
" springeri St. John & Worthen.	......	......	Kind.	......	......
" succinctus St. John & Worthen	......	......	Kind.	......	......
" wachsmuthi St. John & Wn....	......	......	Kind.	......	......
Cochliodus costatus Newberry & Wn....	......	......	Burl.	......	......
Ctenacanthus burlingtonensis St. J. & Wn	......	......	Burl.	......	......
" excavatus St. John & Worthen.	......	.....	Keok.	......	......
" gradocostus St. John & Wn....	......	......	Burl.	......	......
" keokuk St. John & Worthen...	......	......	Keok.	......	......
" mayi Newberry & Worthen....	......	......	Burl.	......	......
" sculptus St. John & Worthen..	......	......	Kind.	......	......
" speciosus St. John & Worthen.	......	......	Kind.	......	......
" spectabilis St. John & Worthen	......	......	Kind.	......	......

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Ctenacanthus varians St. John & Worthen	......	......	Kind.	......	......
Ctenopetalus (Petalodus) bellulus St. John & Worthen...	......	......	St. L.	......	......
" occidentalis St. John & Wn..	......	......	L.Cl.	......	......
" vinosus St. John & Worthen...	......	......	Keok.	......	......
Deltodus angularis Newberry & Wn.....	......	......	U.Cl.	U.Cl.	......
" intermedius St. J. & Wn.......	......	......	L.Cl.	......	......
" undulatus Newberry & Wn....	......	......	Keok.	......	......
Desmiodus ligoniformis St. J. & Wn....	......	......	Keok.	......	......
Diplodus compressus Newberry & Wn..	......	......	U.Cl.	U.Cl.	......
" sp. undet........	......	......	Coal	......	......
Drepanacanthus gemmatus Newb. & Wn.	......	......	Keok.	......	......
Glymmatacanthus irishii St. J. & Wn...	.....	......	Kind.	......	......
Helodus biformis Newberry & Worthen	......	......	Kind.	......	......
" compressus Newberry & Wn....	......	......	Burl.	......	......
" coniculus Newberry & Worthen	......	......	Burl.	......	.....
" limax Newberry & Worthen....	......	......	Burl.	......	......
" placenta Newberry & Worthen..	......	......	Kind.	......	......
Hybocladodus compressus St. J. & Wn..	......	......	Burl.	......	......
" plicatilis St. John & Wn...	......	......	Burl.	......	......
" tenuicostatus St. J. & Wn..	......	......	Keok.	......	......
Lambdodus calceolus St. John & Wn....	......	.....	Burl.	......	......
" costatus St. John & Worthen..	......	......	Burl.	......	......
Leiodus calcaratus St. John & Worthen.	......	......	Burl.	......	......
Lisgodus curtus St. John & Worthen....	......	......	Burl.	......	......
" serratus St. John & Worthen. .	......	......	Burl.	......	......
Mesodmodus explanatus St. John & Wn.	......	......	Kind.	......	......
" exsculptus St John & Wn....	......	......	Kind.	......	......
" ornatus St. John & Worthen..	......	......	Burl.	......	......
Orodus alleni St. John & Worthen......	......	......	L.Cl.	......	......
" carinatus St. John & Worthen...	......	......	Keok.	......	......
" daedaleus St. John & Worthen..	......	......	Kind.	......	......
" elegantulus Newberry & Wn...	......	......	Burl.	......	......
" fastigiatus St. John & Worthen.	......	......	Burl.	.....	......
" major St. John & Worthen......	......	......	Burl	......	......
" neglectus St. John & Worthen..	......	......	St. L.	......	......
" parallelus St. John & Wn......	......	.....	Kind.	......	......
" variocostatus St. John & Wn....	......	......	Burl.	......	......
" whitei St. John & Worthen	......	......	Kind.	......	......
Oracanthus consimilis St. John & Wn..	......	......	St. L.	......	......
" pnigeus (see Pnigeacanthus deltoides	......	......	......	......	......
Periplectrodus warreni St. John & Wn..	......	......	Burl.	......	......
Peripristis semireticularis Newb. & Wn	......	......	......	U.Cl.	......
Petalodus destructor Newberry & Wn...	......	......	......	U.Cl.	......
Petalorhynchus distortus St. John & Wn	......	......	St. L.	......	......
" spatulatus St. John & Wn	......	......	St. L.	......	......
Petrodus occidentalis Newberry & Wn..	......	......	Coal	......	......
" pustulosus Newberry & Wn...	......	......	Burl.	......	......
Phoebodus sophiae St. John & Worthen.	......	......	Dev.	......	......
Physonemus altonensis St. John & Wn.	......	......	St. L.	......	......
" proclivus St. John & Wn..	......	......	Kind.	......	......
Pnigeacanthus deltoides St. John & Wn.	......	......	Keok.	......	......
Polyrhizodus nanus St. John & Worthen	......	......	Keok.	......	......
" porosus Newberry & Wn..	......	......	Burl.	......	......
" williamsi St. John & Wn..	......	......	Keok.	......	......

NAMES OF FOSSILS.	STATES AND FORMATIONS.				
	Wis.	Minn.	Iowa	Neb.	Dak.
Pristicladodus springeri St. John & Wn	......	.....	Kind.	......	......
Pristodus acuminatus St. John & Wn...	......	......	Kind.	......	......
Psephodus reticulatus St. John & Wn...	......	......	Kind.	......	......
Rhynchodus occidentalis Newberry.....	......	......	Ham.	......	......
Rhynchonodus excavatus Newberry....	Ham.	......	......	......	......
Stemmatodus bicristratus St. J. & Wn...	......	......	Burl.	......	......
Stemmatodus bifurcatus St. John & Wn.	.....	......	Burl.	......	......
" cheiriformis St. John & Wn	......	......	Burl.	......	......
" simplex St. John & Wn...	......	......	Burl.	......	......
" symmetricus St. J. & Wn..	......	......	Burl.	......	......
Tanaodus praenuntius St. John & Wn...	......	......	St. L.	......	......
" pumilus St. John & Worthen..	......	......	St. L.	......	......
" sculptus St. John & Worthen..	......	.....	St. L.	......	......
Thrinacodus duplicatus Newb. & Wn...	......	......	L.Cl.	......	......
" nanus St. John & Worthen.	......	......	Kind.	......	......
Venustodus robustus St. John & Wn....	......	......	Burl.	......	......
" tenuicristatus St. John & Wn.	......	......	Burl.	......	......
" variabilis St. John & Worthen	......	......	Burl.	......	......
Xystrodus occidentalis St. John.........	......	......	U. Cl.	U. Cl.	......
VEGETABLE KINGDOM.					
Bythrotrephis gracilis Hall.............	Tr.	......	......	......	......
" succulens Hall............	T. Ga.	......	......	......	......
" sp. undet.................	Tr. N.	Tr.	......	......	......
Cruziana sp. undet.....................	P. T. Ga.	......	......	......	......
Cyclopteris sp. undet..................	......	......	......	Perm.	......
Fucoides gen. & sp. undet..............	L Mag	L Mag	......	......	......
Gulielmites permianus Geinitz..........	.....	......	......	Perm.	......
Nullipora (?) obtexta White...........	......	......	Chem.	......	......
Odontopteris sp. undet.................	......	......	......	Perm.	......
Pachyphyllum nordmanni White.......	......	......	Chem.	......	......
" solitarium White.........	......	.....	Chem.	......	......
woodmanni White..............	......	......	Chem.	......	......
Palaeochorda* prima Whitfield.........	......	......	......	......	P.
" sp. undet.................	P.	......	......	......	......
Palaeophycus carspitosum Hall.........	Tr.	......	......	......	......
" duplex Hall..............	P.	......	......	......	......
" occidentalis Whitfield.....	......	......	......	......	P.
" plumosus Whitfield.......	P.	......	......	......	......
" simplex Hall.............	P.	......	......	......	......
"* tubulare Hall	P.	......	......	......	......
" sp. undet..................	P. Tr. H.	Tr.	.....	......	P.
Sigillariae sp. & gen. undet.............	Ham.	......	......	......	......
Sphenothallus sp. undet................	L. Hl.	......	......	......	......

*Palaeochorda and Palaeophycus may be filled-up burrows of wandering marine worms.

October 2, 1888.

A few names may be noticed which have appeared subsequent to the date appended to the foregoing list; they have been added while the paper was going through the press.—EDITOR.

[*Paper AA*]

THE DEEP WELL AT MINNEOPA, MINNESOTA.—*C. W. Hall.*

[The following description is based chiefly on notes and borings secured by Mr. Bruno Bierbauer. The notes were taken on the spot from week to week and the borings were kindly furnished by Mr. Fox, who was in charge of the work. When the depth of 800 feet was reached, Mr. Bierbauer was obliged to leave Mankato. Subsequently Mr. W. D. Willard tried in vain to obtain further data. All borings which had been saved were so mixed and changed that even the workmen could not distinguish them. So he could learn positively no more than this:—the contract had been fulfilled and the depth of 1,000 feet had been reached. No gas but a good flow of water was secured.]

During the season of 1888 a deep well was bored at Minneopa, about one-half mile southwest of Minneopa Falls. The purpose of the well was an exploration for natural gas, by some Mankato gentlemen, possibly aided by men and capital from Ohio. The spot selected for the well lies about 100 feet above the level of the Minnesota river, which flows easterly only one mile away. The well is within the Minneopa creek valley and is bounded both east and west by hills 150 to 200 feet above the top of the well.

After penetrating soil and glacial debris to the depth of 88 feet, the Cambrian rocks were entered and were probably not bored through when work ceased at the depth of 1,000 feet. The first of these Cambrian rocks was a white sandstone; this soon gave place to a dolomitic rock which first appeared at 116 feet below the surface. Soon a white calcareous, flinty rock took the place of the dolomite, after which shales and sands alternated until the depth of 585 feet was reached, when a coarse conglomerate of quartzite pebbles appeared. Below this conglomerate, or below 800 feet, the record is uncertain and unsatisfactory.

In detail, the record of the well is as follows:

	THICKNESS.	DEPTH OF WELL.
1. Soil and clay with evidences of vegetation..........	10 ft.	10 ft.
2. Quicksands and gravels..............................	40 ft.	50 ft.
3. Blue clay with some pebbles.......................	10 ft.	60 ft.
4. Material chiefly sands of different degrees of coarseness to the bottom of the glacial drift............	28 ft.	88 ft.
5. White sandstone. This sandstone in a part of its thickness is quite indurated, it effervesces vigorously and breaks down into a loose sand when thrown into dilute hydrochloric acid. It is of medium coarseness............................	28 ft.	116 ft.

6.	Limestone of a light pink color and rather fine texture. This layer has the color and texture of the best stone in the Kasota quarries	10 ft.	126 ft.
7.	A rock of uneven hardness carrying many flinty chips, an arenaceous dolomite which breaks down in warm hydrochloric acid with effervesence, losing from 75 to 80 per cent. of its weight	14 ft.	140 ft.
8.	A green shaly sandstone whose lumps harden on exposure to quite a firm, distinctly stratified green sandstone	15 ft.	155 ft.
9.	A red sand easily crumbling (no sample)	30 ft.	185 ft.
10.	A green shale containing a considerable proportion of sand grains	20 ft.	205 ft.
11.	A clean white sandrock of medium texture and very friable (no sample)	30 ft.	235 ft
12.	A green shale again appears to be the predominant rock (no sample)	65 ft.	300 ft.
13.	Coarse, red, granular drillings which carry in numerous small grains a dark green mineral. This rock consists largely of a dolomitic material and appears to be quite impervious, thus affording a cover to the water-bearing strata which lie below	5 ft.	305 ft.
14.	A white water-bearing sandstone from which a small stream of water flowed	30 ft.	335 ft.
15.	A white and brown sand, very compact and apparently a cover to the layers below	40 ft.	375 ft.
16.	A white water-bearing sandstone	150 ft.	525 ft.
17.	A white water-bearing sandstone, differing but little from the preceding number	60 ft.	585 ft.
	[When the drill entered No. 16, water rapidly rose in the well and long before the bottom of No. 17 was reached a heavy volume was flowing from the mouth of the casing. It completely filled a 5¾ inch pipe. In temperature this water is from 53 degrees to 55 degrees Fahr. and is comparatively soft.]		
18.	Sandstone and conglomerate. The workmen were still boring in this bed when Mr. Bierbauer closed his notes; they had penetrated it 215 feet. In places the rock was apparently a compact red sandstone; in others it was a conglomerate made up of pebbles of a bright red, vitreous, non-granular quartzite. In size they vary from a fraction of an inch to several feet in diameter. The microscope shows that the silicious cement in which the original grains are imbedded is clear quartz interstitially deposited in axial continuity with the grains them-		

selves. *In short, these pebbles are fragments not of quartz but of quartzite*........................	215 ft.	800 ft.
The records for the remaining distance are regarded as valueless, but the record of the Mankato well (this volume Bull. 1, p. 143) leads to the belief that the rocks penetrated must have been silicious sediments..	200 ft.	1,000 ft.

However, authentic records have been preserved for the first 800 feet of this well; and that depth is sufficient to prove its importance to geologists, for one more fact is presented in evidence of the correctness of the position for which the Wisconsin geologists have contended, namely, that the great red quartzite formation of the northwest belongs to an earlier geologic age than the white and friable sandstones of the Upper Mississippi valley. Only 16 miles from this well the Courtland exposures of red quartzite can be seen and they show a rock identical in chemical and physical characters with the material out of which these pebbles were worn. These quartzite exposures with their southwesterly extension through Watonwan and Cottonwood counties into South Dakota are the only belt of this kind of rock known in Southern Minnesota. We conclude that the conglomerates penetrated in sinking this well must have been formed from the erosion of these quartzite beds.

But in the case of the sandstones the way to a conclusion is not so clear. For all the well record can show to the contrary, there may be a great unconformity between the quartzite conglomerates and the overlying sandstones and shales. Such unconformity, did it exexist, would afford a place here in Southern Minnesota for the Keweenawan formation between the Cambrain complex of sandstones, shales and dolomites and the quartzites and would offer strong, presumptive evidence that the quartzites are of Huronian age. An unconformity here, it must be admitted, is far from proven.

Whether we here call them Huronian quartzites or not, we know that the time necessary for their formation, their thorough vitrification and their subsequent erosion must have been enormous. Therefore the Sioux quartzite, as the formation of this lithologic character stretching from Courtland to the southwest into South Dakota has been called by Dr. White, belongs to an earlier and entirely distinct horizon from that of the so-called Potsdam or Saint Croix formation of the Upper Mississippi valley, and the time-gap between the two is one of great extent.

October 2, 1888.

[*Paper BB.*]

NOTES OF A GEOLOGICAL EXCURSION INTO CENTRAL WISCONSIN.— *C. W. Hall.*

This excursion was made because the writer was desirous of seeing in the field some of the rocks which had been described by Professor Irving and C. R. Van Hise in the reports of the Geological Survey of Wisconsin, and of comparing them with certain Minnesota rocks which he then had under examination. The localities visited were the Wisconsin river valley from Rhinelander to Stevens Point; the neighborhood of Waupaca, where are situated some notable granite quarries; and the iron ore deposits of Black River Falls. In the few days at his disposal only a hurried reconnaissance could be made, but the specimens collected have been subsequently examined more in detail.

THE WISCONSIN RIVER VALLEY.

From Stevens Point, where the Wisconsin Central railroad crosses the river, to its head waters the Wisconsin river is used largely for lumbering operations. One of the richest pineries in the Northwest lies around these upper waters, and a thriving lumbering industry has grown up along the stream. In area the district embraces several thousand square miles. Originally it was throughout a timber-covered area, and it is still largely so covered. A thick mantle of glacial debris is well-nigh universal; there are but few rock exposures in the valley, save along the streams, where water has bared and eroded the underlying rocks.

The Wisconsin river rises near the boundary of the state of Michigan, at 1,530 or more feet above the sea. Until Township 23, Range 6, is reached, the stream flows over a bed of glacial drift, save where this has been cut through and the old crystalline rocks are laid bare. In the neighborhood of Stevens Point outliers of a light-colored to white sandstone are seen, and these soon become a continuous rock formation towards the south, and, a short distance below Port Edward, the crystalline rocks disappear altogether beneath it. This sandstone belongs, according to the Wisconsin geologists, to the Potsdam age, and is undoutedly of the same age as the sandstones of identically the same physical and lithologic characters occurring around Hinckley, Sandstone and along the Snake river in central and eastern Minnesota. In Minnesota as well as in Wisconsin these sandstones lie unconformably on crystalline schists, gneisses, granites and the Keweenawan eruptives.

Throughout this area of old crystalline rocks the descent of the river is considerable. Point Bass, near which place the gneisses disappear beneath the sandstones, is only a little over 900 feet above the sea. From its source to this place the Wisconsin river must fall about two feet to the mile for the distance it flows, or about four and one-half feet to the mile for the actual air line distance between the two points. This rapid rate of descent is the occasion of great erosion and of numerous rapids and waterfalls along its course. These rapids afford disclosures of the crystalline rocks which were seen, and whose study furnishes most of the material of this paper.

It should be said in passing that this paper is not based on that of Irving and Van Hise already referred to,* nor on the notes which are published in another place,† and are supposed to embody the results of the earlier investigations on these same and many other rocks. The work here outlined is based wholly on the observations of the writer. The map, however, Plate III, Fig. 1, is based on the maps of the Wisconsin geologists, but with such modifications as the writer has thought best to add to that ground plan.

The following rock types were noted:—

Diabase. No exposure of this rock was seen in the whole length of the valley traversed, an unexpected result considering the fact that diabase dikes abound throughout the area of crystalline rocks in Michigan, Wisconsin and Minnesota. Some large boulders occur on the island at Merrill just below the dam which are diabasic. They are very angular, which condition indicates that they could not have been transported far. These boulders exhibit a dark green or black rock of medium texture, weathering to a gray color, a result due to a more rapid alteration of the pyroxene and hornblende than of the plagioclase. Vein-like segregations of pyrite appear on the fresh surfaces of the rock. In addition to the weathering which the surface discloses, the interior of this rock exhibits considerable change. The lath-like feldspars have altered but little, save where cracks and opened cleavage

*Crystalline Rocks of the Wisconsin Valley, by R. D. Irving and C. R. Van Hise.—Geology of Wisconsin, Vol. IV, Part VII, pp. 625-714.

†Ibid, Vol. II, pp. 637-642.

planes have allowed the infiltration of hornblendic material; kaolin as a result of their decomposition is scarcely seen. The augite has suffered severely; indeed only a few cores of this mineral remain. Hornblende has very generally taken its place. This last named mineral is of the green variety, and is sometimes fibrous and sometimes more compact, with well developed cleavage. The manner in which the fibres of hornblende have penetrated the labradorite crystals, especially in the direction of the axis *c*, is interesting. They enter the feldspars only at their ends and at certain cracks where the largest and longest feldspars have been broken.

Magnetite occurs in small crystals and crystal clusters in sufficient quantity to be separated from the powdered mineral by use of the magnet. The chief interest attached to this mineral lies in the segregating around it of folia of biotite, which mineral away from the immediate vicinity of magnetite scarcely appears. With the quantity of ferric oxide in ordinary augite at 8.75 per cent.,* in green hornblende near 6 per cent.,† and that in biotite at about $11\frac{1}{2}$ per cent.,‡ and with the basic constituents of the rock profoundly altered, it would seem clear that an oxide of iron must be separated out with the secondary development of biotite. Such development of this mineral as well as of hornblende seems clearly proved. But few other minerals were noted, and those apparently accessory—the chief of these were apatite in long minute needles, and epidote in equally minute granules, scattered through both labradorite and hornblende, but more particularly the latter.

It may be mentioned here that at Grandmother Falls the darker colored rock is regarded as completely altered diabase. This rock is described further on in this paper.

Gabbro. In geographical distribution the gabbros and the gabbroid rocks occupy four different and disconnected localities, viz: around Rhinelander, Merrill, Wausau and Mosinee. As there seem to be certain points of difference in the typical samples of these localities they will be briefly described separately. All save those at Mosinee are hypersthenic gabbros.

At Rhinelander, between the Milwaukee, Lake Shore & Western railway tracks and the river south of the railway bridges is a

*Note Dana's tables, System of Mineralogy, 5th edition, p. 218.

†Ibid, p. 237.

‡Ibid, p. 305.

conspicuous exposure of the gabbro. The rocks are not high, they are glaciated and river-worn at the surface, and have been quarried sufficiently to enable the collector to secure very fresh material. Exposures in several localities to the south and east are said to occur. In texture the rock is medium to coarse grained, and its color is dark owing to the large proportion, about two-thirds, which the basic minerals, pyroxene, hornblende and biotite make of its bulk. Pyrite and chalcopyrite appear as accessories scattered through the freshest part of the rock. Many joints appear in the rock, and along them a green alterations product is spread like a thin film. Occasionally this is stained with ferric oxide. The joints can be grouped into two systems, the one extending N. 10° E. magnetic, and the other N. 45° W.

Coursing through this gabbro in every direction are veins of a lighter color and a much finer texture. They vary in width from a fraction of an inch to more than two and one-half feet. As a rule these veins are light colored and finely textured, although in a few places a pegmatitic structure and texture can be seen. A few occurrences of a darker colored veinstone appear. Near these darker colored bands are many gneissic modifications of the rock, as there are at the East Saint Cloud quarries in Minnesota. These gneissic bands have no definite width or position; they appear and disappear in all directions and are frequently interrupted, but nowhere are they of great extent. So it is difficult to regard them as resulting from pressure applied steadily in any one direction; they may therefore be regarded not as flowage lines, but either as due to a flowage structure which existed in places in an original eruptive rock, or they may represent the utter demolition of the original crystalline structure and its replacement by the present one. Inclusions quite different in outward appearance from the veinstuff and gneissic bands are also seen; they are of a dark color and biotite in large folia gives a porphyritic appearance to them. No lithologic significance is attached to these inclusions more than that they represent areas in which a larger proportion of basic constituents has promoted a more extensive alteration of the primary constituents of the rock. In structural features these masses remind one of the augite diorite* bodies of Richmond and Little Falls, Minn.

*This name was given in 1887 by Streng and Kloos, Neues Jahrbuch fur Mineralogie, n. s. w., 1877, pages 117, et. seq. The more recent studies of the writer show these rocks to be hypersthene bearing gabbros. Compare forthcoming bulletin U. S. geol. survey.

In mineral constitution this Rhinelander gabbro is hypersthenic and hornblendic. The feldspar is still well preserved and polarizes strongly, although in places some alteration has taken place. Its optical characters show it to be a labradorite with a liberal proportion of oligoclase intermingled. In form the individuals are allotriomorphic; they give the typical, broadened gabbroid form as distinct from the idiomorphic or diabasic form of feldspar individuals seen in the diabase boulders just described. These feldspars are plentifully strewn with many gas and liquid inclusions as well as crystalloids of different minerals.

Augite, diallage and hypersthene occur in these gabbros; the two former, in the slides examined, are present in about equal proportions. There is no special feature to mention touching these minerals, save their proneness to alter into hornblende. Everywhere a rim of this mineral can be seen around the pyroxenes. As a rule the normal crystallized hornblende appears as the resultant product, although at times a fibrous modification is the one present. Augite insensibly gives place to hornblende as the alteration proceeds, as is shown in Fig. 3, Pl. III. The two minerals are seldom oriented together, as is seen to be the case in the figure just mentioned. In other places areas are partly diallage and partly hypersthene—with a reaction zone between. Along this reaction zone there lies a fibrous hornblende. Every consideration which position and contact relations can give points to the derivation of the diallage from the hypersthene; yet the mutual relations of these minerals to the normal composition of the gabbros of the Northwest preclude the assumption that such derivation has here actually taken place.

Biotite is frequent in these rocks, and the conditions suggest that it is derived from the hornblende. Figure 3, Plate III, suggests such derivation. Pyrite is present in decidedly subordinate quantity. Magnetite is nearly everywhere present. It appears most prominently in the normal gabbro as an incidental alterations product from hypersthene, although in many other associations it is prominent. In places it is said that magnetite appears in large proportion. Exposures three miles south of Rhinelander, on the Merrill wagon road, are reported, where considerable quantities of magnetite ore are seen. Some assays of this ore have been made; selected material gives 68 per cent. metallic iron, while one assay of what was called an average sample was furnished by Mr. John Doherty of

Rhinelander, showing the following result:

Metallic iron, 59.31 per cent.
Phosphorus, 0.017 per cent.

It is very probable that these are segregations of iron oxide precisely similar to those occurring in the gabbros of so many other localities in the Lake Superior basin, notably in northeastern Minnesota, along the so-called Mesabi range.

The veins and other modifications which have been mentioned as occurring numerously are of varying extent, and are from somewhat basic to highly acidic in their chemical composition.

The microscopic characters of these incidental phases of the Rhinelander gabbro are not complex. A large proportion of quartz, in small, brightly polarizing grains, arranged as a sort of mosaic work, characterizes them all, but there are some larger areas of this mineral filled with liquid inclusions, needles of rutile, and minute crystals of apatite, bearing every evidence of being of original development. The feldspar is partly of the ancient order and partly secondary. That which seems to be original is considerably corroded on its borders, giving place there to quartz, other feldspars and epidote. Many of these older individuals show a distinct zonal structure in their central portions. The general acidification which these rocks seem to have undergone would suggest the correctness of the explanation Höpfner has given of this phenomenon:—"Probable that the feldspathic material, which, in many cases, built up the small isolated secondary grains, when in contact with these older areas, enlarged them to their present new dimensions." Several varieties of feldspar abound; microclinic and albitic types of low extinction are most abundant. The epidote is thickly strewn in many sections, but it is plainly secondary; it lies in small granules, seldom rising to the dignity of individuals, which can be measured by optical methods. Biotite and hornblende are, in the more acidic veins, very sparse, but in the schistose bands and dark-colored inclusions they are comparatively abundant, and are distributed in nearly equal proportions. They carry needles of rutile and crystals of apatite, as well as the quartz. The hornblende frequently twins, and both minerals are very free from inclusions of all kinds.

At Wausau, where the next masses of gabbro were seen, the conditions of occurrence seemed to be identical with those at Rhinelander; large bosses of a dark-colored rock, anastomosed with many granitic veins of a lighter color than the gabbro itself, a more or less shattered condition, and well-worn and rounded surfaces. But the penetrated rock in that case was a hornblende gneiss; in this, a silicious rock, more or less schistose, and of sedimentary origin. A greenish brown color prevails, which is not cheerful nor neat to the eye as it appears in the quarry and in the walls of many buildings in the city constructed of this stone.

The further structural features of this rock are well set forth in the report of Irving and Van Hise* and in the earlier published field report of Professor Irving.†

In situation and extent the exposures visited lie on the west side of the Wisconsin river, and on the islands, natural and artificial, within the stream. The rapids at Wausau, the Big Bull falls of the early settlers, are formed by these rocks opposing a barrier to the stream for a distance of a mile or more. For the most part the rock is quite massive, although here and there gneissic areas appear, having a northeast and southwest trend. Hornblendic veins‡ and segregations were frequently noted.

Microscopically, quartz is everywhere present in minute, clear grains, often apparently taking the place of corroded feldspars. Possibly some of it occurred as one of the primary constituents of the rock. The feldspar is plagioclastic, partly of the labradorite type and partly albitic, and is present in two generations, as is the quartz. Frequently large areas are singularly flecked with intergrowths of another species, which, according to the writer's observations, extinguishes but few degrees from the extinction angle of the host. Again, considerable areas are burrowed and filled with vermicular quartz. In other places minute crystals of hornblende and biotite stud the feldspar field thickly, although, as a rule, these minerals lie in proximity to the pyroxenic constituents.

Diallage is better developed here than in the gabbros of Rhinelander. The peculiar markings, the rod-like structure, of this mineral in two series, parallel or coincident with the cleavages, are very common. It alters into hornblende, and numerous crystal plates of hornblende are strewn thoughout even the freshest diallages, while the borders of the grains are entirely changed into the secondary substance. Less biotite is to be seen here than at Rhinelander.

*Geology of Wisconsin, Vol. IV, pp. 661, 662.

†Geology of Wisconsin, Vol. II, pp. 486-488, and elsewhere.

‡Compare Geology of Wisconsin, Vol. II, p. 487.

Hypersthene appears here in about the same proportion as there. It alters here, as there, by the corrosion of its borders and the change of its material into a hornblendic substance, and by the alterations along fractures and cleavage planes, into a fibrous green product, with the fibres standing at right angles to the corroded surfaces. The pleochroism of the hypersthene in the sections from this locality is unusually weak.

Olivine was noted in one or two slides.

Quartz Diorite. The rocks at Merrill and Mosinee which are here grouped as gabbroids are really, in their present condition, simply quartz diorites. They possess a generally massive structure and medium texture, but they vary somewhat in both these characters. For instance, at Merrill, on the island, where this rock comes in contact with the gneiss, it exhibits a distinctly laminated structure. Where this structure appears much jointing is also present, and the major system is parallel with the plane of contact. In other places the lamination is more obscure. Everywhere the rock is very tough and firm, and usually it is more than one-half hornblende. At Mosinee, on both sides of the river at Little Bull falls, and on the island, the dark colored massive rock prevails. Normally it contains about the same proportion of hornblende as does that at Merrill. Here and there is more feldspar or a coarser texture than the average. No lamination was seen at this point, save in the neigborhood of a large quartz vein. This vein, which carries white quartz, has been worked somewhat for gold. It is in places much split up and faulted; one fault throws the vein 30 or 40 feet from its course. The rock here is thoroughly shattered. The "nests of a very fine-grained and compact black rock," which Irving mentions* are seen on the east side of the river near the railroad tracks.

It is unnecssary to repeat here the microscopic descriptions of these rocks which the Wisconsin geologists have given.† The conclusion drawn from an examination in the field and with the aid of thin sections, is that they are altered gabbros. The present constituents, save possibly the older generation of feldspars and the pyroxenic cores still remaining, are wholly secondary, due in part to the infiltration of chemical matters, but in very large part to the molecular transformations, and conse-

*Ibid, Vol. IV, p. 651.

†Ibid, Vol IV, pp. 655-657; 706, 707.

quently, transformations in mineral constituents and in structure,* which the original group of substances has undergone. Through the disguise under which they now present themselves there can be seen all the essential characters of rocks precisely similar to those studied at Rhinelander and Wausau. The reasons why these rocks are more changed than those were not traced. They may be surmised to lie in the nearness to, or even contact with rocks of quite different constitution. Such contact metamorphism has been noted in hundreds of places throughout the world.

There is one phase of these Merrill gabbroids which cannot be passed by unnoticed. Scarcely seen with the unaided eye, under the microscope it is the most conspicuous feature in their mineral structure. It is the semblance of the eye structure which so abounds in the acidic laminated rocks, and it seems to spring from a segregation into nests of the hornblende and the feldspars, all of which minerals are secondary. The basic constituents, and hornblende is the chief, are arranged around the nests of feldspar granules. But among the latter the peculiar requisite of the eye structure, viz: a core of rounded lenticular feldspathic material,† is lacking—all individuals are minute in size, fresh looking and limpid. Every character of these rocks seems to show that one of the prime causes of their present condition was pressure.

The Gneisses. Crossing the bridge to the west side of the river from the knobs of gabbro, in Rhinelander, one finds at the intersection of the railway with a wagon road, a typical mass of hornblende biotite gneiss. The color is dark; the texture medium; the lamination strong and somewhat contorted; the general direction is N. 25° E., with a southeasterly dip of 60°. Lenses of quartz are not infrequent, and true granitic veins occur. In addition to these, one sees masses consisting largely of hornblende of medium texture and with some parallelism of structure.

Microscopically, the gneiss presents no peculiar characters. The quantity of hornblende is very small in proportion to the biotite, and the proportion of plagioclastic feldspars is very large. Indeed, orthoclase is scarcely seen. The hornblendic masses just mentioned are very fresh in the condition of their constituents, hornblende being the chief and plagioclase abundant. The twinning striae of the plagioclases are sharp and strong. A pyroxene is un-

*Prestwich, Geology, Chemical, Physical and Stratigraphical, Vol. I, p. 397.
†Compare Zirkel F., Lehrbuch d. Petrographie, Vol. II., page 414.

doubtedly the source of the hornblende. Epidote abounds in these inclusions, as well as in the normal gneiss. While the normal gneiss carries biotite in large proportion, here only occasional areas are to be seen.

If one asks for the proofs of the gabbroid nature of the lenticular hornblendic masses, his attention must be directed to several considerations; in the first place, the proximity of large eruptive masses of gabbro and the undoubtedly shattered condition of the penetrated gneissic rocks render such a nature quite possible; again, they are more altered than the large masses of gabbro, as, indeed, they should be, buried as they are in a rock of diverse chemical composition and molecular constitution; the feldspars of the gabbro and of the inclusions seem to be of the labradorite-anorthite type and identical, while together they differ from those of the gneisses; biotite plays an important role in the gneisses, while here it takes an insignificant place; the texture of the two is diverse; and those metamorphic changes represented by corroded constituents, kaolinized feldspars, conversion of hornblende into biotite and the general sprinkling throughout the mass of epidote granules similar to those so conspicuous in the matrix gneiss are largely wanting in the inclusions.

Going south from Rhinelander the next exposures of rocks of any kind are the gneissic rocks at Grandmother falls, Section 10, T. 33, R. 6 E. Here the rocks are partly granitic, although the gneissic condition prevails; they frequently become epidotic through the occurrence of bands or veins of the mineral epidote. In texture, the rocks are not so

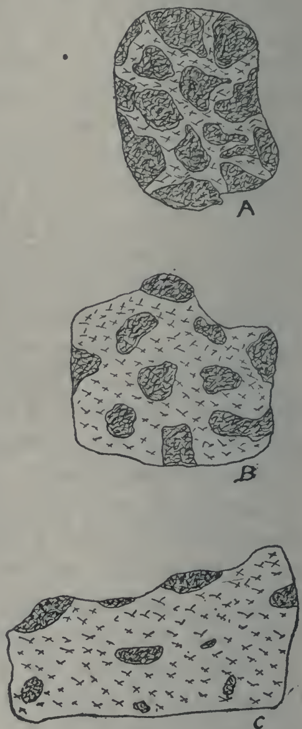


FIG. 4.—Sketched from the gneissic rocks at Grandmother falls. *A* represents the largest proportion of the amygdaloidal basic rock; *B* represents a medium proportion of the basic and gneissic rocks; while *C* shows the matrix gneiss carrying only a few small masses of the included material.

coarse as are those at Rhinelander, and are much more weathered. Towards the lower end of the rapids the gneissic rock becomes more granitic and carries as an inclusion a dark colored rock of rather fine and uniform texture. As a rule this dark colored rock is amygdaloidal. The amygdules are very irregular in shape and diverse in size. The structural relations of the gneiss and the inclusions are set forth in the accompanying figure (Fig. 4 *A*, *B*, *C*). The gradual disappearance of the gneiss, with the constant increase of the darker colored rock; the rounded character of the inclusions and the inclosing situation of the gneiss, and finally, the finer texture of the darker colored material in proximity to the gneissic all point to the irruption of a dike with a shattering of the penetrated rock along the plane of contact. Exposures showing the same general characters seen here are not infrequent among the old crystalline rocks of the Northwest.

In lithologic characters the gneissic rock is granitoid and of the biotite type. Hornblende occurs in small proportion. Quartz is very abundant, and frequently occupies large areas with firmly interlocking grains. A portion of the feldspar is triclinic, with a low extinction; as a rule it is so badly altered that twinning striae can be seen only around its borders, while within are nests of kaolin (?) and epidote. While some orthoclase was seen, more than half of the feldspathic constituent is microcline. This is apparently the least altered of all the feldspars. In the mosaic which usually lies between the larger and more or less altered individuals, small, brightly polarizing grains can be seen, which represent at least two species of feldspar, which are certainly secondary, orthoclase and microcline.

The darker colored rock, the inclusion as it is here designated, is granitic in habit. It carries feldspars, quartz, hornblende, biotite and epidote. At its contact with the gneiss the two are firmly knitted together and the typical characters of each are carried up to the very plane of contact, save perhaps in a finer texure and a larger sprinkling of epidote. The hornblende in its general anatomy bears strong evidence of secondary origin; the quartz is infiltrated into certain portions of the mass in larger proportion than elsewhere and the feldspars seem to no little extent to have the general outline of the lathlike or diabasic type. Occasionally an individual shows the alteration phases into epidote and kaolin, but as a rule the feldspars are very fresh and clear.

In this darker colored rock there lies a porphyritic substructure. When fresh fractures are held to the light reflecting surfaces sometimes as large as three-fourths of an inch across are seen. These are cleavage planes of microcline crystals. Within these areas the microcline serves as the matrix in which are embedded large numbers of individuals of hornblende, biotite, albite, and oligoclase; also, epidote, apatite and quartz. These minerals do not crystallize perfectly, yet they take on quite strongly individualized forms. There is a vague tendency among them to assume a direction generally parallel to the axis *c* of the microcline matrix in which they lie. This structure is distinguishable by the unaided eye only by the reflection of the microcline cleavage planes; the inclusions within the microcline are like, in all their external features, the same constituents within the matrix rock in which the microclines are in turn embedded. The microscope emphasizes this structure in showing a strong parallel extinction in the microcline areas, a very fresh and limpid condition of this mineral and the very new and unaltered condition of all the minor constituents embedded within it. Figure 4, plate III is an attempt to sketch the features described. It seems quite analogous to the lustre mottling among the melaphyres of Lake Superior.*

Further down the river at Morin's farm, Section 30, Town 33, Range 7 E, many knobs of gneiss stand above the surface striking N. 10° E and dipping westerly at 60°. Outwardly this seems to be a typical gneiss in color, texture and structure. The lamination is strong and moderately fine. At the surface the biotite has assumed a golden hue in the weathering, but beneath it is bright and clear. The microscope shows that peculiar oil-vitreous lustre which so often characterizes changing acidic rocks. The mineral constituents, particularly the feldspar, are in two generations, an older with gnawed outlines and corroded and changed interiors and a younger with limpid clearness, polarizing strongly and sharply defining each other's boundaries. The former are well sized individuals, the latter generally quite minute. Much epidote characterizes this rock. It lies in small clustered grains or in larger individuals around which are usually grouped minute

*Raphael Pumpelly, Proc. Am. Acad. Arts Sci., Vol. XIII, p. 260. See also R. D. Irving, Copper bearing rocks of Lake Superior, Mon. v.U. S. Geol. Survey, p. 42.

particles of epidote and quartz. It may be mentioned here as the only occurrence of the kind noted by the writer in the Wisconsin valley, a few very well formed crystals of epidote lie in the matrix of essential constituents.

A half mile further down the river at Grandfather falls, a long rapid barely mentioned in the Wisconsin reports,* the rock is almost identical both in the strongly marked features of the bold rock masses over which the river plunges and in its more detailed microscopic characters, with that at Morin's farm. In color this rock is a beautiful gray of varying dark and light tone, and persistent banding. Weathering bleaches its color very noticeably. Its texture is medium with a general tendency towards the eye structure called by the Germans "augengneiss." The strike at the falls is N. 25° E. magnetic and the S. S. W. dip is 65°.

Quartz is the prevailing mineral. In the eyes the grains are of good size, possessing the wavy extinction so common in this structure and induced, as is generally supposed, by stretching or pressure. Elsewhere the grains are very minute and exhibit a striking mosaic when polarized. The feldspars are small and fresh-looking, probably all of secondary origin. Small size and great elongation parallel with the lamination of the rock characterize the hornblende and biotite individuals. The specimens taken show a great excess of the latter mineral over the former. Epidote is plentifully present. Veins and segregations of quartz course through the rock.

Not until Merrill was reached were further samples of gneiss taken, although exposures lie in the river and along the carriage road at several intermediate points. At this city, on the island formed between the mill-race and the river, occurs a considerable exposure and a bountiful contact of gneiss and an eruptive rock which has already been noted as a quartz diorite of gabbroid ancestry (ante, p. 258). A darker colored, coarser textured and more shattered gneiss is seen here than at Grandfather falls and Morin's. A concentric weathering is very strikingly displayed; the rock seems to be rotted away, save the few hard, spherical nodules left on the surface. Where one of these nodules lies up against the contact zone of the diorite the cohesion of the two is quite firm.

To detail the microscopic characters of this Merrill hornblende biotite gneiss would be to repeat the description of that at Grand-

*Vol. IV. p. 702 and accompanying sketch, Map VIII.

father falls, or at Morin's farm just given. There is one point of difference, yet this difference must be apparent rather than real; it pertains to the "eye structure" of the rocks. In all three cases there is the peculiar "streaming" or parallel arrangement which other authors* note in the position of the biotite and hornblende individuals; there is the same fine mosaic of quartz grains, intermingled with these basic constituents, and there are the same texture and color. While there the mosaic extends to the very center of the eyes (augen), here in almost every case the central part is a corroded feldspar crystal. These crystals can usually be identified as plagioclastic. Particles of kaolin and epidote becloud them to some extent and their borders are so changed that they can no longer be traced; in other words, these feldspar cores lie in a segregation of fine grains of quartz, with which are intermingled a few impurities such as epidote, hornblende and biotite particles. The attempt has been made to represent this peculiar eye structure in figure 5, plate III, where a sketch of the author's slide No. 884 is given. Perhaps no better description of this slide can be given than Chelius gives of a deformation of granite-porphyry near Eberstadt: "Mutual shattering of the feldspar crystals can often be seen; yellowish-green biotite and green hornblende individuals wind through the ground-mass in bands around the feldspars, so that a streaming can well be distinguished since the rock microscopically exhibits no flaser-structure. Within narrow zones between the interjected particles, the grains of the ground-mass show a distinct consecutive arrangement in the direction of their longer axis."†

Crossing the Wisconsin river to the west side from Knowlton a mass of very compact, dark colored, granitoid gneiss is reached. It has a medium texture and is chiefly biotitic in its basic constituents, although to the naked eye a greenish color is quite apparent. The feldspars are somewhat altered to kaolin and muscovite; in two or three places calcite was seen to have been deposited as an alterations product—the only instances of the kind noted among

*Lehmann, Untersuchungen ueber die Entstehung der Altkrystallinischen Schiefergesteine, Bonn, 1884, p. 189. Chelius, quoted by Rosenbusch, Mikroskopische Physiographie, 2d ed., Stuttgart, 1887, p. 294. Teall, British Petrography, London, 1888, p. 243. The rock Teall described however is an "augenschist."

†Rosenbusch, Mikroskopische Physiographie der Massigen Gesteine, p. 294.

the gneisses of the valley. A rounding of the feldspar individuals is quickly seen. These individuals are partly orthoclase and partly albite and oligoclase, as determined from the relics of a twinning striation.

Scarcely more than mention need be made of the gneisses of Stevens Point, for details have been published by the Wisconsin geological survey.* The strike of these rocks in one place was N. 45° E., and in another, where the direction was determined rather by the parallel position of the feldspar crystals than by any distinct lamination, N. 65° E., with a northwesterly dip of 75°. There is considerable variation in the texture, some areas being quite fine and others normally coarse, and almost everywhere granitic veins of greater or less extent appear. In lithologic composition the gneiss is a hornblende biotite one, the last-named mineral predominating. Muscovite can be seen in a few scattered folia, but for a Wisconsin valley gneiss, epidote is singularly wanting. The feldspars, both orthoclase and the plagioclases, are considerably altered internally and corroded externally, some of them, without doubt, to entire obliteration, as the areas of quartz mosaic extending from the circumference to the center of the eyes seem to show. That the silica which now abounds in these rocks must have come in part from some external source seems clear. These rocks have until recently been covered with the Cambrian sandstone (see page 251), whose outlyers still stand in the vicinity, becoming a continuous sheet towards the south.† One of these knobs still stands only a few hundred paces away from the gneissic exposures sampled. The suggestion comes with no little force that the acidic character of the gneiss may be due in part to the silica which has percolated from the overlying sandrock into the rock beneath, to take the place of those constituents which have been gradually dissolved and removed. The changed feldspars and the surrounding mosaic of secondary quartz grains are represented in figure 6, plate III.

The Granites.—Around Trapp city and Kickbusch and just above Wausau are several exposures of granite which have assumed considerable economic importance. The fresh condition of the rock, its bright, cheerful color, its texture and freedom from fracture make it a most valuable quarry stone. The color is usually reddish,

*Geology of Wisconsin, Vol. II, p. 478, et seq.

†Geology of Wisconsin, Vol. IV, p. 627.

varied in places by a tendency to form chlorite to a greenish hue. Joints are in two groups; at Trapp city the major one showing a direction N. 85° E. mag., and at Kickbusch N. 15° W., and in both places nearly vertical.

Judging from lithologic evidence all these granites are poor in lime and magnesia. While there is a fair proportion of triclinic feldspars they seem to have the low extinction angle of the albite-oligoclase end of the series. In the mineral changes going on some small, fresh, secondary areas have been formed which are seen lying in the quartz mosaic fringing the large and primary individuals. In a few cases an enlargement of these old albite individuals was seen where fresh limpid material was added to them in crystal continuity and apparently at the expense of the microclines and orthoclases. If this observation be a valid one, its explanation would doubtless presume the disappearance of the potash from the potash feldspars and its replacement by the soda lime constituents of the albite-oligoclase members.* Prof. Van Hise some time ago noticed the enlargement of feldspar fragments in certain clastic rocks of northern Michigan and Wisconsin.†

These granites are highly silicious. Large areas of clear quartz can anywhere be seen and much in the form of microcrystalline aggregates also occurs. The basic constituents, hornblende and biotite, are far from abundant, yet they occur in about equal proportion. Occasionally, and particularly in the quarry at Kickbusch, there are thin seams or veins of segregated mineral matter. While it is suspected that most of this matter is chlorite still hornblende is present as is altered pyrite and a uniaxial mineral which is possibly zircon.

There were some evidences of pressure noted among these granites such as bent feldspars and lines of fluid inclusions. The latter are particularly noticeable as they extend entirely across the slide, through quartzes and feldspars alike. No marked lamination was noted in the exposures visited.

The Schists.—Under this name are grouped rocks of quite diverse characters, both macrocrystalline and microcrystalline. There are, on the one hand, rocks which, although squeezed and

*Compare Sauer A., * * * sowie ueber Neubildung von Albit in granitischen orthoklasen, Neues Jahrbach, 1889, Band I, Referat, S. 202.

†Bulletin No. 8, U. S. Geol. Survey, p. 44; also Amer. Jour. Sci., May, 1884.

folded and displaced, are still clastics in every character; on the other hand, the schistose character is so predominant as to obliterate all genetic characters. Typical examples of the first type appear in the northern part of Wausau city, where silicious schists have been cut through both by river erosion and by railway construction; examples of the other extreme of the series, equally typical, can be seen along the Trapp river and at the bend in the Wisconsin river a mile below Merrill.

In external aspect the rocks above Wausau are firm and compact, very finely crystalline, and strictly speaking they are not schists. They vary considerably in color, being in places, as on the west side of the river near the upper mills and opposite the city waterworks, of a reddish hue, which within becomes brown and black with more or less mottling. Everywhere the rock is greatly shattered; it is hard and brittle under the hammer and breaks conchoidally. The texture is very fine, although in places it assumes a greater coarseness and a very visible crystalline texture. Across the river towards the northeast the rock is very finely textured, highly silicious and of the same hard, brittle and conchoidal character. A banding occurs in the darker rock, which, while obscure on the fresh fracture, is clearly seen on the weathered surfaces. It is not regular either in continuity or direction; often it is considerably contorted. Bands of conglomerate lie in the rock. These bands, as represented by the exposure in the cut nearest the Wausau station, show, for a conglomerate, a medium coarseness and so thorough a knitting together of the pebbles that the granular character is almost wholly lost. The strike of these beds is N. 10° E. magnetic.

Microscopically the leading constituents of these rocks at and to the north of Wausau is quartz in very fine and brightly polarizing grains. In places more coarsely crystalline streaks appear made up of a series of large interlocking individuals of quartz. Biotite is also a constant constituent; its folia are small and arranged in bands or streams between layers composed almost of clear quartz and its abundance marks the position of the darker bands of the rock. In a few cases secondary individuals of microcline and members of the plagioclase series were seen. Pyrite is almost unfailing although its quantity is small.*

A mile or two further north the rocks become quite markedly

*Compare Irving and Van Hise, Geology of Wisconsin, Vol. IV. p. 668.

schistose. A medium texture prevails, a more or less vertical position is assumed and they strike N. 10° E. as a rule. The prevailing color of these schists is green, that of the leading constituent. In the midst of these green schists which are very close to the chloritic and sericitic schists of the Lake Superior region in nearly all their characters are lenses of hematite ore. On Section 7, Town 29, Range 8 E., considerable exploration has already been done. While ore has been found in masses of many inches in thickness at the lowest depth reached in these explorations, still the prospects of a sufficient yield to authorize mining operations on an ordinary and commercial scale are not encouraging.

Other modifications of these schists were noted in several places as on the hill between Mosinee and Knowlton and between Knowlton and Junction City. Their general aspect is that of more or less weathered schists having strike and dip nearly like those above Wausau.

November 13, 1888.

[*Paper CC.*]

WHAT OUGHT THE PEOPLE OF A COMMUNITY TO DO TO HELP THEIR LOCAL BOARD OF HEALTH?—*By Charles N. Hewitt, M. D., Secretary of the State Board of Health of Minnesota, ex-President of the American Public Health Association, etc.*

The work of public health has come to such proportions in our state that I am sure if our people knew more about it they would more generally "bear a hand" in the doing of it. The commonest complaint from our best health officers is "We need more popular support." I have the feeling that no better subject presents itself for my essay of to-night and I venture to begin with a little sketch of the history of sanitary effort in Minnesota since I have known it.

In 1872 there were but two local boards of health in the state, making any pretense of being alive. All over our country there was an increasing interest in public health, and Massachusetts with California, had given practical expression to the professional and popular demand, by organizing state boards of health. Minnesota, moved by the same impulse, established our state board, and Governor Austin signed the bill March 4th, 1872. The old law

PLATE III.

[To accompany Paper BB.]

Figure 1. A map of Central Wisconsin showing a sandstone covered area in the southern portion, the possible extension of the Menominee schists to the vicinity of Black River Falls from the northeast and the probable Archaean character of the underlying rocks of the northern portion of the area mapped. The whole area is drift covered. In part based on the general geological map of Wisconsin, 1881.

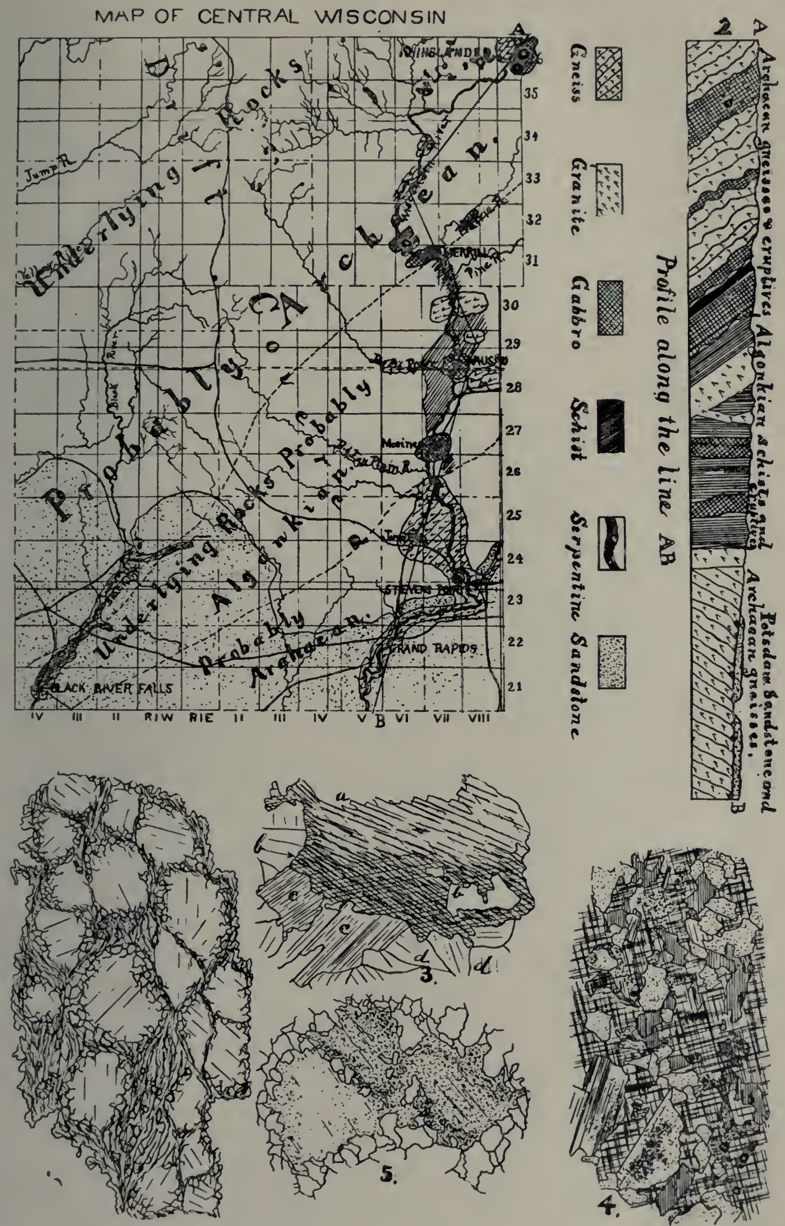
Fig 2. Profile along the Wisconsin river from Rhinelander southwards beyond the point where the gneisses disappear beneath the Potsdam sandstone.

Fig. 3. From the altered gabbro at Rhinelander to show the alteration of augite into hornblende and the contiguity of biotite which doubtless sprang from the hornblende. *a*, augite; *b*, hornblende; *c*, biotite; *d*, surrounding plagioclase individuals. See page 255.

Fig. 4. Microcline matrix carrying the remaining constituents of the rock. See p 262.

Fig. 5. A corroded individual of plagioclastic feldspar in the midst of segregated microcrystalline quartz granules and feldspars, the eye structure very common in the valley. See p. 264.

Fig. 6. A reproduction of almost an entire thin section (author's slide No. 884) to show the eye structure so common in these gneissic rocks. The finely granular matrix here carries the biotite and hornblende, which minerals are arranged with considerable parallelism of position. The feldspars, which are plagioclastic, are considerably more altered than is shown in the slightly magnified figure. See p. 265.


MAP OF CENTRAL WISCONSIN
RHINELANDER
MERRILL
WAUSAU
Mosinee
STEVENS POINT
GRAND RAPIDS
BLACK RIVER FALLS
Profile along the line AB
Gneiss
Granite
Gabbro
Schist
Serpentine
Sandstone
Archaean gneisses & eruptives
Algonkian schists and eruptives
Potsdam Sandstone and Archaean gneisses.
2
3.
4.
5.

relating to local boards of health, was left untouched. That law we brought from New England, and it is a curious evidence of the opinion our forefathers had of the duties of such boards, that though giving them the most arbitrary power, they do not seem to have thought of them as needed except in emergency, like the old bucket brigade, or militia company. Like them the board of health, very likely, had the watch-word "Semper paratus," which being interpreted must have meant "always prepared to get ready," but doing little or nothing, except in the presence of an actual outbreak of infectious disease. This is the very reverse of what is needed, as our experience has repeatedly proved, yet the old notion persists, and is difficult to eradicate because so many people are content with a traditional faith in sanitary matters, and apparently blind, or indifferent, to the facts of to-day. In the awakening which began all over the country in 1868, or thereabouts, it is notable that the organization began with the highest form, The State Board of Health, as if a long popular education would have to precede the re-organization of the local boards. So it proved, at any rate. The state board was at first an advisory body chiefly, though it was intended to give it the same power as local boards, for the state at large. It soon found enough to do in assisting local organizations, or oftener acting for them in doubt or difficulty. In its own special work it was guided by the needs of the time. A special investigation of the character and extent of the abuse of stimulants—drunkenness—was made, and the secretary visited and reported on inebriate asylums. The result was a plan for an inebriate asylum which, if the advice of the board had been followed, would have been a useful institution to-day. The first study of leprosy in this country was begun by your state board and has been regularly continued since. It was the first state board to study systematically the water supply of its population, and the work is going on regularly in the analysis of suspected, and other waters, still. This by the way: In 1872, the first year of our organization, an epidemic of small-pox, with over 1,000 cases and 250 deaths, proved the weakness of our local board of health organizations, and there was no difficulty in getting legislation to better it, for in 1874 we had nine boards representing 100,000 of the population. So the work went slowly on, the state board doing all it could, by personal inspection, office and laboratory work, and in other ways, to hasten the advance.

In 1881 it was evident that the delay was rather in the unwillingness of local authorities to incur expense or responsibility than anything else. The township boards, officered by farmers, mostly, with occasional help from health officers, or the secretary of the state board have been doing better work every year. In 1883 we secured the sanitary code which is the basis of all subsequent growth (Chapter 132, Laws of 1883). This act consolidated the sanitary forces of the state, enforced compulsory notification of infectious diseases of men, and defined not only the powers of boards of health, but inflicted penalties for their neglect to perform their duties. But increased responsibilities discovered other defects in the laws, and in 1885 the legislature still further enlarged the duties and completed the organization of the local boards. The terms of members' service was so arranged as to keep the organization perpetual, with at least two old members always on duty, so that the experience of the board was continuous. The care of infectious diseases of domestic animals was given to them, with compulsory notification by owners and others; the control of offensive trades and the duty of regular sanitary inspection of their respective localities, with power to deal promptly with "nuisances, sources of filth or causes of sickness." In no other state has this unification of duty and authority been so thoroughly effected. The result of the legislation of 1885 was to increase local activity wonderfully. In the country districts the interest in infectious diseases of domestic animals drew to the support of the local boards many whose pecuniary interests had suffered in that way, hitherto without help. It has resulted not only in the very large reduction of death from these diseases, but has enabled us to strengthen the work for the reduction of the prevalence of the infectious deseases of men, in country districts where before not an effort was made. The number of local boards in direct relation with the state board were soon more than 1,000 in number, and some means must be found to keep up regular communication between them. The secretary of the state board asked permission to issue a monthly journal for that purpose. It was granted and "Public Health in Minnesota" has ever since proved a very great help to the common work. It has made that work known all over the country and abroad, and set an example which has been followed by most of the other state boards. In 1887 legislation put the collection of the returns of births and deaths upon a useful and practical basis, making them available for the study of disease prevalence, causation and mortality. They are collected monthly by the city clerks of St. Paul and Minneapolis and by all township clerks, as also by the health officers of other cities, and of villages. It is the duty of the secretary of the state board of health to receive, collate and publish them.

I have given, in this little sketch, the general outline of what ought to be, to every citizen of Minnesota, a matter of importance —the efforts of our state to provide the organization to keep pace with her sanitary needs. If, now, you will remember that organization is not work or efficiency, but resembles the "resolve" of an average convention, you will get the gist of what I am aiming at to-night. Boards of health, unless their executive officers and members are exceptional men, soon get to represent the average sentiment of the communities which they serve. The answer to the question with which this paper began will depend then on another. What are the every-day duties of boards of health? In their ultimate analysis they are simply these: To keep the public supply of air, water, soil and food pure; to forefend infectious disease by precautionery measures, vaccination against small pox, compulsory notification and isolation of the sick of infectious diseases, both men and animals; the sanitary control of offensive trades, and the removal of all "nuisances, sources of filth and causes of sickness." There it is in a nut shell, and I am very sure that you will not dispute my next position, which, though evident, seems as likely to be forgotton here as it is claimed to be by some in England—that these very duties begin naturally in the home, and the house and lot it occupies, that the first responsibility for the sanitary care we have outlined, begins there, belongs to the head of the family, and cannot be shifted. He, or she, is a health officer in the best and highest use of the name. While their responsibility for the sanitary care of the home cannot be shifted, they very soon learn that causes of ill-health and premature death come from outside, and that therefore mutual co-operation is a necessity. Hence comes the local board of health, whose duty it is to administer rules which represent the sanitary needs of neighbourhoods, groups of families, for themselves and for the large class of careless, shiftless, ignorant or criminally negligent.

The duties of such boards increase with populations as a rule. Extend the duty to the larger community, the state, and you learn the "raison d' etre" of the state board of health. But, underlying all, is the sanitary duty of individual and family, which in the long run, determines that of the community, and the character of its performance. To go into the details of the whys and hows of the duty of the individual and family, though of the utmost importance, is desirable, but impossible now. It would take a course of lectures, illustrated from large experience, and with the aid of the microscope, test tube, lantern and diagrams. It is not needed to clinch my argument of to-night. Appealing to the experience of all who hear me, and in the light of what has been said, I claim it to be proved that the duty of the citizen, as an individual, or as head of a family, is: 1st. To recognize his duty as a health officer, to learn it, and to do it. 2d. That this will compel him to learn his duty, as a citizen, to the local board of health and to the state board. He will take a business interest in their personnel, work, and efficiency, which they need. I think of nothing more, available here, to strengthen my appeal, in the name of the sanitary forces of the whole population. Come up to the duty, every one, and do your share of the work of public health which is to prolong the life and increase the efficiency and happiness of every man, woman and child of our commonwealth.

December 4, 1888.

[*Paper DD.*]

ANALYSES OF WATER USED IN A BOILER EMPLOYED FOR HEATING A PUBLIC BUILDING IN ST. PETER, MINN.—*J. A. Dodge.*

Two samples of water were sent, one being a sample of the water as supplied to the boiler, the other a sample of water run off from the boiler (circumstances not stated).

1. Analysis of the mineral matter found in the water as supplied to the boiler:

Sulphate of lime, $Ca\ SO_4+2H_2O$,	247.2	parts per million.
Carbonate of lime, $Ca\ CO_3$,	251.0	" " "
Carbonate of magnesia, $Mg\ CO_3$,	135.3	" " "
Sulphate of magnesia, $Mg\ SO_4$,	27.6	" " "
Sulphate of soda, $Na_2\ SO_4$,	185.0	" " "
Chloride of sodium, $Na\ Cl$,	38.0	" " "
Undetermined, - -	11.0	" " "
	895.1	

2. Analysis of the mineral matter found in the water run off from the boiler:

Sulphate of lime, $Ca\ SO_4+2H_2O$,	1677.8	parts per million.
Carbonate of lime, $Ca\ CO_3$,	traces.	
Carbonate of magnesia, $Mg\ CO_3$,	traces.	
Sulphate of magnesia, $Mg\ SO_4$,	275.7	" " "
Sulphate of soda, $Na_2\ SO_4$,	1850.0	" " "
Chloride of sodium, $Na\ Cl$,	386.0	" " "
Undetermined, - -	20.0	" " "
	4209.5	

COMMENTS ON THE RESULTS OF FOREGOING ANALYSES.

(1). The amount of mineral matter as a whole was greatly increased by the boiler. Often the reverse of this is observed.

(2). The increase is seen to be due chiefly to the presence of *sulphates.* The sulphate of soda and the sulphate of magnesia being very soluble salts of course remain in the water and produce a *concentrated solution.* In this case the same is seen to be true to a great extent with the sulphate of lime.

(3). Some matters were removed by the boiling process, by precipitation, namely the carbonates of lime and magnesia. If these alone had been present, the second sample of water would have been quite soft.

(4). A saturated solution of sulphate of lime contains about 3,000 parts of $Ca\ SO_4+2H_2O$ to one million of water, at temperatures from 60° to 212° Fahr. Above the boiling point less sulphate of lime remains dissolved. Hence the water in the boiler may have been a saturated solution of sulphate of lime, though found to be less than saturated when run off and cooled (disregarding the effects of other salts on the solubility of this).

NOTE.—Specimens of the dry residues from equal volumes of the two samples of water, in porcelain evaporating dishes, were shown. They exhibited a marked difference in appearance. From the second sample there was a large residue with abundant crystals of sulphate of lime and some of sodium chloride; from the first sample there was a comparatively small residue, with very few crystals noticed.

April 2, 1889.

[*Paper EE.*]

THE STILLWATER DEEP WELL.—*A. D. Meeds.*

The Stillwater deep well was bored by a stock company of Stillwater citizens organized for the purpose of investigating the nature of the underlying rocks with reference to the occurrence of natural gas. It was begun June 23, 1888, by Mr. Paige Guthrie, contractor of Pittsburgh, Pa., and continued until the summer of 1889, when it was abandoned after reaching a depth of 3,440 feet. The well is situated in the centre of town, two blocks west of the city hall, is about 75 feet above Lake St. Croix, and 740 feet above sea level. It is 5⅝ inches in diameter and cased to 740 feet, below which no water was found. Water was struck at various depths above that but nowhere in sufficient quantity to be of value.

The drift here is but 18 feet thick. The Palaeozoic rocks extend below the drift to a depth of 717 feet and consist of light colored sandstones, limestones and shales. The remaining rocks are of Keweenawan age, extending to the bottom of the well. They consist of dark red sandstones in the upper part, changing to fine grained and much altered diabases in the lower part. In thin slides these rocks agree well with descriptions of Keweenawan rocks from Lake Superior.

The following is the record of the well taken from samples preserved by the men in charge:

No.		THICKNESS.	DEPTH.
1.	Coarse yellow sand consisting of rounded grains of quartz, much rusted		18 ft.
2.	Gray limestone	85 ft.	103 ft.
3.	Fine grained quartz sand mixed with some limestone from No. 2	39 ft.	142 ft.
4.	Very fine grained and almost pure white sand	20 ft.	162 ft.
5.	Light green shale with some grains of sand and pieces of limestone	41 ft.	203 ft.
6.	Very fine white sand mixed with some green material from No. 5	12 ft.	215 ft.
7.	Light green shale with some grains of sand	56 ft.	271 ft.
8.	Fine grained white sand which has a grayish appearance, owing to coating of lime	31 ft.	302 ft.
9.	Coarse grained grayish sand with pieces of drab shale or limestone and some green material	10 ft.	312 ft.
10.	Coarse grained white sand, consisting of rounded grains of quartz, some of a grayish color, some pyrite and some pieces of shale from No. 9	10 ft.	322 ft.

No.		Thickness.	Depth.
11.	Grayish sand with some green grains. Effervesces slightly with hydrochloric acid	27 ft.	349 ft.
12.	Gray shale or limestone with some rounded grains of quartz. Effervesces strongly. Resembles No. 2, but more shaly	31 ft.	380 ft.
13.	Impure sandstone made up of rounded with some angular grains of quartz, with much broken up dark material, some red and yellow grains which effervesce with acid	70 ft.	450 ft.
14.	Fine grained quartz sand with some impurities from No. 13	10 ft.	460 ft.
15.	Pinkish shale with streaks of white and green, some quartz grains. Effervesces strongly with acid	80 ft.	540 ft.
16.	Coarse quartz sand, some grains of a yellowish color. Some grains very large and mostly rounded	90 ft.	630 ft.
17.	Same as last but more yellowish	58 ft.	688 ft.
18.	Dark red shale with grains of sand. Effervesces with acid	13 ft.	701 ft.
19.	Coarse quartz sand, mostly rounded grains, with some red shale from No. 18	5 ft.	706 ft.
20.	Fine dark red shale. Effervesces	11 ft.	717 ft.
21.	Fine grained dark red sandstone. Effervesces	79 ft.	796 ft.
22.	Same as last	96 ft.	892 ft.
23.	Same as last, very fine grained. In thin section* this is shown to be undoubtedly a clastic rock, made up of grains of quartz, feldspar and metallic grains probably magnetite, with a cement highly stained by ferric oxide and containing masses of calcite. Many of the clastic grains as well as the cementing material are heavily charged with ferric oxide	31 ft.	923 ft.
24.	Same as last in general appearance. A small amount of salt water was struck at a depth of 1,950 ft. In thin section, however, this rock is shown to consist of an altered diabase porphyrite. The pyroxenic mineral is almost completely changed to chlorite and hornblende, and the feldspar is badly kaolinized. This latter mineral lies in long, lath-like individuals extinguishing very nearly to labradorite. With these non-metallic minerals there occurs quite a large quantity of some metallic mineral, probably magnetite, which is beginning to change slightly to hematite as can be seen on the borders of irregular and interstitial matters. The texture of this rock is medium	1327 ft.	2250 ft.

*In identification of minerals in thin sections the writer was assisted by Prof. C. W. Hall.

25. This rock consists of material same as last but mixed with a large amount of calcite and pinkish grains of feldspar, giving it a mottled light appearance. At a depth of 2,450 ft. another salt pocket was struck and a small amount of brine continued to flow into the well to the close. A thin section of a piece of the light material proved to be a hornblende biotite granite in which the feldspar is quite badly altered to kaolin..........	650 ft.	2900 ft.
26. Darker than last; less of the light colored material. In this was found a piece of quite a large pebble, one surface worn smooth and rounded...........	46 ft.	2946 ft.
27. Dark red sandstone about same as 21. In thin section it appears to be almost identical in general characters with that occurring at 2,200 feet. It is badly altered and the more intimate structure of the grains is difficult to make out................	4 ft.	2950 ft.
28. A very dark-brown diabasic rock with pieces of kaolinized feldspar and some green grains........	225 ft.	3175 ft.
29. Consists of the dark brown diabase similar to last, with some kaolin, calcite, and a notable amount of a green mineral found in long slender fibres, half an inch long, probably serpentine................	100 ft.	3275 ft.
30. Slate colored, fine grain diabase. In this rock pieces of native copper were found..............	25 ft.	3300 ft.
31. Same as last but mixed with considerable white material as in 29................................	5 ft.	3305 ft.
32. Same as 30..	5 ft.	3310 ft.
33. Same as last...	91 ft.	3401 ft.
34. A very fine grained drab colored rock which is reduced to dust, it is so finely broken up. It is a diabasic rock, with some white and some green material..	39 ft.	3440 ft.

Slides were made of the rock at 3,275 ft., and at other depths to the bottom. The rock appeared to be a diabase porphyrite, which at places is very fresh, as at 3,300 ft., and at other depths somewhat altered, as at 3,275. Where altered, it shows a darker color, the formation of hematite, the kaolinization of feldspar which is near labradorite, and the occurrence of quite numerous cavities filled with calcite. It does not appear from thin sections examined whether the calcite fills amygdaloidal cavities or cavities formed during the process of alteration which the rock has undergone. The feldspars for the most part have the peculiar lath-like shape noticed in layers above and the augite occupies interstitial places. There is comparatively little opaque mineral in the freshest pieces but scattered through these are numerous grains of a partially decomposed mineral, which is doubtless olivine. Probably it is the decomposition of this mineral which forms the metallic portion of the more altered slides. One interesting feature of the fresher porphyrite is the fact that the interstitial augite which acts as the matrix for the feldspar individuals, extinguishes simultaneously over quite large areas, a fact which has been observed in both granites and gabb os as well as in the fresher portions in the so called mottled melaphyr of Pumpelly, here in the northwest.

April 2, 1889.

[*Paper FF.*]

THE IRON BEARING ROCKS OF MINNESOTA.—*H. V. Winchell.*

[ABSTRACT.]

After speaking of the mining industries of northeastern Minnesota and pointing out on a chart some of the geographic and geologic features of our state Mr. Winchell continued :

The oldest formation in which we find iron bearing strata is the crystalline schist series, called the Vermilion series by the Minnesota geologists.

This formation consists of mica and hornblende schist strata, which spread over a large part of northeastern Minnesota. On the shores of Pelican lake, Rainy lake, Namekan lake, Vermilion lake and many others of our largest bodies of water, there are extensive out-crops of these rocks. Their dip is at all angles, from horizontal to vertical, but generally the latter. However, on Rainy lake several anticlinals are seen, where the dip changes from south to north, or vice versa. The general trend or strike of this formation is that of all the stratified rocks of the region, *i. e.*, about north, sixty degrees east.

It is only very recently that this formation has been proved to be iron-bearing. But during the past few months samples of good ore have been obtained from it in township 63 N., Range 12 W., north of the town of Ely. In sections 4 and 5 of this township the hornblende schist becomes charged with magnetite to such a degree that it is apparently a fair quality of magnetic ore. No analyses have yet been made of it. It may contain titanium.

It is not at all unlikely that this formation may prove to be of great value as an iron-producing horizon in Minnesota, since many productive mines are situated in the same rocks in New York and Canada.

Next younger than the Vermilion series is the Keewatin. This formation was first described under this name (which means "north") by Mr. A. C. Lawson of the Canada geological survey, who studied it on Lake of the Woods. It consists of vertically-bedded green schists and slates, which are in places hydro-micaceous and have a soft, greasy feel. The Keewatin appears to grade insensibly into the older crystalline schists, which are found between it and the granite on both sides. It is largely composed of eruptive material which has been re-arranged and re-deposited in water. In it are found peculiar agglomerate schists in which the pebbles are of the same green diabasic material as the magma which surrounds them.

In this formation are found the wonderfully pure and extensive deposits of specular iron ore, which have made the Lake Superior region famous. In fact, the only mines that have been really worked in this state are in the Keewatin, at Tower and Ely. The ore is largely hematite, but contains some magnetite in places. It is very hard, as a rule, and the cost of explosives is no small item in the mining expenses. At the Minnesota mine, for instance, there was used in the month of July over 30,000 pounds of dynamite and powder, and 1,300 men were employed to drill, break up and handle a quantity of ore not very much greater than was mined by half that number of men at the Chandler mine where the ore is in a crushed or brecciated condition.

The ore beds are in vertically placed lens-shaped masses, and are mingled with or accompanied by large amounts of banded red, white, black and gray jasper. So intimately mixed are the ore and jasper rock or "jaspilite" as it is called, that much of it is worthless. But at many places there are deposits 100 feet long, 30 to 90 feet wide and of indefinite depth where the ore contains on an average less than 2 per cent. of all impurities and that mostly silica. Its particular value lies in its low content of phosphorus, averaging less than one-tenth of one per cent. For this reason Minnesota ore is in great demand by the manufacturers of Bessemer steel.

While speaking of the mines in the Keewatin formation it will not do to omit mention of the Chandler mine at Ely, which may fairly be considered the most wonderful mine in the world.

It has only forty acres and works but a small part of that. It is only fifteen months since the first work was done on the wooded hillside, now covered by shaft houses, hoisting machinery and railroad tracks. And in that short space of time nearly 300,000 tons of iron ore have been mined and shipped by rail to Two Harbors, and thence by boat to Cleveland and other points.

Considering the area covered by the mine, this is a record never before equaled, and chief credit is due to the superintendent and general manager, Capt. Joseph Sellwood of Duluth, who has put into operation a very simple but efficient method of mining rapidly and cheaply.

The next formation which contains workable deposits of iron ore is the Huronian, which lies unconformably upon upturned edges of the Keewatin. In this formation we find sedimentary slates and quartzites interbedded with some gabbro and greenstone.

In the vicinity of Gunflint lake, on the international boundary, this formation is found to contain deposits of granular, shiny magnetite, more or less mixed with quartz and olivine. Hematite ore is found in this same formation in connection with the red and gray quartzyte of Pokegama Falls near Grand Rapids, on the Mississippi river above Aitkin. At this locality is the most western outcrop of iron ore-bearing strata in the state.

In this same Huronian formation are situated some of the mines of northern Wisconsin and Michigan. The Penokee-Gogebic range is composed of rocks of this age. We may therefore confidently expect to find profitable deposits of ore in this state in many places where it is now unlooked for and unexpected.

This ore is more regular in its manner of deposition than that of the Keewatin. It is in beds interstratified with quartzite, all having a general dip in this state of perhaps fifteen degrees to the southeast. This quartzite is supposed to be the upper part of the Huronian and to lie unconformably on the slates beneath.

Next in order above the Huronian is found the gabbro, which has been erupted and has flowed over the top of the Huronian strata, in some places entirely concealing them from sight, burying them under 200 or 300 feet of gray igneous rock, and in others, breaking up the Huronian quartzites and surrounding masses in areas a half mile or more in extent.

The iron ore found in the gabbro is unquestionably of igneous origin. It is a dull, massive magnetite with feebler magnetic attraction than the shiny granular ore of the Huronian quartzites. It also differs from the latter in containing titanic acid, ranging from 1 to 30 per cent. Although it is found in mountains which would be almost inexhaustible were they mined, the titanic acid renders the ore undesirable with the present methods of iron smelting. Where beds of the ferruginous Huronian quartzites are found involved in the gabbro overflow, as mentioned above, we seem to have non-titaniferous magnetite from the gabbro itself, but the appearance of the ore generally shows its true nature; and it may be stated as a general truth that the gabbro magnetite is titaniferous.

Ascending now through geologic time past all the rocks of the Silurian, Devonian and Carboniferous, we find our last iron ore formation to be the Cretaceous. At the bottom of this formation are found beds several feet thick of a low grade limonite ore. It occurs in Fillmore county, where the Cretaceous lies upon the Lower Magnesian, and is reported to be more than thirty feet thick in places. Some of this ore has been used at the furnace at Black River Falls, Wisconsin. It is probably of as good quality and as extensive in quantity as much of the ore formerly mined and smelted in Pennsylvania. But as long as we have mines in the northern part of our state of the best ore in the world, the poorer Cretaceous ore of the southern part of the state will not be used.

October 8, 1889.

[*Paper GG.*]

CRYPTOZOON MINNESOTENSE IN THE SHAKOPEE LIMESTONE AT NORTHFIELD, MINNESOTA.—*L. W. Chaney, Jr.*

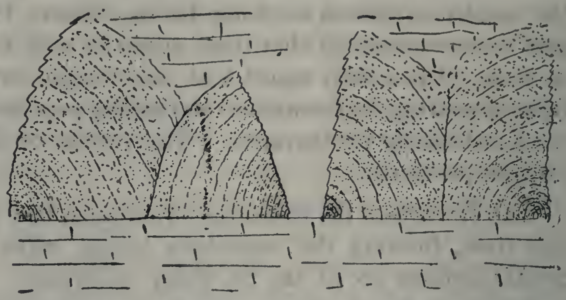
Several years ago I noticed frequently what appeared to be curved strata in the Shakopee limestone at a point near Northfield. A carriage road passed along under the ledges near the river so that one traveling that way could scarcely fail to notice the peculiar arrangement. After puzzling somewhat over them, attention was called elsewhere and a railroad having usurped the place of the former carriage road, they were seen but little and forgotten.

Two years ago Mr. F. O. Higbee and Mr. W. S. Wingate of the junior class in Carleton College were prospecting for fossils and came upon them again. As the class had been considering the smaller cryptozoa not long before, Messrs. Higbee and Wingate at once suspected that these might be such fossils on a gigantic scale. Upon their report I at once began examination, carefully measuring the formations and noting peculiarities of arrangement and taking photographs. The results of that examination are now presented.

At Northfield the Shakopee outcrops on both sides of the Cannon river, forming the immediate banks, while the bluffs at a greater distance are of the St. Peter sandstone. Wherever seen, the Shakopee limestone presents many peculiarities. It is full of flinty layers of unusual structure and its strata are exceeding irregular in composition and arrangement. A quarter of a mile below the town begins the ledge before spoken of, and it extends along the railway for half a mile or more. Along the face of the ledge at a height of from fifteen to twenty feet above the river is a very distinctly marked shelf which projects in some place two feet. Above this shelf are to be found the dome shaped masses which are now to be considered. As may be seen from Fig. 5, they present upon the face of the ledge the appearance of concentric layers, quite fine and close near the lower central part, becoming thicker and coarser as we proceed toward the outside. The inner layers curve somewhat sharply and seem to rest upon their edges on the shelf before mentioned. The outer layers change their direction and become apparently continuous with the adjacent horizontal layers. Occasionally two domes abut against each other. The line of division is then clearly marked, as a rule, and takes on two forms. One dome may be complete, its layers extending down to the general level upon which all seem to rest. The adjacent dome rests with the ends of its layers upon the sloping side of the

Fig. 5, showing structural features in the Shakopee limestone at Northfield.

first dome. In the second form the layers of each structure seem to terminate sharply at the line of junction. Fig's. 6 and 7.



FIG'S 6 & 7, showing further structural features, possibly *Cryptozoon.*

So far as can be learned from study without microscopic examination the central portion of each dome is finely laminated with occasionally a lacuna between the laminae. Across these lacunae there extend frequent calcareous filaments. The outer layers as before stated are thicker and the cellular spaces larger. In a few instances it has been possible to view horizontal sections of these structures. At a point about a mile west of Dundas, Minn., I found such a case and was able to confirm the conclusions drawn from the vertical sections. The size of these domes varies considerably, the smaller ones being two feet along the base and eighteen inches high, the larger reach ten feet in horizontal dimensions and six feet in height.

With this statement of facts some discussion of the origin of these remarkable structures may be undertaken.

Three views are possible. 1st. They are entirely organic; 2nd. They are entirely concretionary, huge inorganic masses; 3rd. They are concretions formed about an organic core of relatively small dimensions.

In the fourteenth annual report of the Minnesota geological survey are described and figured specimens of cryptozoon found near Northfield and Cannon Falls. The figure is from a large specimen some sixteen inches across, which is in the general museum of the University of Minnesota. Similar specimens of even larger size were found in grading a street in Northfield and are now in the cabinet of Carleton College. Smaller specimens have been found in considerable numbers. The figure in the report just named shows the same general structure above described. The microscopic structure is shown to be finely laminated. the laminae being wavy. It is found that by patient digging there may be extracted from some of the domes a central mass having all the characteristics of the smaller masses which are regarded as undoubted fossils. The difficulties in regarding the entire mass as fossil are: 1st. The size of the mass. If they are single fossils they are entirely unique as to size. It is true that corals have produced masses fully as large, but a colonial protozoon reaching anything like such dimensions is unknown so far as I can discover. 2nd. The change in structure which is observable as we pass from the center toward the outside. There appears to be no good reason why any such change should occur. If they are entirely organic there should, it would seem, be a substantial uniformity in structure from center to periphery.

The supposition that we are dealing with a simply concretionary structure seems untenable in view of the opinion of those who have made the most careful examinations.

The microscopic structure is regarded by Prof. N. H. Winchell as conclusive evidence of organic origin. Prof. Henry M. Seely writes me that he has discovered in the Calciferous of the Champlain valley two forms similar to those described and which he names provisionally Cryptozoon steeli and C. saxirodeum. C. steeli varies in size from two inches to two feet, while C. saxirodeum rarely exceeds nine inches. It will be noticed that the Northfield specimens are immensely larger than either of these. Professor Winchell in his report has given to the forms found at Northfield and Cannon Falls and varying from two inches up to twenty-five inches in diameter, the name Cryptozoon minnesotense. Should it seem that these larger forms are specifically distinct, C. *giganteum* would certainly not be an inappropriate name.

The third possible view suggested, namely that these structures are concretionary about an organic core, has several points in its favor. 1st. It accords with many other well known cases. Nothing is of more frequent occurrence than to find a concretion having a well preserved fossil in the centre and the dimensions of the concretion having no particular relation to the size of the fossil around which it has formed. 2nd. The marked difference between the inner and outer layer may thus be accounted for. The change in structure appears to be rather gradual, but in a few cases there is a somewhat clearly defined boundary between the central core and the surrounding layers. 3rd. The structure of the outer layers so far as can be judged from observation with a lens is suggestive of concretionary rather than of organic origin.

From whatever point we consider these structures, they are highly curious and interesting and at some time when more information is available, a more definite theory of their origin may be possible. At present they remain something of a mystery in spite of their close relation to things about which we think we have knowledge.

October 8, 1889.

[*Paper HH.*]

A RECENT VISIT TO LAKE ITASCA.—*By Warren Upham.*

Far in the northern forest of Minnesota, about a hundred and ninety miles north-northwest from Minneapolis and St. Paul, there lies a little lake which probably has become known, at least by name, to as many people throughout all civilized lands, as any lake of the whole world. Its pre-eminence comes from its being the head of the great river Mississippi, which first flows out from it fourteen miles northward, more nearly thirty miles by the meandering course of the river, and thence flows to the east through a succession of small and large lakes, and afterward to the south through the central part of this state and along its southeast boundary and onward thousands of miles to the Gulf. In size, Itasca belongs to the middle class of the ten thousand lakes and lakelets of Minnesota, its length from south to north being a little more than three miles, with a branch extending from its center about two miles to the east and southeast. It thus consists of three parts, which are called its Southwest, Southeast and North arms; and the width of each of these varies from about a quarter to a half of a mile. Its water is deep and clear, having a maximum depth, according to soundings by Mr. J. V. Brower, of about eighty feet in the Southeast arm, while the main lake, consisting of the Southwest and North arms, is found by him to be shallow at each end, thence gradually deepening to a maximum of about forty feet between Schoolcraft island and Bear point, which projects into the lake from the north at the junction of the Southeast arm. Its shores are mainly well wooded, and rise steeply from the water's edge, excepting small tracts of bog or tamarack swamps, through which most of the tributaries of Itasca enter the lake.

The first expedition seeking to reach the head of the Mississippi was that of General Cass in 1820, penetrating the northern forest to Cass lake, which seems to have been regarded for some years afterward as the principal source of the river. A few years later, in 1823, Beltrami traversed the country between the Red River valley and the upper Mississippi, crossing Red lake and entering the Mississippi basin above Cass lake by way of the Turtle lake and river, which, from his sentimental and interesting narrative published as letters to a lady named Julia, are called the Julian sources of the Mississippi. But another stream, somewhat larger than the Turtle river, was known to come from the west and southwest, and in 1832 Schoolcraft, under instructions from the government, conducted an expedition up that stream, which has ever since been rightly considered the main Mississippi, to the lake at its head, which the Indians called Omushkos, that is, Elk lake, but which Schoolcraft then named Itasca, from the Latin words *veritas*, truth, and *caput*, head, the name being made by writing the words together and cutting off, like Procrustes, the first and last syllables. Four years later, in 1836, Nicollet more fully explored this lake, and claimed that its largest tributary, the creek or brook flowing into the extremity of its Southwest arm, is "truly the infant Mississippi."

Here the question rested until Glazier in 1881, six years after the Government sectional survey of that area, made his expedition to Itasca and to the lake in Section 22, Town 143, Range 36, called by the Government survey plats Elk lake, lying close southeast of the Southwest arm of Itasca, and thence voyaged in a birch canoe to the mouth of the Mississippi. His ridiculous re-naming of Elk lake in his subsequently published book and maps has anew directed the attention of geographers to the determination of the source of the Mississippi. In October, 1886, Mr. Hopewell Clarke of Minneapolis, for Ivison, Blakeman, Taylor & Co., publishers, New York, made a reconnoissance of lake Itasca and its basin, occupying five days. His report, which appeared in Science for December 24, 1886, fully sustains the work and conclusion of Nicollet, whose admirable map of the Northwest, comprising Minnesota and adjacent states, published about fifty years ago, when the first settlement at Saint Paul was beginning to be made, cannot receive too high praise. A far more detailed examination of the Itasca basin has since been made by Mr. J. V. Brower, for the Minnesota Historical Society, chiefly during last autumn and spring, and his report, illustrated by maps and photographs, will soon be published by that society. He also agrees with Nicollet and would apply the name Mississippi river to the largest tributary of lake Itasca, which Mr. Clarke calls Nicollet's creek. My own preference, and I think also that of the people of Park Rapids and the whole Itascan region, is for the latter name, leaving lake Itasca to be regarded as the true head of the Mississippi, in accordance with the etymology of its name.

With Mr. George M. Carson, of Osage in northeastern Becker county, a nephew of the famous guide and scout, Kit Carson, the friend and companion of Fremont, I started at sunrise Wednesday morning, September 18, 1889, to visit lake Itasca and the northwardly flowing portion of the Mississippi to Section 28, Town 146, Range 35, where the river begins to take a generally eastward course. The purpose of my journey was to observe the character of the drift deposits of that area, and, learning that the nearest farmers are about twenty miles distant from Itasca, I availed myself of the opportunity to accompany Mr. Carson, who was going with his team and lumber wagon to carry goods to an Indian trading-post in the Section 28 mentioned, and to bring back a load of Seneca snake-root, which is dug in great quantities by the Indians. We were provided with provisions and blankets for camping out; and two days were occupied in going, one day for resting our horses at the trading-post, and two days in returning.

Our route from Osage to Itasca passed west and north of Straight lake, and through the north edge of Two Inlet lake to avoid crossing its principal inlet, the head stream of the Fish Hook river. This road is joined by that leading from Park Rapids to Itasca at a distance of about three miles northeast of Two Inlet lake, between the two fording-places of Dinner creek, which is the eastern one of the two inlets. About two miles farther north and a mile east of the Itasca road, this creek has its source in Little Man Trap lake, about two miles long, so named because its many peninsulas and tamarack swamps at the head of its bays baffle the hunter, or the "cruiser" in search of pine lands, who attempts to pass around it. A dozen miles east-southeast from this is a larger Man Trap lake, much more beset with these difficulties. From either Osage or Park Rapids, which lies ten miles farther east and is the county seat of Hubbard county, the distance by road to lake Itasca is about thirty miles; but the distance from the middle point of the road between Osage and Park Rapids, where it crosses the line of Becker and Hubbard counties, due north to the extremity of the Southeast arm of Itasca is only nineteen miles.

Besides the generally crooked course of the road, detours from it must be made in many places to pass around large fallen trees, some of which were lordly white pines that rose to a height of one hundred feet and had withstood the storms of a century. Stumps and boulders, the latter occasionally very abundant, projecting six to eighteen inches in the wheel ruts, jounce and jolt the wagon merrily; frequent sideling places threaten to tip it over; and here and there the horses struggle through quagmires in approaching the bridges or fording-places of streams, which however at the fords have a hard and safe gravelly bed. A shaky bridge, the uppermost on the Mississippi, built of tamarack poles, carried us safely over Craig's crossing at the southeast corner of Section 26, Town 145, Range 36, seven miles due north of the mouth of Itasca, the stream there being about twenty feet wide and twelve to eighteen inches deep. It is becoming to say a good parting word for this bridge and indeed for the whole road; they shall be long remembered for their help to me in this journey, which had no mishap nor noteworthy adventure, and was blessed with the finest of sunshiny, clear and calm autumn weather.

Two or more railway surveys have crossed the Mississippi, selecting routes from the Red River valley to Duluth, at rapids of the river about two miles and five miles northeast of Craig's crossing. One of these railways is now in process of construction from Duluth to Grand Rapids on the Mississippi eighty miles east of Itasca, and its western extension will probably be built in the near future. It is also very probable that a railway will be built from the south to Park Rapids and the vicinity of Itasca. A large inducement toward these enterprises is the valuable pine timber, which occurs sparingly or in groves, sometimes covering several sections, throughout nearly the whole district of the upper Mississippi, the Clearwater river, and the basin of Red lake. When such means of travel are supplied, the beautiful lake Itasca, and probably also Cass, Winnebagoshish and Leech lakes, will be counted among our most attractive resorts for summer rest or in autumn for the capture of game and fish.

The Mississippi river at the crossing of the Saint Paul, Minneapolis & Manitoba railway survey in Section 8, Town 145, Range 35, about eleven miles distant in a direct line a little to the east of north from the mouth of Itasca, is 1,373 feet above the sea. Between the lake and this point the river probably falls about seventy-five feet, from which estimate the elevation of lake Itasca is shown to be 1,450 feet approximately. On the east, south, and west the land rises within a distance of one to three miles from the lake to heights 100 to 250 feet above it, as determined barometrically by Mr. Clarke, or 1,550 to 1,700 feet above the sea; and the highest lakes that probably drain underground to lake Itasca, in Sections 3 and 4, Town 142, Range 36, three to four miles south of its Southwest arm, have a height of 101 feet above Itasca, as determined by levelling under Mr. Brower's direction. The highest hills enclosing the Itascan basin on the south and west have thus nearly the same altitude above the sea as the tops of the Leaf hills in southern Otter Tail county; but they lack about 300 feet from reaching the height of the Coteau des Prairies in southwestern Minnesota, and 500 or 600 feet from the highest parts of the Mesabi range and other hills in the northeast part of this state between lake Superior and the international boundary. A line drawn from Minneapolis to Winnipeg ascends gradually in the southern half of its extent from 830 feet above the sea here to about 1,600 feet at the height of land three miles south of lake Itasca, the average ascent being very nearly four feet per mile; and thence an equal rate of gradual descent falls to 757 feet above the sea at Winnipeg and 710 feet at the level of lake Winnipeg.

All the country about lake Itasca consists of the glacial and modified drift, the nearest outcrops of the bed-rocks being eastward on the Little Boy river and southward near Motley. The thickness of the drift there may be estimated between 100 and 200 feet, from comparison with the similarly drift-covered areas of the Red River valley and all western and southwestern Minnesota, including the Coteau des Prairies, where the depth to the bed-rocks is ascertained by wells. Over the preglacial surface, as it had been sculptured into hills, ridges, and valleys by stream-erosion before the Ice age, the drift is found to be spread with a somewhat uniform thickness, but it is generally increased 50 to 75 or 100 feet in its depth upon belts of specially hilly and knolly deposits, with abundant boulders, which are called terminal moraines.

One of the most distinct morainic belts of this state, denominated the Itasca moraine, extends with a width of five to ten miles from the south side of Pokegama and Leech lakes westward to

Little Man Trap lake and the southern arms of Itasca. Thence, following the height of land, it bends to the northwest and north between Itasca and the source of the Red river, and continues northward between the Upper and Lower Rice lakes to Clearwater lake, from which it passes westward along the south side of the Clearwater and Lost rivers, entering the area of the glacial lake Agassiz between Maple lake and Red lake. This is the tenth in the series of moraines in Iowa, Minnesota, and South and North Dakota, formed by the last ice-sheet that overspread this region, marking its boundaries in its maximum area, when it reached south to Des Moines, and in successive stages of halt or slight re-advance interrupting its recession.

The southern border of the Itasca moraine, where it is crossed by our road to Itasca, is called Stony Ridge. It consists of small ridges of till, trending from southeast to northwest, with very plentiful boulders, all Archæan from the northeast and north, chiefly granite and gneiss. No limestone boulders were observed by me in this journey; but in the vicinity of the White Earth Agency and about Red lake they form a considerable proportion of the drift, having been brought by glacial currents from the region of lakes Winnipeg and Manitoba. Very irregularly grouped morainic hills 50 to 100 feet high rise on each side of our road, which winds and climbs and descends over them, along a distance of about eight miles, from Stony Ridge to Mr. Peter Turnbull's claim cabin on the Southeast or Turnbull's arm of Itasca.

Many empty hollows twenty to forty feet deep are seen beside our road, being kettle holes, as they are called, well known as characteristic of morainic drift deposits. Several similar hollows, but of larger area and greater depth, contain a series of picturesque little lakes, lying east of our road, in descending order from south to north, the lowest having an outlet to lake Itasca by Mary creek. These small lakes fill depressions of the drift, and lake Itasca doubtless owes its existence to greater thickness of the drift in the valley at the mouth of the lake and for several miles down the Mississippi, rather than to greater prominence of the underlying rock there. But the great valley 100 to 200 feet deep and two to four miles wide, in which lie lake Itasca and the Mississippi northward to Craig's crossing and to its rapids over boulders in Section 8, Town 145, Range 35, also the similar but smaller valleys of the La Salle, Hennepin and Schoolcraft rivers, successively tributary to the Mississippi from the south between lakes Itasca and Pemidji, existed as grand topographic features of the country before the glacial period, and were then occupied by streams flowing in the same northward direction as now. It is improbable, however, that Minnesota or any part of the northern states then had any considerable number of lakes, their condition in this respect having been like that now found in the southern states beyond the limit of the glacial drift.

Three species of pines occur plentifully about Itasca. Red pine, commonly but erroneously called Norway pine, constitutes perhaps three-fourths of the timber available for manufacturing lumber. This species grows seventy-five to one hundred feet in height and one and a half to two feet in diameter. In its most dense groves it is almost unmingled with other species of trees, and its reddish brown straight trunks rise forty to sixty feet to the first limbs and are so thickly set that their canopy of boughs almost excludes the sunshine. These groves have little or no underbrush, and seem prepared by nature for picnic grounds. The white pine attains a height of ninety to a hundred and twenty-five feet and a diameter of two to three or four feet. It is about a third as plentiful as the red pine, and grows on more clayey soil, either scattered or in groves, through whose tops every wind plays inimitable music. The jack pine (Pinus Banksiana, Lambert) occupies sandy and gravelly land, and is very abundant on such tracts in the Itascan district and far eastward and northward. It has a small but straight and tall trunk, sixty to eighty feet high and nine to eighteen inches in diameter at the base. This species is used for fuel; and the Indians split and prepare its long, pliant roots, called *watab*, for sewing together the strips of birch bark of their canoes.

Among the other principal forest trees and shrubs of Itasca are the common poplar or aspen, very plentiful, the large-toothed poplar, the balsam poplar, cottonwood, canoe birch, black and burr oaks, white elm, white and black ash, red and sugar maple, basswood, wild plum, bird or pin cherry, high bush cranberry, common and beaked hazel, prickly ash, moosewood, willow, and alder. In the swamps, and frequently on higher land, tamarack, black spruce and balsam fir grow in abundance, often festooned with moss.

Last June a great fire ran through the woods northeast of lake Itasca and northward to Craig's crossing, almost wholly burning up the dense young poplar growth upon thousands of acres where the ground beneath was thickly strown with the trunks of a former generation of poplars that had fallen years ago after being killed by fire. Many scattered trees and groves of red and white pines were also overrun by this fire, which was carried by the gale up the pitchy trunks and fanned into masses of flame enveloping the branching tops like hugh torches. Now these trees, scorched and blackened, with all that remains of their foliage withered, stand dead, awaiting the slow decay of many years and the ravages of wood-eating worms and insects, to lay them low. Large tracts of forest composed of many species were killed, and through their leafless branches the sun shines down on the rank young shoots and seedlings which during the past summer have sprung up to replenish the loss.

The first frost of this fall in the vicinity of Itasca was two nights before I left Osage on this trip, and on the morning when we started ice was frozen an eighth of an inch thick. Looking for the effect of these frosts on the rankly grown and still green leaves of the young oaks, basswood, and other species, I saw no immediate harm produced, except in the case of the ash shoots, whose foliage was withered, seeming to be nearly as tender to the frost as the dahlias of our gardens. Ten days later all the deciduous trees were in their brightest autumn coloring of red, yellow and russet brown.

Tall game is occasionally found in these woods. Hundreds of moose are killed every year, mostly by the Indians, but their numbers are said to be increasing and to exceed the deer, which are also plentiful. But the elk, which supplied the aboriginal name of Itasca, have retreated to the northwestern edge of Minnesota where a few are said to survive in the neighborhood of Roseau lake and river. The caribou ranges southwestward to the Rainy river, but probably not to Itasca. Among the fur-bearing animals are the black bear, lynx, wolf, mink, muskrat, skunk and otter. Beavers, which were formerly plentiful, are now wholly driven away or very rare.

This article may well close with a notice of the relationship of Itasca and Elk lakes, which has supplied the aboriginal name of the latter. Rev. J. B. Gilfillan, of White Earth, tells us that the Indians call Elk lake *Gabukegumag*, meaning "water which juts off to one side." And so this lake is outlined on Nicollet's original map, appearing as a bay connected with Itasca by a narrow strait. During recent years the level of Itasca has fluctuated only a few inches, varying from thirteen to eight inches below Elk lake; but fifty-three years ago, when Nicollet was there, his map indicates that lake Itasca stood at least two or three feet higher than now, being raised so high that Elk lake became a part of Itasca. The method of Nicollet's exploration of Itasca was probably by a canoe trip around its entire shore, for he mapped every noteworthy tributary; and therefore his testimony of the relationship of these lakes in 1836 seems decisive. This date was only ten years after the highest known flood of the Red river, when its water rose five feet above the surface where Winnipeg is now built; and it was two years before the highest known stage of the great Laurentian lakes in 1838, when lake Erie stood six feet above its lowest recorded level, which was in the winter of 1819-20. It is also interesting to note in comparison with these high stages of the Red river, Itasca and the Laurentian lakes, that Devil's lake, in North Dakota, which has no outlet, shows evidences of having attained, about the year 1830, a level eighteen feet higher than now, reaching then to the line that limits the large and dense timber of its bordering groves. Below that line are only smaller and scattered trees, of which Captain E. E. Heerman informs me that the largest found by him had fifty-seven rings of annual growth. Within the twenty-two years since the building of Fort Totten, Devil's lake has fallen nine or ten feet; and it has fluctuated five feet under the influence of the changes in the average annual precipitation of rain and snow during the past ten years. Itasca, affected by similar changes in the average rainfall and snowfall, but having an outlet, has varied in level not more than six or eight inches since 1880.

October 8, 1889.

PROCEEDINGS

OF THE

MINNESOTA ACADEMY OF NATURAL SCIENCES,

VOLUME III. BULLETIN 3.

January 15, 1890.

The annual meeting of the Academy.

The following persons were elected to membership: O. J. Griffiths, P. Kennedy, C. W. Jackson, F. W. Sardeson, C. L. Chase.

A unanimous vote of thanks was extended to the Library Board of the City of Minneapolis, for their prompt and generous action in affording quarters for the Academy, and in furnishing cases for the preservation and exhibition of its collections.

The reports of the retiring officers were presented.

Recording Secretary Hall made the following report:

Membership fees collected during the year..................	$216 00
Election fees of new members elected during the year.......	50 00
Total receipts for the year..................	$266 00
Amount on hand at last annual meeting....................	123 49
Total amount available for the year..........	$389 49

Corresponding Secretary Fellows reported the following additions to the library during the year 1889:

THE UNITED STATES.

Baltimore, Md.—Johns Hopkins University: Circular Nos. 69, 72, 74 and 77.

Boston, Mass.—Boston Society of Natural History: Proceedings, Vol. XXIII, Parts 3 and 4.

Massachusetts Horticultural Society: Transactions, 1888, Part 1; Schedule of Prizes for 1889.

Buffalo, N. Y.—Historical Society: Annual Report, January 8, 1889.
Cambridge, Mass.—Museum of Comparative Zoology: Bulletin, Vol. XVI, Nos. 3, 4 and 5; Vols. XVII, Nos. 3, 4 and 5.
Chapel Hill, N. C.—Elisha Mitchell Scientific Society; Journal, Vol. VI, Part I.
Cincinnati, O.—Cincinnati Society of Natural History: Journal, Vol. XI, Part 4; Vol. XII, Part I.
Davenport, Ia.—Davenport Academy of Natural Science: Proceedings, Vol. V, Part I (pages I to 184).
Denver, Col.—Colorado Scientific Society: Proceedings, Vol. III, Part I.
Des Moines, Ia.—State Historical Society of Iowa: Iowa Historical Record, Vol. V, Parts I, 2, 3 and 4.
Granville, O.—Denison University: Bulletin Scientific Lab., Denison University, Vol III.
Lansing, Mich.—State Agricultural College; First report of the Forestry Committee, 1887-8; Bulletins Nos. 43 to 48 inclusive.
Lincoln, Neb.—University of Nebraska: University studies, Vol. I, No. 2.
Little Rock, Ark.—Geological Survey of Arkansas: Annual Report, 1888, Vols, I, 2 and 3.
Madison, Wis.—Wisconsin Natural History Society: Proceedings, April, 1889, pages 191 to 231.
Seventh An. Rep. Public Museum, October I, 1889.
State Historical Society: 36th Annual Meeting, January 3, 1889.
Meriden, Conn.—Scientific Association: Transactions, Vol. III (1887-1888).
Middletown, Conn.—Wesleyan University: Eighteenth Annual Report of Curator of Museum.
Connecticut Historical Society: 250 Anniversary of the adoption of the first Constitution of Connecticut.
Minneapolis, Minn.—The University of Minnesota: Annual Report, 2 copies.
The Agricultural Experimental Station: Bulletins Nos. 5, 6, 7, 8 and 9.
New York, N. Y.—American Geographical Society: Bulletins, Vol. XX, index. Vol, XXI, Nos. I, 2, 3.
American Museum of Natural History: Annual Report of Trustees, 1888-1889. Bulletin, Vol. II, No 8.
New York Academy of Sciences: Transactions, Vol. VIII, Parts, I to 8.
New York Microscopical Society: Journal, Vol. V, 1889, Nos. I, 2, 3 and 4.
Torrey Botanical Club: Bulletin, vol. XVI, I to 8; Vol. XVI, 10 to 12.
Philadelphia, Penn.—Academy of Natural Sciences: Proceedings, 1888. Part 3; 1889, Parts I and 2.
Second Geological Survey of Pennsylvania:
Atlas Northern Coal field, Parts, 3 AA; Parts 4 AA.
Atlas Reports HH. and HHH.
Museum Catalogue, 3 OOO.
South Mountain Sheets, C, I, 2, 3, 4.
" " " D, I, 2, 3, 4, 5, 6.
Annual Report, 1887.
Dictionary of Fossils.

Zoological Society: Seventeenth Annual Report, 1889.

Portland, Me.—Portland Society of Natural History: Proceedings of Annual meeting, May 20, 1889.

Catalogue of Birds, N. C. Brown.

Providence, R. I.—Rhode Island Historical Society: Proceedings, 1888-9.

St. Louis, Mo.—Academy of Sciences: Transactions, Vol. v, Parts 1 and 2.

Salem, Mass.—American Association for the Advancement of Science: Proceedings, Vol. 37. (1888.)

San Diego, Cal.—West American Scientist: Journal, 1889. May, No. 43, July No. 45, August, No. 46, Sept., No. 47, Oct., No. 48, Nov. No. 49.

San Francisco.—California Academy of Sciences: Proceedings, Sec. 2, Vol. 1, Parts 1 and 2.

California State Mining Bureau: 8th An. Report, State Min. Bureau.

Topeka, Kan.—Washburn College Laboratory of Natural History: Bulletin, Vol. 1, No. 9, Jan., 1889.

Trenton, N. J.—Natural Hist. Society: Jour. Vol. ii, No. 1, (Jan., 1889.)

New Jersey Historical Society: Proceedings, Vol. x, No. 3.

Washington, D. C.—Smithsonian Institution: Report International Exchanges for year ending June, 1888; Mound Explorations, C. Thomas; Ohio Mounds, C. Thomas.

Treasury Department: Production of Gold and Silver in U. S. 1887.

United States Geological Survey: Mineral Resources of the U. S. 1887; Monograph No. 13, Quicksilver Deposits Pacific Slope; Monograph 14, Fossil Fishes and Plants of N. J. and Conn. valley; Bulletins No. 48 to No. 53 inclusive.

United States House of Representatives: 50th Cong. 1st Sess. Pres. Mess., Ex. Doc. 434.

United States Patent Office: Bound volumes, Parts 1 and 2 for May, 1888, of specifications and drawings; 52 weekly numbers Official Gazette.

United States Senate: 50th Cong., 1st Sess., Pres. Mess., Ex. Doc. No. 51; 50th Cong., Fisheries Treaty, Misc., No. 109; 50th Cong., President's opening Mess.; 50th Cong., 2d Sess, Congressional Directory.

FOREIGN.

Berlin, Germany.—R. Friedlander & Sohn: Naturae Novitates 1889, 1, 2, 3, 6, 7, 8, 11, 13, 14, 16, 17, 18, 20, 22, 23.

Bombay, India.—Royal Asiatic Society (Bombay branch): Journal, Vol. xvii, No. 47, Part 2.

Brussels, Belgium.—Malacological Society of Belgium: Proceedings, Vol. xvii, pages 1 to 72.

Cairo, Egypt.—Institute Egyptien: Memoires Tome ii, Parts 1 and 2; Bulletin 2d Ser. No. 9.

Calcutta, India.—Geological Survey of India; Bibliography of Indian Geology; Records, Vol. 22, Parts 1 and 2.

Christiania, Norway.—Scientific Society: Proceedings, 1887, 1888.

Cordoba, Argentine Rep.—National Academy of Sciences: Bulletin, Tomo xi, No. 3.

Demarara, Brit. Guiana.—Royal Agricultural and Commercial Society: "Timehri" Vol. II, Part 2; Vol. III, Part I.

Edinburgh, Scot.—Geological Soc.: Transactions Vol. VIII, Part 2 (2 copies).

Florence, Italy.—Institute of Higher Studies: 1. Archivo della Scuola d' Anatomia patologica Vol. II.

2. Esegesi medico legale del methodus testisicandi di Gio Batta Codronchi. A. Filippi.

3. Linnegenerali sulla fisiologia del cerevelletto mem. I, L. Luciania.

4. Osservarioni contemne seell' elettricita at mosperica in Frienze Mem. I, Rothe Pasqualine.

National Library: Bulletins 79 to 94 inclusive; Index to Bulletins for 1888, pages 1 to 11; General Index 1887; Title page and General Index for 1888.

Halifax, N. S.—Nova Scotia Institute of Nat. Science: Proceedings and Transactions, Vol. IV, Part 3; Vol. V, Part 4; Vol. VI, Parts 3 and 4; Vol. VII, Part I.

Halle, Germany.—Imperial Leopold-Carolus Academy of German Naturalists, "Leopoldina Heft 24 (1888).

Kassel, Germany.—Natural History Society: Report 1886 to 1888.

Liverpool, Eng.—Liverpool Geol. Society: Proceedings, Vol. VI, Part I.

Madrid, Spain.—Royal Academy of Natural Sciences and Arts: Meneoria Inaugural 1888-9.

Mexico, Mex.—Geographical and Historical Society: Bulletin 4th Ser. Vol. I, Nos. 3 and 4.

Montreal, Can.—Canadian Institute: Proceedings, 3d Ser. Vol. VI, No. 2, (or whole Vol. XXVI, No. 151.)

Natural History Society: Canadian Record of Science, Vol. III, Nos. 3, 4, 5, and 6.

Moscow, Russia.—Imperial Society of Naturalists: Bulletin, 1888, Nos. 3 and 4, Meteorological supplement to Parts I and 2; Bulletin 1889, No. I.

Munster, Germany.—Provincial Society of Sciences and Arts; 16th Annual Report (1887).

Paris, France.—Linnean Society: Annals Vol. XXXII, 1885: Annals, Vol. XXXIII, 1886; Annals, Vol. XXXIV, 1887.

Rio Janciro Brazil.—Historical, Geographical and Ethnographical Institute, Revista Trineusal, Vol. LII, Part I.

Rome, Italy.—National Victor Emanuel Library: Bulletin, Vol. III, Nos. 5 and 6; Vol. III, title page and index; Vol. IV, Nos. I, 2 and 3.

Saint John, N. B.—Natural History Society of New Brunswick; Bulletin No. 8; Index to Bulletins I to 5.

Shanghai, China.—Royal Asiatic Society (North China branch): Journal, Vol. XXII, No. 6; Vol. XXIII, Nos. I, 2 and 3.

Sydney, N. S. Wales.—Geological Survey of N. S. Wales.

Memoirs of the Geol. Sur. N. S. W. Palaeontology, No. 2.

Descrip. Cat. of Exhibits of Metals, Minerals, etc., to the Melbourne Cen. Internat. Exhibit, 1888.

Public Library Museum and National Gallery: Prodromus of Zoology of Victoria; Decades 16, 17, 18; Report of trustees, 1887.

Royal Society of New South Wales: Journal and Proceedings, Vol. XXII, Parts 1 and 2.

Turin, Italy.—Museums of Zoology and Comparative Anatomy: Bulletin, Vol. III, Nos. 49 to 52, and plate No. 3; Vol. IV, Nos. 53 to 61 and plate No. 1.

Officers were elected for the year 1890 as follows:

President, - - - - - P. L. Hatch.
Vice President, - - - H. F. Nachtrieb.
Recording Secretary, - - - - C. W. Hall.
Treasurer, - - - - Edward C. Gale.
Corresponding Secretary, - Chas. S. Fellows.
Trustees for three years, { W. H. Leonard. C. W. Hall.

January 16, 1890.

In the records of the Board of Trustees under this date, the following preamble and resolutions appear:

WHEREAS, Dr. A. F. Elliot has now retired from the Presidency of the Minnesota Academy of Natural Sciences and from membership in this Board;

Resolved, that the Board of Trustees recognize in this retirement the loss of a tireless worker, one who at all times and under all circumstances, was loyal to the interests of the Academy and eager to advance its work in the community, and one whose enthusiasm in this work commanded the respect of all;

Resolved, That we extend our thanks as a Board to Dr. Elliot for his efficient labors as President during the past eight years, and that we wish him a speedy and perfect recovery to many years more of work in advancing the interests of this Academy;

Resolved, That these resolutions be published in the forthcoming PROCEEDINGS of the Academy.

February 4, 1890.

Twenty-five persons present.

The following communications were read:

From J. S. Harris, touching the native plum in Minnesota.

The writer believed that this fruit had developed its many varieties through its cultivation by the Prehistoric tribes of the Mississippi valley, and thought that further cultivation by horticulturists would finally develop a perfect and valuable native fruit.

From G. Brown Goode, informing the Academy how to solicit collections from the Smithsonian Institution.

From City Engineer Andrew Rinker, offering the loan of a mounted bird.

From Henry T. Claghorn, of Philadelphia, to President Hatch, inviting him and the Academy to an inspection of his collections.

And one from Dr. Sandberg, touching the purchase of a set of Mexican plants.

Conway MacMillan introduced the subject of aquatic gardening in this climate and particularly at Minneapolis, and in the neighboring lakes. As an expression of the opinion of the Academy, the following resolution was unanimously passed:

Resolved, That the Minnesota Academy of Natural Sciences recommend to the Park Commissioners of Saint Paul and Minneapolis, the consideration of plans for aquatic gardening in the park lakes of the Twin Cities.

Mr. MacMillan then presented some botanical notes:

[ABSTRACT.]

Attention was directed to the lately published researches of Ed. Schenck, on the cupric compounds of chlorophyll, the isolation of anilophyll and the chemical composition of phyllocyanin. A review was given of several recent botanical memoirs, principally those of M. Ward, on the nitrogen-supply of plants. (Ann. Bot. Feb., 1888), of Seignette on tubercles and their germination (Rev. Gen. Bot. Dec. 1889) ; of H. Jumelle on the second function of chlorophyll (Rev. Gen. Bot. Jan., 1889). A general resume of the late articles on the position of dorsiventral organs was appended.

Actinoceps besseyi, Hyphomycetous fungus occurring on putrescent orange skin was described as new.

A brief discussion followed.

Secretary Hall read a paper giving some historical notes and discussing, The Place of the Academy of Sciences in an American community.

March 4, 1890.

Thirty-four persons present.

The section of botany presented the following papers:

Conway MacMillan discussed the question, How to teach a three months course in Botany. (This paper was published in *Education* March and April, 1890.)

Dr. J. H. Sandberg gave a few practical directions as to how to collect, prepare and preserve an herbarium.

A number of samples were exhibited to illustrate different methods practiced by him in mounting and curing plants for his herbarium.

Mr. R. E. Grimshaw presented the Academy with the mounted head of a moose, a fine specimen. A vote of thanks was extended to Mr. Grimshaw for the gift.

John B. Hawley read an introductory paper on Water Powers of Minnesota.

This paper will be printed in a future Bulletin, with others which Mr. Hawley has in preparation.

April 8, 1890.

Thirty-two persons present.

Professor J. A. Dodge read the analysis of a cement rock from Mankato, Minn., made by W. C. Smith in the chemical laboratory of the State University.

Professor Dodge then read for Professor Sidener the report of an analysis of the efflorescence on red pressed brick.

A discussion followed upon the common statement of brick-makers that the efflorescence is from the mortar instead of from the brick; but the evidence seemed to show that the efflorescence comes from the brick.

Mr. P. Christianson read an analysis that he had recently made of a marl from a bed near Gladstone, Mich.

In answer to an inquiry touching its microscopic character, Secretary Hall gave a brief outline of the characters noted by him in one or two prepared slides.

Dr. A. E. Johnson presented the Academy a series of Palaeozoic fossils, consisting of 117 species with duplicate specimens of several. The thanks of the Academy were voted to Dr. Johnson for the valuable gift.

Horace V. Winchell called the attention of the Academy to a proposed trip by two members of the University of Michigan, to the Philippine Islands. The advantages which would accrue, if we could share in the collections to be secured, were pointed out, and the President was directed to appoint a committee of three (3) to canvass for subscriptions to this fund.

The committee appointed was as follows: E. C. Gale, S. P. Channell, H. L. Osborn.

May 6, 1890.

Twenty-one persons present

Rev. R. T. Cross and C. C. Jones, of Minneapolis, and F. W. Pettigrew, of Sioux Falls, S. D., were elected members.

Professor H. L. Osborn read a paper entitled: Class instruction in Crustacean Morphology.

[ABSTRACT.]

The crustacea are an especially favorable group for class instruction, in the principles of animal morphology:

1. Because it presents a wide range of subgroups, each one very large and with wide divergence of form, *e. g.* Copepoda, Ostracoda, Cirripedia, Amphipoda, Isopoda and macroura and brachyoura.

2. Because of the extensive larvae life of many of the forms, *e. g.* Peneus, Schizopoda, etc.

3. Because the important structural characters are drawn from parts extremely favorable for fossilization—viz: the outer shell.

4. Because the members of the group are some of them of sufficiently large size and anatomical simplicity to permit of their being studied by beginners.

5. Because of great range of physiological habit in closely allied forms, parasitism and free swimming life and commensalism. Also the spiral symmetry *e. g.* of hermit crab, and many other cases.

A series of minerals and ores was presented to the Academy, by Dr. A. F. Elliot, for which a vote of thanks was tendered. Museum numbers (778-784).

A series of specimens of typical minerals was presented by the United States National Museum. The thanks of the Academy were extended for this fine gift. Museum numbers (721-777).

A comunication from Mr. J. C. Slafter, proposing to deposit certain specimens in the Museum, was referred to the president and secretary.

Dr. Thomas S. Roberts reported the king rail from the vicinity of Mineapolis. This bird is rare further north than Illinois. having been seen in Minnesota only three times before; at Minneapolis in 1880; once in Kandiyohi county; and at Winona in 1886.

Franklin Benner and Dr. Hatch both contributed ornithological notes.

June 10, 1890.

Thirty-five persons were present.

Louis F. Menage, John H. Cook and W. M. Dodge were elected members.

The regular program was the report of the section of Geology.

C. W. Hall read a paper on Artesian and Deep wells as a source of water supply in the Northwestern States.

J. B. Hawley read a note on the boring of shallow wells in Saint Paul, around the lakes, which are used for the water supply of that city.

A paper by Warren Upham, entitled, Artesian Wells in North and South Dakota, was read by Secretary C. W. Hall.

A paper entitled, A Prehistoric Indian Village, was read in the absence of its author, Fred W. Pettigrew, of Sioux Falls, South Dakota, by J. P. Goode. The paper was illustrated by photographs.

Dr. A. F. Elliot presented some minerals, and also a photograph of prehistoric articles from a burial place in California.

Secretary Hall then announced informally that Mr. L. F. Menage had decided to assume the expenses of fitting out an expedition to the Philippine Islands, under the direction of Dean C. Worcester and Frank S. Bourns, for the purpose of collecting natural history specimens.

July 2, 1890.

Under the above date, in the records of the Board of Trustees, the following stands:

There was placed before the Trustees for their consideration a communication from Mr. Louis F. Menage, bearing date of June 26, 1890, tendering to the Minnesota Academy of Natural Sciences, under certain conditions named in the comunication, the collections to be made by The Menage Scientific Expedition to the Philippine Islands.

It was moved that the President and Secretary be a committee to take the tender of Mr. Menage under consideration and, after consultation with Mr. Menage and representative members of the Academy, to call a meeting of the Trustees or of the Academy, or both, and report on a line of action.

The motion was seconded and carried.

July 21, 1890.

Under the above date the following entry was made in the records of the Board of Trustees:

To the Trustees of the Minnesota Academy of Natural Sciences:

Your committee has acted in conformity with your directions of July 2, inst., that is, we have consulted with Mr. Louis F. Menage and other members of the Academy, and now recommend that the Trustees report the tender by Mr. Louis F. Menage to the Minnesota Academy of Natural Sciences of the collections to be made by The Menage Scientific Expedi-

TION TO THE PHILIPPINE ISLANDS, to the Academy with our hearty and unqualified approval and ask the Academy to accept the same.

P. L. HATCH, } Committee.
C. W. HALL, }

The report was adopted.

July 21, 1890.

A special meeting was called pursuant to a request signed by five members.

Sixty-five persons were present.

The Trustees reported to the Academy on the proposition of Mr. Louis F. Menage, relating to the disposition of the collections to be made by THE MENAGE SCIENTIFIC EXPEDITION TO THE PHILIPPINE ISLANDS, by reading the tender made by Mr. Menage, and the recommendation of the Trustees that the Academy accept the same.

It was moved and seconded to adopt the report of the Trustees.

After some little debate on the second condition of Mr. Menage's proposition, *i e.,* in regard to the securing of Messrs. Worcester and Bourns "to properly work up *in Minneapolis* the scientific results of said expedition on their return to this country;" and after the statement was made by Mr. Worcester, that they only desired to control the description of new species, more particularly in the line of birds, because they did not intend to stay in Minneapolis more than a few months or a year after their return to the United States, the motion was *unanimously carried.*

On motion of Dr. W. H. Leonard, Dean C. Worcester and Frank S. Bourns were elected members of the Academy.

Mr. Worcester and Mr. Bourns both gave the Academy brief accounts of what they would probably find in the Philippines, since both had been there before, accompanying Professor Steere, of Michigan, two years previous. They also gave vivid sketches of the inhabitants, and briefly pointed out the prominent physical features of the islands. An informal reception was then held, and the good wishes and good byes of all present were extended.

October 7, 1890.

Nineteen persons present.

Mrs. A. B. Murray, P. D. McMillan and C. H. Pratt were elected members.

Prof. N. H. Winchell read a paper entitled "The Eastern equivalents of the Minnesota iron ores."

[This paper is published in full in Bulletin No. 6, Geological and Natural History Survey of Minnesota, "The Iron Ores of Minnesota." pp. 411-419.]

Uly. S. Grant discussed some "Notes on a collecting trip into the Tertiary of Maryland and Virginia."

[ABSTRACT.]

A brief account of the annual geological expedition of the Johns Hopkins University for 1890 was given. The different formations of the coastal plain—from the Potomac (late Mesozoic) to the recent —and the characteristic fossils of each were noted. Most of the fossils collected were found in the Tertiary, where remains of molluscan life are extremely abundant. This formation is divided into an upper and a lower member, each of which consists mainly of variegated sands and blue clays. As a rule these are unconsolidated, rendering the collection of well preserved fossils comparatively easy. The general similarity of the fauna to that now existing along the eastern coast was noted, and attention was called to very large specimens of *Ostrea* and of a certain *Venus,* which is thought to be a large variety of the common edible clam (*Venus mercenaria*). A few photographs were shown, exhibiting the abundance of certain forms—*Pecten* and *Turritella*—in some of the beds.

C. W. Hall gave some notes from the Indianapolis meeting of the A. A. A. S. and the excursion of the Association into the gas fields of Indiana.

Horace V. Winchell presented the Academy with four (4) small aerolites which fell in Winnebago county, Iowa, May 2, 1890.

Through Librarian Herbert Putnam, Mrs. Wm. Welch presented the Academy with a group of quartz crystals from Cornwall, England. The thanks of the Academy were voted Mrs. Welch and Mr. Winchell.

November 11, 1390.

Fifty persons present.

E. F. Allen, J. F. Calhoun, Rev. D. S. McCaslin, G. A. Smith, E. P. Sheldon, of Minneapolis, Prof. Henry S. Baker, of Saint Paul, Benedict Juni, of New Ulm, were elected members.

The report of the evening was from the section of Sanitary Science, Dr. Chas. N. Hewitt, chairman.

Dr. Hewitt gave an address in which he discussed: The causes, prevention and control of those things which occasion the ill health and premature mortality of our population, in the light of an experience of eighteen years as a health officer, and of a season's study abroad.

The presentations at this meeting were the following:

One yellow breasted chat, presented by Thomas Miller, Heron Lake, Minn. The specimen was taken last spring in Jackson county, as the first for Minnesota.

One king rail, Dr. Thos. S. Roberts. Taken at Minneapolis.

One king rail—female—with nest of ten eggs. The specimen is of interest bearing on the distribution of this bird in the Northwest.

The following were presented by Dr. A. F. Elliot:

Twenty-one specimens of birds from California.

December 2, 1890.

Twenty-three persons present.

D. P. Jones and C. P. Lommen were elected members.

D. N. Harper, Chemist of the Minnesota Agricultural Experiment Station, read a paper on the production and manufacture of sugar in Minnesota.

Warren Upham presented a paper (read by Professor MacMillan) on "The Geographic Limits of Plants in the basin of the Red River of the North."

December 16, 1890.

Nineteen persons present.

This special meeting was called to finish certain business of the year.

C. W. Moulton was elected a member.

Prof. C. G. MacMillan discussed a paper on "The Distribution of some potentillas."

The paper was discussed by several members.

O. W. Oestlund gave an outline of the life history of the gall making insect which infects our poplar trees.

January 6, 1891.

Fourteen persons present.

W. X. Sudduth and W. H. Pratt were elected members.

Chas. S. Fellows presented the following articles, which the Academy received with thanks: One piece coquino, one branch with fruit of mangrove, one branch of oak with ingrown mistletoe, all from eastern Florida.

The Recording Secretary read his report of the scientific work of the Academy during the past year, and of the collections of membership dues.

The treasurer read his report for the year as follows:

To balance from the year 1889	$ 78 51
To membership fees collected by the secretary during the year	310 00
	$388 51
By cash paid to Kimball Printing Co., for printing of Bulletin, Vol. III, No. I	$256 50
By cash to Kimball Printing Co., for miscellaneous printing	5 00
By cash to A. S. Dimond for printing letter heads	2 50
By cash for interest on note for the L. Kimball Printing Co.	1 59
	$265 59
Cash on hand January 6, 1891	$122 92

The corresponding secretary read the following report of books, pamphlets, etc., received during the year 1890:

THE UNITED STATES.

Baltimore, Md.—Johns Hopkins University: Register, 1889-90; Circulars, Nos. 79 to 84 inclusive.

Boston, Mass.—American Academy of Arts and Sciences: Proceedings, Vol. 24.

Boston Society of Natural History: Proceedings, Vol. 24, Parts 3 and 4.

Buffalo, N. Y.—Historical Society of Buffalo: Annual Report, 1890.

Cambridge, Mass.—Museum of Comparative Zoology: Bulletin, Vol. 16, Nos. 7, 8, and 9; Vol. 19, Nos. 1-4; Vol. 20, Nos. 1 and 2.

Champaign, Ill.—Illinois State Laboratory of Natural History: Prelim. report of Animals of the waters of Mississippi bottoms near Quincy, Ill., in August, 1888; Bulletin Vol. 2, Title and Index; Vol. 3, Articles 5, 6, 7, 8, 9 and 10.

Chapel Hill, N. C.—Elisha Mitchell Scientific Society: Journal, Vol. 6, Part 2; Vol. 7, Part 1.

Cincinnati, O.—Cincinnati Society of Natural History: Journal, Vol. 13, Parts 1 to 3.

Colorado Springs, Col.—Colorado College: "Studies." (First annual publication.)

Denver, Col.—Colorado Scientific Society: Proceedings, Vol. 3, Part 2.

Des Moines, Ia.—Iowa Academy of Sciences: Proceedings, 1887 to 1889.

Iowa City, Ia.—State Historical Society of Iowa: Iowa Historical Record, Vol. 6, Nos. 2, 3 and 4.

Jefferson City, Mo.—Geological Survey of Missouri: Bulletin, No. 1.

Lansing, Mich.—Michigan State Agricultural Society: 28th Annual Report, July, 1888, to July, 1889, Bulletins.

Lincoln, Neb.—University of Nebraska, University Studies, Vol. 1. No. 3.

Madison, Wis.—Wisconsin Academy of Science, Arts and Letters: Transactions, Vol. 7, 1883 to 1887.

Manhattan, Kan.—Washburn College Laboratory of Natural History: Bulletin, Vol. 2, No. 11.

Middletown, Conn.—Museum of Wesleyan University: 19th Annual Report.

Minneapolis, Minn.—The University of Minnesota: Agricultural Experiment Station Bulletin, No. 10.

New York, N. Y.—American Geographical Society: Bulletins, Vol. 21, sup.; Vol. 22, Nos. 1, 2 and 3.

American Museum of Natural History: Bulletin, Vol. III, No. 1; Vol. III, pages 117 to 122.

Linnean Society of New York: Abstract of proceedings, year ending March 7, 1890.

New York Academy of Sciences: Transactions, Vol. IX, Nos. 1 and 2.

New York Microscopical Society: Journal, Vol. 6, Nos. 1 to 4.

Torrey Botanical Club: Bulletin, Vol. 17.

Philadelphia, Pa.—Academy of Natural Sciences: Proceedings, 1889, Part 3; 1890, Part 1.

Second Geological Survey of Pennsylvania: Atlas Southern Anthracite field, Part 2 AA; Middle Anthracite field, Part 3 AA; Northern Anthracite field, Part 5 AA.

Wagner Free Institute of Science: Transactions, Vols. 2 and 3.

Zoölogical Society of Philadelphia: 18th Annual Report.

Providence, R. I.—Rhode Island Historical Society: Proceedings 1889-90; Early voyages to America; R. I. adoption of the Federal Constitution.

Rollo, Mo.—Mo. School of Mines: Scien. Baccalaureus, Vol. 1, No. 1.

Salem, Mass.—American Association for the Advancement of Science: Proceedings Vol. 38.

Saint Louis, Mo.—St. Louis Academy of Sciences: Constitution of the Academy.

San Diego, Cal.—San Diego Society of Natural History: West American Scientist, Nos. 50 to 55 inclusive.

Santa Barbara, Cal.—Santa Barbara Society of Natural History: Bulletin, Vol. 1, No. 2.

San Francisco, Cal—California Academy of Sciences: Proceedings, second series, Vol. II; Occasional papers, Nos. 1 and 2.

California State Mining Bureau: Ninth annual report State Mineralogist.

Topeka, Kas.—Kansas Academy of Science: Transactions Vol. XI, 1887 and 1888; Vol. XII, Part 1.

Washington, D. C.—United States Geological Survey: Bulletins 54 to 57; Monographs, XV, Parts 1 and 2, and XVI; Eighth Annual Report, 1886-7, Parts 1 and 2.

Smithsonian Institution: Annual Report, 1886, Parts 1 and 2; 1887, Parts 1 and 2.

United States Patent Office: Official Gazette, 52 Nos.

FOREIGN.

Amsterdam, Netherlands.—Konmklyke 11 Vol. Genootscap Natura Artis Magistra: Bij. tot d' Dierkunde, 50th Acct., No. 1; Bij. tot d' Dierdunde, 10th to 14th and 16th alferering; Nedev tij d'voor de Dierkunde, Jaargang 2, af 1

Berne, Switzerland.—Schweizerische Entomologische Gesellschaft: Mittheilungen, Vol. VIII, Heft 1 to 8.

Societe Elvetica della Science Naturale: Atti, 72d session, 1888-1889.

Berlin, Germany.—N. A. Lepidoptera, part 1: Grate, A. Radcliffe.

K. Preus. Meterologischen Institut: Deutsche Met. Jahrbuch fur 1890, Heft 1.

Naturæ Novitates: 1890. R. Friedlander & Sohn.

Brussels, Belgium.—Societe Malacologique de Belgique: Procesverbal tom XVII; procesverbal, tom XVIII, pages 1 to 124.

Buenos Ayres, Argent. Rep.—Museo Publico de Buenos Ayres: Report of foundation and development of the Musee de la Plata.

Cairo, Egypt.—L'Institute Egyptienne: Bulletin 2d Ser. No. 10, 1889.

Calcutta, India.—Geological Survey of India: Records, Vol. 22, Part 4; Vol. 23, Parts 1, 2 and 3; Memoirs, Series 13, Vol. IV, Part 1.

Cornwall, England.—Royal Geological Society of Cornwall: Transactions, Vol. II, Part 4.

Cordoba, Argent. Rep.—Academia Nacional de Cenceas Exactes: Bulletin, Tomo, x, Ent. 3.

Demarara, British Guiana.—Agricultural and Commercial Society of British Guiana; "Temehri," Vol. IV, Part 1.

Haarlem, Netherlands.—Foundation de P. Teyler vander Hulst: Archives Series 2, Vol. IV, Part 4; Catalogue, Vol. II, Parts 1, 2 and 3.

Halifax, Nova Scotia.—Nova Scotia Institute of Natural Science: Proceedings, Vol. VII, Parts 1 and 3.

Hamburg, Germany.—Naturwissenschaftlicher Verein: Transactions, Vol. XI, Heft 1.

Verein fur Naturwissenschaftlicher Unterhaltung: Verhandlungen Bund 1 to 6, 1871 to 1885.

Kiev, Russia.—Society des Naturalistes: Memoires Vol. x, Parts 2 and 3; Vol. XI, Part 1.

Liverpool, England.—Liverpool Geological Society: Proceedings, Vol. II, Part 2, 1889-90.

Lunenburg, Germany.—Naturwissenschaftlicher Verein: Jahrsheft II, 1888-1889.

Manchester, England.—Literary and Philosophical Society of Manchester: Memoirs and Proceedings, Vol. I, Nos. 1 to 5; Vol. II, Nos. 1 to 4; Vol. III, Nos. 1 to 6.

Montreal, Canada.—Natural History Society of Montreal: Canadian Record of Science, Vol. III, No. 8; Vol. IV, Nos. 2 and 3.

Moscow, Russia.—Societe Imperiale des Naturalistes de Moscow: Bulletin, 1889, Parts 2, 3, 4; Noveau Memoires, Vol. xv, lis 6; Bulletin, 1890. Part 1; Meterological Report for 1889, 2 parts.

Munster, Germany.—Provenzial Verein fur Wissenschaft und Kunst: Annual report for 1888.

Ottawa, Canada.—Geological Survey of Canada: List of Canadian Hepaticæ; Catalogue of Canadian plants. Part 5.

Rio Janeiro, Brazil.—Instituto Historico Geographico e Ethnographico: Revista Tremensal, Vol. LII, parts 1 and 2; Vol. LIII, part 1.

Rome, Italy.—Biblioteca Nazionale Vittorio Emanuele: Bulletin, Vol. v, No. 2.

Stockholm, Sweden.—Kongliga Svenska Vetenskaps Akademien: Bihaug, Bd. XIII, 4 parts; Bd. XIII, 4 parts; Oversight, 1886, 1887, 1888.

Sydney, N. S. Wales.—Australian Association for the Adv. of Science: Report for 1887, Vol. 1.

Department of Public Instruction: Tech. Educational series No. 6. (Wattles and Wattle barks).

Geological Survey of New South Wales: Memoirs of Paleontology, Nos. 3, 4, and 8, pt. 1; An. Report of Dept. of Mines, 1888, 1889; Records of the Geo. Survey, Vol. 1, part 3; Vol. II, part 1.

Royal Society of New South Wales: Journal Proceedings, Vol. XIII, Parts 1 and 2; Catalogue of Library.

Tokio, Japan.—German Society of Nat. Hist. and Ethnology of Eastern Asia: Mittheilungen Heft 44, Pd. 5 secle 149 to 189

Toronto, Canada.—Canadian Institute: Proceedings, Vol. VI, Ser. 3, No. 2; Vol. VII, Ser. 3, No. 2.

Turin, Italy.—Musei di Zoologia ed Anatomica Com. della R. University: Bulletin, Vol. v, Nos. 74 to 86.

Victoria, N. S. Wales.—Public Library, Museum and National Gallery of Victoria: Prodromus No. 19; Report of Trustees Public Library for 1888.

The officers elected for the ensuing year were:

President. - - - - -	P. L. Hatch.
Vice President, - - - -	H. F. Nachtrieb.
Recording Secretary, - - -	C. W. Hall.
Treasurer, - - - -	Edw. C. Gale.
Corresponding Secretary, -	C. S. Fellows.
Trustees for three years,	T. B. Walker. Thos. S. Roberts.

February 3, 1891.

Twenty-five persons present.

C. A. Ballard, of Minneapolis, and Hon. L. R. Moyer, of Montevideo, were elected members.

A paper by Warren Upham, entitled: Grasses and flowers of the prairie, being part III of the series of papers on geographic limits of species of plants in the basin of the Red River of the North, was read by Prof. MacMillan, who also, after the reading, called attention to the analogy between the Red River valley and that of the Minnesota river in some of their vegetal aspects.

Patrick Kennedy presented a paper on the Geology of the Minnesota river valley. It was read by Peter Christianson, of which the following is an

[ABSTRACT.]

The paper was prefaced by a short history of the geological explorations in the valley of the Minnesota.

Major Warren and Capt. C. E. Davis, of the U. S. Army, were the first to explore this part of the state. The first part of the paper discusses the surface geology—the nature of the river bed, the character of the banks, the position and arrangement of the various rocks, stratified and unstratified. The second part discusses the glacial geology of this region—gives the history of the Minnesota river. Gen. Warren was the first to advance the theory the Minnesota river is the successor of a glacial stream, now called River Warren. This river drained the valley of the Red River of the North and flowed into the Des Moines river valley through Union Slough. Mr. Warren Upham has collected facts and made extensive explorations of the ancient shore line of Lake Agassiz, confirmatory of this view. The third part of the paper is devoted to the discussion of the geological formations, which are of interest from an economic point of view as well as from the fact that they are a record of the changes which this part of the state has undergone. Early explorers: Le Seuer (1700), Prof. Keating of Pennsylvania University (1823), Mr. Featherstonaugh (1835), Drs. Owen and Shumard (1847-1850) and Prof James Hall (1866), N. H. Winchell, the state geologist, in 1873. In recent years the entire valley has been thoroughly explored by Prof. C. W. Hall of the U. S. Geological Survey and Mr. Warren Upham.

The location, extent and value of the various granites, limestones, sandstones, etc., are noted, after which there is a brief sketch of the materials used in the manufacture of lime, cement, glass, pottery and brick.

The paper closes with an allusion to the pre-glacial river which occupied the present Minnesota river valley.

Fred W. Sardeson then read two short papers, one entitled: "Paleozoic fossils in the Glacial drift of Minnesota," and the other, "Fossils recently discovered in the Saint Peter sandstone of Minnesota."

The first of the two papers was discussed by Dr. H. C. Leonard, who had lived for some years at Fergus Falls, of which the following is an

[ABSTRACT.]

There is a great quantity of limestone in the drift of Ottertail, Wilkin and Grant counties. Near the western edge of the hilly lands and the eastern shore of the glacial lake Agassiz it is mostly very fine gravel, and mostly of limestone. Around some of the present lakes in these counties the gravel and shore sand are mostly limestone. Around lake Oscar, in Wilkin county, the finer gravel and smaller pebbles are certainly as much as three-fourths limestone, while 20 to 50 miles further east and northeast in the neighborhood of the range of hills known as the Leaf hills, there are many limestone bowlders, some of them rounded but others are more or less angular, showing little wear; some weigh a ton or more, yet far the greater number of them are not larger than one can lift. They are all white limestone, probably of Devonian age, and make a good lime. These bowlders are being collected and burned into lime so fast that they will soon be gone. There are fossils in all of them. I have seen pieces of crinoid stems in the gravel. The drift is not less than 500 to 600 feet thick in parts of Ottertail, Grant and Douglass counties, and no doubt thicker than that in the Leaf hills. It is difficult to find clay free enough from calcium carbonate for brickmaking in the counties mentioned. Even the clay will effervesce strongly in acids. There is a stratum containing limestone gravel lying under a sandy surface around Ottertail lake and the Battle lakes which lie beyond the Leaf hills from lake Agassiz, and some 50 to 60 miles away. It seems as if the siliceous deposit had drifted in later than the calcareous.

Secretary Hall remarked as follows:

[ABSTRACT.]

The discovery of Paleozoic fossils in the glacial drifts of Minnesota and Wisconsin, is one of no little geological significance. It has been no uncommon thing around Minneapolis and St. Paul to find winrows of the blue Lower Silurian fossiliferous shale piled up within the mass of drift material without being commingled with the gravel and sand from the older crystalline rocks; and the occurrence of fossils in the drift material to the south of the northern border of the Paleozoic should naturally be expected. When, however, specimens are found to the north of this border the significance is much deeper, and particularly so since there are no known beds of Paleozoic limestones in the northern part of the two states named, nor in Ontario within 100 miles of Lake Superior, according to Dr. A. C. Lawson. To the westward, however, there are many basins filled with still undisturbed Paleozoic rocks, which, in the opinion of that writer, are but fragments of what was once an extensive bed.* With such evidence for the surface to the north of Minnesota, and the constantly accumulating evidence which drift fossils show touching conditions within the state, we are forced to conclude that the northwestern states were to a large extent beneath the sea in early Paleozoic times.

March 3, 1891.

Twenty-nine persons present.

*Note on the Pre-Paleozoic Surface of the Archaen Terranes of Canada. Bull. Geol. Soc. Am; Vol. 1, p. 169.

The program of the evening was the reading of the following papers:

"The weeds of the Red river valley," by Warren Upham—read by Professor MacMillan.

"The Age of the Saganaga syenites," by Horace V. Winchell.

This paper is printed in full in the *American Journal of Science* for April, 1891, Vol. XLI, p. 386.

"The Color of the Fixed stars," by N. H. Hemiup.

A letter from Messrs. Worcester and Bourns of the Menage Scientific Expedition to the Philippine Islands, was read by the secretary.

The secretary also made the announcement that life memberships had been taken by R. J. Mendenhall and Bishop J. McGolrick.

April 7, 1891.

Thirty persons present.

Miss Bertha L. Wilson and George C. Andrews, of Minneapolis, and Frank T. Wilson, of Stillwater, were elected to membership.

Rev. D. S. McCaslin gave a description of "The Artesian well basin of North and South Dakota.

Secretary Hall read by title two short papers; one, "The deep well at Blue Earth City, Minnesota," and the other "A Note on the well at Owatonna" recently bored for the city water works.

May 5, 1891.

Twenty-four persons present.

C. W. McCurdy, of Winona, was elected to membership.

A paper entitled "The migration of plants during and since the Glacial period," the last of a series of papers by Warren Upham, was read by Professor MacMillan.

The next paper was by Professor Conway MacMillan on "The Rhythmic growth of the Potato tuber."

"Analyses of specimens of efflorescence on brick buildings," by Professor C. F. Sidener, and "Some Analyses of waters from Artesian wells and other sources," by Professor J. A. Dodge, completed the programme for the evening.

The secretary announced that the Sophia Cross collection had been secured for the Academy's museum.

The Sophia Cross collection is a series of minerals, many of them in large and perfect crystals. The specimens were partly collected and partly secured in exchange by Rev. R. T. Cross, chiefly during a residence of some years in Colorado. The collector and his brother, Judson N. Cross, Esq., a resident of Minneapolis, have contributed largely towards securing this choice collection for the Academy. The brothers Cross name it the Sophia Cross collection in memory of their mother.

June 9, 1891.

Twelve persons present.

A. W. Stacy and Dr. Adele S. Hutchison were elected members.

Secretary C. W. Hall read a paper entitled "Physiographic and geologic notes of several excursions into northeastern Minnesota." These notes embody the results of several seasons' work in that portion of the state.

The following presentations were made:

An additional mummy case by Thomas Lowry, Esq.

A boot carrying a colony of oysters, by Charles W. Jerome.

The secretary was directed to extend the thanks of the Academy to the above named donors for their valuable gifts.

October 6, 1891.

Seventeen persons present.

Albert Schneider was elected a member.

The following papers were read:

The Lower Silurian formations of Wisconsin and Minnesota compared, by Fred W. Sardeson.

Preliminary notes on the conglomerates and amygdaloids of the Snake river valley, by Herbert W. Smith.

[ABSTRACT.]

Mr. Smith remarked: Beginning at the lower terminus of the enlargement of Snake river, known as Chengwatona lake, and observable at frequent intervals from thence, to, or posisbly beyond the Wisconsin line, where this river joins the St. Croix in the eastern part of Pine county, Minnesota, occur several prolonged exposures, *in situ,* of rocks mentioned in the title to this paper.

The *conglomeratic* formations are well displayed along the bed of snake river, particularly in low water; and an exposure say twenty rods wide, gives the appearance of having been cut through by the erosive action of this stream. This may be located as near Section 24, Township 38, Range 21, the rock being generally of a brownish-black shade, although the paste-rock being rather ferruginous, weathers through alteration to a considerable friability with the production of much coloring matter. It is conspicuous that the pebbles held conglomeratically by this rock-paste are often large—*i. e.*, 6 to 10 inches in diameter, quite generally well rounded, and of a nearly uniform lithological structure and constitution. In composition they may be roughly described as a fine-grained trap.

The *amygdaloidal* rocks are to be seen both above and below the conglomerate exposures, beginning at Chengwatona dam and continuing to the banks of the St. Croix river. The color and hardness vary considerably; the dark purple varieties are usually softer than the brick reds. Inclusions are as a rule crystalline—the cavity diameter ranging from 1-16 to ½ in., and the mineral closely resembling Thomsonite.

In the *epidotic* material of the veins in the rocks mentioned above, native copper is sparingly found. And at the location of the "Chengwatona copper mine," where considerable boring and some shafting have been done, the writer obtained a crystal of native copper and silver alloy. This metallic crystal is about ⅛ in. in diameter, rising from the vein rock in a single termination. A portion of its mass examined qualitatively in the wet way, demonstrated the presence of both silver and copper, but no quantitative analyses have been effected.

The members of this Academy will call to mind that northward from this region 12 to 15 miles are the Hinckley sandstones, now much quarried for building material. That also within a few miles are outcroppings of trap rock. These conglomerates and amygdaloids rise at irregular intervals above the horizon, the rounded masses frequently similar in mere outward appearance to the granitic masses in Stearns Co. Inasmuch as no contact points between these Snake river rocks and the sandstones and traps mentioned above, have come under the author's observation, he does not venture an opinion as to their geological relationship. This last point, together with conclusions as to range direction, through this comparatively level, sometimes low and swampy region; as well as to results respecting the micro-lithological structure of these rocks and their accompanying minerals, form the subject for his further attention.

The development of Acrostalgmus conidia bearers, by Professor Conway MacMillan.

List of European plants introduced into the valley of the Minnesota river, by Professor MacMillan (read by title).

An Epinastic Potato plant, by Professor MacMillan.

The following gifts to the museum were received from S. C. Gale, Esq.: one alligator, a stuffed specimen; one *Tetrodon turgidus mitch;* one *Diadon hystrix* L., from Florida, for which the secretary was instructed to express the grateful acknowledgments of the Academy.

Professor Nachtrieb gave a brief and informal account of the summer's work of the zoological survey of Minnesota.

[ABSTRACT.]

Professor Nachtrieb briefly outlined the plan of work of the zoological division of the geological and natural history survey of Minnesota, as laid down by him after the botanical and zoological work of the survey had been placed under the directorship of the respective departments of the university by the Board of Regents. He also stated that during the first two summers nothing could be done by the State Zoologist—one season on account of other special university duties, and the other season chiefly on account of sickness. During the past summer about four weeks (as much of the season as the amount left after purchasing necessary apparatus, etc., out of the year's allowance, would permit) were spent in the field around lake Vermilion. The season was stormy and very disagreeable, so that a large portion of the time had to be spent in camp. Notwithstanding this hindrance considerable material and data were collected that will be of value in the future. Special attention was devoted to the Fishes and their parasites. It is the intention of the State Zoologist to investigate first those things of direct and immediate economic importance. But even such problems absolutely require the kind of work popularly called purely scientific and impractical. The fact is that no investigation of living things, however remote from practical ends it may at first sight appear, is ever completed without having an economic bearing. During about two weeks insects were looked after by Professor Otto Lugger, who gained some valuable information that will be given to the public as soon as he has studied his material. Among other interesting things found in certain bays of the lake were mentioned *Hydra fusca, Cristatella mucedo, Flascularia ambiqua* and several species of sponges. The survey is also taking steps to get the status of the beaver in Minnesota and to find out whether it will be possible to have a beaver reserve established in some suitable quarter of the state, and thus do something towards preventing the elimination of this valuable and interesting animal. Such reserves have been in successful operation for years in England and Europe, and there is every reason for having at last one in our state.

November 8, 1891.

One hundred and twenty-five persons present.

Messrs. J. C. Bryant and Chas. Schuchert were elected to membership.

The programme consisted of a lecture by Dr. W. Xavier Sudduth, of the College of Dentristry, University of Minnesota, on the evolution of the teeth. The lecture was well illustrated by means of a series of photo-micrographs thrown upon the screen. A series of skulls was also displayed to illustrate points in the lecture.

[ABSTRACT.]

The lecturer, in discussing the subject of mechanical evolution, held that, in so far as the teeth were concerned, the theory had no basis in fact, no matter how plausible it may appear, for the following reasons:

1. The crowns of teeth are fully formed before they are erupted, hence cannot come under the law of use and disuse, which is the central idea of the Lamarckian school.

2. Anatomically they are so constructed as to resist impact to the very best advantage; consisting, as they do, of a hollow tube (pulp canal or canals) the walls of which are made up of a series of tubes (dental tubuli) standing at right angles to the central tube, and these in turn, in the crown, being surmounted by solid prisms (enamel prisms) in such manner that every part of the surface presents the form of an arch with the springers resting upon the hollow columns of the dentine. In addition to the above the surface is highly polished, making an ideal structure to resist impact.

3. The roots of the teeth are covered by a soft membrane which serves as a cushion during the process of mastication and thus relieves the force of impact.

4. That these same roots are imbedded in cancellated bone which would yield to the force of impact before the crowns.

5. That enamel is a non-vital coat of mail which, when the tooth erupts, is carried away from its source of development and hence cannot be renewed or repaired when injured.

6. A tooth crown once erupted is subject only to two forms of changes, mechanical abrasion or chemical erosion.

7. That change in form due to either of these two causes is not subject to inheritance.

Louis F. Menage was elected to the committee of the Academy for conference with the Library Board in the place of H. L. Gordon.

The following gifts to the museum from President Hatch, were received:

1. A series of Unio and Anadonta shells from lake Pepin and vicinity, said to be the first series ever collected in Minnesota.

2. A specimen of silicified wood from Montana.

The secretary was directed to acknowledge the gifts.

December 8, 1891.

Twenty-one persons present.

James E. Bradford and Julius Hortvet were elected members.

The following papers were read by title: "The range and distribution of the Lower Silurian fauna of Minnesota, with descriptions of some new species." F. W. Sardeson.

"Observations on some American Rhizobia." Dr. A. Schneider.

[ABSTRACT.]

The author gave a short review of recent investigations on Rhizobia, especially those of Hellriegel and Frank. Attention was called to the existing controversies. It was suggested that there may be more than one species of *Rhizobium leguminsorarum* notwithstanding the opposing views of Frank and others who maintain that this is a single species. The following new species were described: *Rhizobium mutabilis, R. curvum, R. Frankii var's, major and minor, R. nodosum, R. dubium.* These were placed in a new family, *Mycodomatiae* under Schizomycetes. *R. mutabilis* is probably the most common among the *Leguminosae* and above all others has the power of assimilating free nitrogen from the air. Two plates accompanied the paper.

"The sources of some of the constituents of Minnesota soils." Professor C. W. Hall.

Dr. Charles N. Hewitt then read the paper of the evening in the form of a report of the section of Sanitary Science. Subject: "Twenty years in the Public Health service of Minnesota."

[The following papers are not arranged in chronological order, as are those of Bulletins 1 and 2 of this volume, since at the time of going to press several papers were in the hands of authors for final revision.—EDITOR.]

PALAEOZOIC FOSSILS IN THE DRIFT.—*F. W. Sardeson.*

So far as I have been able to learn, very few Palæozoic fossils have ever been found in the Drift formation of Minnesota, excepting in the scattered patches of Trenton shales and limestone that are seen occasionally more or less mixed with the drift material, but are merely torn up and left near their original position.

But more than four years ago I picked up in Prospect park, St. Paul, two fossils that are evidently not from the Trenton, a honeycomb coral and a brachiopod.

In 1889, two more were found by Professor Hall, in the Drift at Dresser Junction, Wis., a honeycomb coral and a gastropod.

Also Principal Childs sent for identification a number of fossils from the drift at and near Morris, Minn., last August.

Again, in the early part of the present winter some more were found. I happened one day to be going through a railroad cut near Kegan's lake (Minneapolis) and noticed some pebbles like the fossiliferous ones from Morris, Minn. There was a crinoid stem on one of them. Later brachiopods, and other forms were found. All the Drift exposures from Parker station to Cedar lake (four miles) were searched, and this same limestone was found everywhere, and was often fossiliferous. The stone itself is white and gray, very hard and compact, and occurs as rounded pebbles, slabs and even boulders, very much scattered throughout the Drift.

For convenience in comparing the fossils I have made out the following list:

NAMES OF FOSSILS	St. Paul	Minneapolis	Morris	Dresser J
Atrypa reticularis........................	....	*	*	....
" *aspera*..............................	....	*	?	....
Brachiopod gen. et. sp. ?............	*	*	....	....
Strophomena sp ?......................	....	*	*	....
Murchisonia major ?....................	....	....	*	*
Lamellibranch gen. et. sp. ?.........	....	*	....	....
Favosites sp. ?............................	*	*	....	*
Os-racol gen. et. sp. ?...................	....	*	*	....
Trilobite (fragment) gen. ct. sp. ?.	....	*	....	....
Gastropod gen. et. sp. ?...............	....	*	....	....
Crinoid stems, etc........................	....		*	....

These fossils seem to be Devonian.

I frequently came across bowlders of Trenton limestone, such as is quarried for building stone in Minneapolis and St. Paul.

Associated with the Devonian (white) and the Silurian (yellow and blue) limestones is also rarely a fine white sandstone, which is sometimes mixed with patches of yellow limestone, and sometimes contains faint fossil marks. Among the specimens from Morris, Minn., there was one of this sandstone which contains a clear cast of one valve of a brachiopod. This is still at the University of Minnesota.

In conclusion: it seems probable that fossils occur quite generally in the drift of Minnesota. But just to what extent, is to be determined. I found over a dozen species in less than that many hours all told. And if the fossils are not so numerous as I think they are, yet this conspicuous white limestone could easily be traced wherever it exists now, and perhaps to where it rested formerly.

February 3, 1891.

FOSSILS IN THE ST. PETER SANDSTONE.—*F. W. Sardeson.*

Last fall, during the Thanksgiving vacation at the State University, I happened to raise the question, why fossils had never been found in the Saint Peter sandstone, in and around Minneapolis? Professor Hall was of the opinion that such fossils could be found; and he also suggested the place where they were most likely to occur.

According to his advice, the next day was spent in looking through some recent cuts along the C. B. & N. R. R., about five miles below Saint Paul. And I brought back to the University, what was considered undoubtedly fossils. Another search during the holidays added other evidence. The following is a list of what has been found:

Gastropods: —	1. *Maclurea* (?) two casts.			
	2. *Murchisonia gracilis* Hall, two moulds.			
	3. " *? tricarinata ?* Hall, two moulds (imperfect.)			
Lamellibranchs	4. *Cypricardites rectirostris* Hall, three.			
	5. "	(?)	?	three halves.
	6. "	(?)		one half.
	7. *Modiolopsis ?*	(?)		four half casts.

There are others but whether they are worm burrows, crinoid stems of bryozoa, or all three, is hard to determine.

The fossils are for the most part, marked out by discoloration (brown or red), but a *few* by cleavage only. They are quite numerous and are easily found when one once knows how and where to look for them.

They occur fifty or more feet below the top of the formation.

I have assigned the specimens found, to the genera and species to which I think they belong. They are remarkably like species found in the lower part of the Trenton shales and in the Trenton limestone which here rests conformably on the Saint Peter sandstone. And it may be, as has been suggested, that the Saint Peter is of the Silurian rather than that of the Cambrian formation.

As soon as spring opens, I shall spend some days in a more thorough search, in order to find out as far as possible, the true nature and horizon of these fossils in the Saint Peter sandstone.

February 3, 1891.

THE LOWER SILURIAN FORMATIONS OF WISCONSIN AND MINNESOTA COMPARED.—*F. W. Sardeson.*

It is the purpose of this paper to give some observations on the Silurian of Minnesota, and the Trenton group in particular; and to compare it with the same of Wisconsin.

There are some difficulties in undertaking such a comparison. For example, the Trenton group in Wisconsin is nearly all limestone, while in Minnesota it is largely composed of shales. This lithological difference is accompanied by some differences in the fauna and in the outward appearance of the fossils. Then, too, four beds are recognized in the Trenton of Wisconsin, the Lower Buff, Lower Blue, Upper Buff and Upper Blue beds, while in Minnesota two are usually spoken of—Trenton limestone, or shell beds, and Trenton shales, or green shales. These difficulties I shall aim to avoid in part and in part explain.

I shall take up one by one the beds as seen in Minnesota and compare them with the same in Wisconsin, so far as I can.

The lower Trenton limestone, or Trenton limestone of Minnesota, consists of three beds differing somewhat in lithological character and fauna; most strongly so in the area around the "Twin Cities," *i. e.*, Minneapolis and Saint Paul. The first of these, next to and conformable with the Saint Peter sandstone, is the same bed as the Lower Buff limestone of Wisconsin, judging from its fauna, a variety of *Orthis suboequata* Con., *O. deflecta* Con., *Rhynchonella orientalis* Bill., *Strophomena minnesotensis* Winchell (varieties), *Ambonychia attenuata* Hall, etc.

At Janesville, Wis., this bed is about eighteen feet in thickness, in Jefferson county, Wis., about fourteen feet; in LaFayette Co., ten feet; at Dodgeville and Platteville, Wis., nearly twenty feet. In Fillmore Co., Minnesota, it is about twelve feet; at Rochester, Olmsted Co., the same; at Minneapolis, fifteen feet; at Faribault, Rice Co., it is either represented by four and one-half feet of green (apparently unfossiliferous) shale, or it is absent.

The second of the three limestone beds at Minneapolis (seven feet of carbonaceous limestone) preserves few fossils well. In nearly all other respects it is like the bed above rather than the one below it. But I am not so sure that this is the case elsewhere. At Faribault the seven feet immediately on the green shale mentioned above has characteristics of this bed. In south-eastern Minnesota it is less easily distinguishable from the bed below. In southwestern Wisconsin I could not find it at all, unless it is there more fossiliferous, and hence confused with the strata above. But at other points in Wisconsin, these strata seem to be distinguishable though in every case less distinctly than at Minneapolis.

The five feet three inches at the top of the limestone at Minneapolis is the fossiliferous bed of the three. The species that occur in it are essentially the same forms as those common in the Lower Blue bed of Wisconsin. *Orthis perveta* Con., *Trochonema beloitense* Whitf., *Cypricardites rectirostris* H., are abundant forms.

At Faribault this bed is of about the usual depth for Minnesota, but is darker and more carbonaceous than usual and brachiopod shells are well preserved. In Wisconsin, at Platteville, Mineral Point and Dodgeville, it seemed to be from ten to fifteen feet thick and perhaps the same thickness at Janesville.

The rest of the Lower Trenton in Minnesota is shale which is supposed to be mainly the equivalent of the Upper Buff and Upper Blue limestone of Wisconsin. But the lithological differences, together with the scarcity of fauna in Wisconsin make this more difficult to decide. All the evidence met with, however, is in favor of the supposition that the lower Trenton shales in Minnesota are the equivalents of the Upper Buff and Blue beds in Wisconsin, with the exception of the first ten feet of our shales. These last are, doubtless, a part of the Lower Blue bed in Wisconsin.

I came to the conclusion, some time ago, that the first strata of the shales could be classed with the limestone below, as easily as with the shales above. They form here a transitional bed, which for convenience I wish to distinguish as the *Stictoporella* bed. The limestone strata, which constitutes part of it, though crystalline like the slabs in the true shales above, are the result of sedimentation like the limestones below. The fauna, too, is as much that of the preceding as of the succeeding strata.

The *Stictoporella* bed, in ascending order, is as follows: Limestone 6 in., limestone 1 ft. 1 in., limestone 2 ft., shale 1 ft. 6 in., limestone 7 in., shale 5 ft., limestone 1 ft. 6 in. (measurements taken at Saint Paul.)

The shaly parts are not unmixed clay, but have numerous thin hard calcareous laminæ in them. The stone and shale vary locally in thickness and alternation, but are of about the same proportion, as seen in Goodhue, Olmsted and Fillmore counties, Minnesota.

There is a bed of dark colored limestone upon the Lower Blue bed at Platteville, Wis., which appears to be the same as the Stictoporella bed in Minnesota. It consists of, first, about four feet of solid strata, with thinner cleavable strata of the same color; second, three to four feet of green shale such as commonly occurs in Minnesota; and third, four feet of dark colored stone, apparently the transitional back to the ordinary limestone. The fossils were most of them characteristic forms of the Stictoporella bed in Minnesota.

At Dodgeville, Wis., the same strata, so far as I could judge, occur as a light brown bed about ten feet thick, but quite unfossiliferous. At the time this place was examined, I was very much puzzled as to whether this bed belonged to the Lower Blue or Upper Buff limestone, but upon reading over the Geology of Wisconsin, Vol. I, I became quite satisfied that it would be classified as equivalent to part of the Lower Blue limestone of the Rock river valley.

Along the Illinois Central railroad near Dodgeville, nearly every stratum from the Saint Peter to the middle of the Galena is clearly exposed. There can be recognized the Lower Buff, Lower Blue including the bed mentioned above, the Upper Buff and Upper Blue beds. But neither there nor in the Rock river valley do any strong evidences appear to prove that the Upper Buff and Upper Blue beds are equivalent to the Trenton shales of Minnesota. Only their position suggests that they are very probably equivalents.

The Trenton shales are about eighty feet thick at Saint Paul. In Goodhue county they are about the same. In Fillmore county they are much thinner mainly on account of the upper strata, as exposed in Saint Paul, being here represented by fifteen or twenty feet of limestone. So far as known the beds of the shales were co-extensive in deposition in Minnesota.

The first ten feet of Trenton shales has been described above as the Stictoporella bed. It is very fossiliferous; *Orthis subaequata* var., *gibbosa* Bill., *Anoloteichia impolita* Ulr., *Pachydictya foliata* Ulr., *and Stictoporella frondifera* Ulr., occur in masses. The last named is unknown except in this bed and is very widely distributed; and for that reason the name Stictoporella has been proposed for this ten feet of shale.

The next thirty feet is of uniform dark green unctuous shale with numerous fossils, but many of them poor on account of the nature of the matrix. But here and there, especially toward the top of the bed, are reefs of bryozoa and brachiopoda, as well as scattering individuals of mollusca, molluscoidea and cœlenterata throughout.

These reefs occur as crystalline slabs from one to four inches thick and of various extent; from their appearance they are easily taken for sedimentary strata. But they have probably been formed by the infiltration of calcium carbonate into lenticular beds of fossils, as shown by the irregular cementing together of the fossils and more particularly by being made up almost entirely of animal remains. Also where a large shell lies horizontally near the under surface of a slab there will usually be a shaly spot or core under the shell as if it had shed off the infiltration from above. Mollusca are preserved as blue calcareous casts.

I could scarcely characterize this bed by enumerating the species which occur in it. An undescribed rhynchonella, which is essentially *R. increbescens* Hall without the concentric lines, occurs from the top of this bed downwards. *R. ainsliei* Winchell has a like distribution, but is more local. Only three species of orthis, *O. subaequata* Con., *O. testudinaria* Dalman (variety) and

Q. tricenaria Con., are known to occur, *Stictopora mutabilis* Ulr., though perhaps not confined to these strata, yet occurs in such numbers here that the name *Stictopora* seemed appropriate in designating this bed.

The next twenty feet is the *Fucoid* bed. The shale is made up largely of fucoidal masses and of calcareous laminæ somewhat irregularly distributed.

At Saint Paul there is, first, 15 feet of shale; then 5 in. limestone; 18 in. shale; 3 ft. of hard crystalline strata that weather reddish brown. This bed will be recognized at once in Ramsey, Dakota and Goodhue counties, by the quantity of fucoidal remains or by the occurrence of *Phylloporina corticosa* Ulr. In Fillmore county I have found the evidences of this bed but never the bed itself exposed. *Orthis pectinella* Con. occurs for the first time at this horizon and also *Rhynchonella increbescens* Hall.

The strata that lie upon the Fucoid bed are without fucoidal remains but are much more fossiliferous upon the whole. *Zygospira recurvirostris* Hall, *Rhynchonella increbescens* Hall, are extremely abundant. This bed is characterized by the absence of certain species that occur above or below. The name *Zygospira* bed is proposed from the most numerous species. There is in this bed three feet of hard shale, four feet of ordinary shale, and one foot of shaly limestone—eight feet in all.

At the upper limit of the Zygospira bed a new fauna appears. *Receptaculites, Platystrophia, Orthisina*—which are unknown below. *Orthisina* [*Hemipronites*] *americana* Whitf., has not been found except in this bed and hence the name *Orthisina* is proposed.

Lithologically the Zygospira and Orthisina beds are difficult to distinguish, and later searching may succeed in merging the former into the latter. In both, there are peculiar calcareous lumps, irregular in shape, rounded in the latter bed and of lighter color than the other parts of the shale, and alternating in strata, with thin smooth surfaced limestone layers. At Saint Paul only part of the Orthisina bed remains. At Kenyon, Goodhue county, there is over fifteen feet of this bed exposed. In Olmsted and Fillmore counties the exposures of this bed are rare, and these do not show more than ten feet thickness. In the last named county the bed consists rather of shaly limestone than a shale.

Just where the division between the Trenton and Galena should be drawn so as to agree with the division in Wisconsin is not determined. I saw the lowest strata of the Galena at Evansville, Dodgeville, etc., in Wisconsin, and formed the opinion that the corresponding line in Minnesota, should be drawn at the top of the Orthisina bed: but the fauna here seems to demand a division at the top of the Zygospira bed or below it.

From the top of the Orthisina bed to the upper limit of the Trenton group is fully 100 ft. in Minnesota, and in many places the rock is exposed in vertical walls, for part or all its thickness.

The fauna in the Galena formation is much more meager than in Trenton, and for that reason close division into beds is less easily made and with less certainty. Three subdivisions however have been noted in Minnesota.

1. The first of these is a somewhat carbonaceous limestone, about thirty feet thick, that crumbles more or less in weathering. The name *Camarella* bed seems appropriate on account of several species of that genus, which occur here and have not been found in other beds.

2. The next twenty feet is of a firm, very durable limestone with few fossils of several species. Inarticulate brachiopods are well preserved. From the occurrence here of *Lingulasma schucherti(?)* Ulr., the name *Lingulasma* bed has suggested itself.

3. The last fifty feet of the Galena formation, which I shall call the *Maclurea* bed, is characterized by large gastropoda—*Murchisonia major* Hall, *Fusispira elongata* Hall, *Maclurea cuneata* Whitf., *Raphistoma lenticularis* (large variety).

This Maclurea bed I feel safe in correlating with the last deposited strata of the Galena formation in Wisconsin, both on lithologic and palæontologic grounds. And indeed no reason is known to me for supposing that the strata composing the Trenton group in Minnesota and Wisconsin were not in every case continuously and contemporaneously deposited. As to the first and the last bed, identical fossil forms and similarity in structure, together with nearly continuous exposures, furnish sufficient evidence of their relation on both sides of the Mississippi valley.

The succession of strata through the Trenton group in Minnesota forms a gradual transition from limestone to typical shale and again back to limestone. In Wisconsin this transition is less and less marked in proportion to the distance from the northwestern extension of the strata in Minnesota, *i. e.* from the line of the advancing and retreating shore of the sea in which the Trenton sediments were deposited.

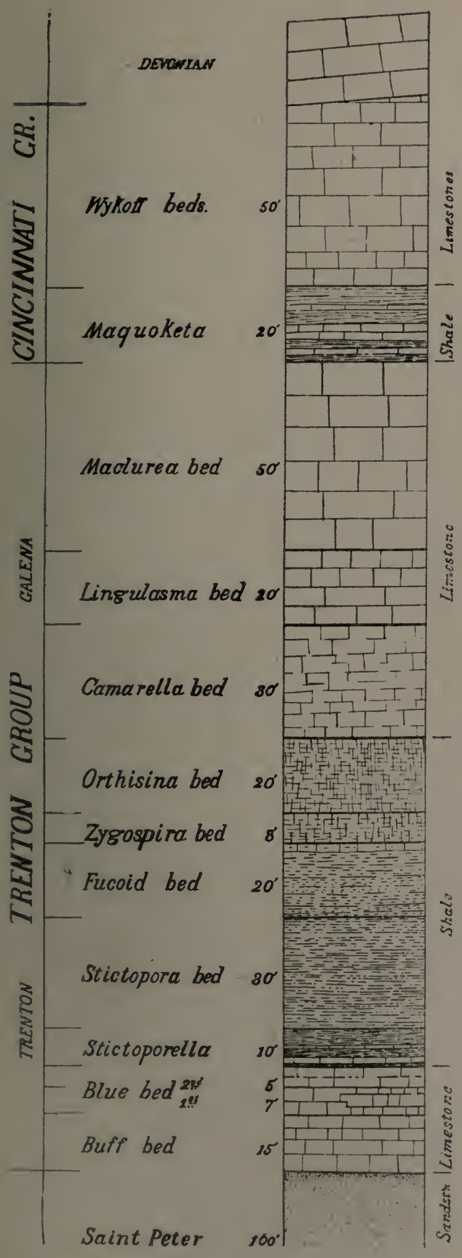


FIGURE 8.

Figure 8 is a diagrammatic section of the Lower Silurian (Ordovician) rocks of south-eastern Minnesota, showing the position of the beds just described, their thickness and their lithologic characters so far as practicable.

The Saint Peter is included in the Lower Silurian but is partly excluded from the diagram for lack of space.

Various combinations of the words Trenton etc., (on the extreme left) and limestone etc., (on the right of the diagram) have been and are still in use in Minnesota. But such names are based mainly on lithologic character and conjecture and are scarcely more than provisional. The division between GALENA and TRENTON is indefinite. Trenton group and Galena group are synonyms. So also are Cincinnati group and Hudson River group.

In Fillmore county the Galena is surmounted by twenty, or more, feet of shales, the Maquoketa. These shales in Minnesota consist of alternating strata of shale and crystalline limestone, and are continuous with the Maquoketa of Iowa. But the fossils consist of numerous specimens of a few species of brachiopoda and bryozoa almost wholly different species from what I was able to find in the Maquoketa near Dubuque, Iowa; yet they are not forms that indicate a difference in the age of the strata exposed near Dubuque, and those exposed in Fillmore county.

Lastly there is upon the Maquoketa shales from fifty to seventy feet of limestone that is very fossiliferous—*O. subquadrata* Hall, *O. testudinaria* (three varieties, *O. whitfieldi* Winchell (*O. kankakensis* McChesney,) *Rhynchonella capax* Con., *Streptorhynchus wisconsensis* Whitf., etc. The fauna appears to belong to the Cincinnati group. But this limestone appears to be continuous with that identified in Iowa as belonging to the Niagara group, though perhaps only in part. In order to avoid confusion in subsequent work, I would propose a new name for this limestone—*Wykoff* beds—from the town near which the best exposure known occurs.

I have never seen any exposures nor any fossils of the Upper Silurian in Minnesota. The Devonian lies unconformably upon the Wykoff beds. Indeed if the Devonian limestone, as is probable, extended much further north than it now does, and in the same manner, it rested unconformably upon the Galena or even the Lower Trenton formations within thirty to fifty miles of its present northern limit. As it now lies there it is much less than fifty feet between the top of the Maquoketa shales, and the base of the Devonian at Spring Valley, while only fifteen miles further south near the boundary of Iowa and Minnesota, at least seventy-five feet of limestone intervenes.

October 6, 1891.

THE RANGE AND DISTRIBUTION OF THE LOWER SILURIAN FAUNA OF MINNESOTA WITH DESCRIPTIONS OF SOME NEW SPECIES.—

F. W Sardeson.

My first intention was to make out a list of Palæozoic fossils found in Minnesota, with notes on their distribution and vertical range as revealed by thirty or forty exposures. But during preparation some changes of plan were made until now the list consists only of Lower Silurian species.

Experience in collecting convinced me that the division into Trenton limestone, Trenton shales and Galena limestone was too indefinite for any practical use in marking the vertical range of fossil remains. The plan, too, of designating the elevation in feet above the top of the Saint Peter formation, was found inconvenient and misleading. As a consequence I finally decided to lay aside the old terminology used in Minnesota, and describe the beds as I find them; to identify what I could with the beds that are described in Wisconsin and to give names to such as had to be defined anew. The terms used in the preceding paper (p. 325) will reappear in this for the designation of several beds.

The matter of correct identification was more difficult, but in each case the material identified has been labeled and stored away, so that corrections can be made without disturbing the facts as to distribution. This serves my purpose as well as that of persons wishing to make exchanges for Minnesota fossils, it being the aim of the Department of Geology in the University of Minnesota (for which the material used was collected) to supply such wants when possible.

To some species no descriptions were found at all and consequently they had to be described before exchange with them was practicable.

I have made a number of sketches to accompany descriptions of fossil forms that for reason of being new, or at least supposed to be new, have been thought worth describing.

The described forms may be considered either as species or varieties without affecting in the least the purpose of this article. That they are distinct forms I deem sufficient for my present purpose, and without any attempt at a detailed discussion upon their classification, the descriptions are offered.

In the preparation of the table below, no species has been included that is not in the collections belonging to the Department; and distribution is indicated only where these species have been found. Question marks indicate doubt as to identification and not as to the occurrence of the species in hand.

CAMARELLA BERNENSIS n. sp.

Plate IV, figures 4, 5, and 6.

Compare C. *hemiplicata* Hall.

Length 17 mm., breadth slightly greater, depth 10 mm.

Shell nearly equivalve, beak of the ventral valve more acute, short and curved closely over that of the dorsal valve. Area very small. Ventral valve with about seven broad plications near the mesial line and a short, distinct sinus embracing three of them; one less plication on the dorsal valve. Immature specimens would have neither sinus nor plications. The specimens are white, in strong contrast to other articulates in the same bed.

If the specimen figured represents a distinct species it will be characterized by nearly equal beaks and equal curvature of the valves. In these two respects as well as in possessing more acute plications and smaller size it chiefly differs from *C. hemiplicata* Hall.

From the Camarella bed, at Berne, Dodge county, Minn.

CAMARELLA OWATONNENSIS *n. sp.*

Plate IV, figures 1, 2 and 3.

Compare *C. bisculata* Emmons.

Shell oval, globose; length 10 mm., breadth 8 mm., depth 7 mm.; surface smooth; beak acute, coiled tightly back upon the dorsal valve, closing (?) the perforation of the beak. On the dorsal valve posteriorly, is a narrow groove or sinus, which bifurcates on the umbo, giving room for a plication which in turn bifurcates nearer the mesial line making three rounded grooves on the dorsal surface. Ventral valve with seven plications, the three central ones arising in front of the umbo, while those ending on the lateral margin arise on the beak.

From the Camarella bed at Owatonna, Minn.

CRANIA HALLI n. sp.

Plate IV, figures 8, 9 and 10.

Shell convex, irregular in outline, an indistinct octahedron when the valves are in place. Diameter 10 to 15 mm.; valves always (?) detached; surface smooth, dark colored, concentrically marked by indefinite wrinkles often incrusted exteriorly by *Aspidopora parasitica* Ulrich, or other bryozoon; ventral valve apparently always so. Ventral valve distinguished most easily by the internal muscle scars one pair of which is against the posterior margin. Interior surface finely sculptured, showing the position of various organs. The strong convexity of the ventral valve distinguishes this species from *C. setegeira* Hall, with which it is associated.

From the Stictopora bed at Minneapolis and vicinity.

DISCINA CONCORDENSIS n. sp.

Plate IV, figures 13 and 14.

Compare *D. pelopea* Billings.

Shell circular, diameter 10 to 20 mm., compressed, subconical, concentrically wrinkled (6 to the mm.); of these wrinkles about two-fifths are circumferences, the others end on the lateral or posterior lateral surfaces. Beak of the dorsal valve acute, not ornamental, situated about two-thirds the distance from the anterior margin, and inclined toward the posterior.

Ventral valve provided with a tube which opens from the apex towards the posterior margin. This species corresponds in many respects to *D. pelopea* Billings, but his description and figure leave some doubts which prevent me from labeling my specimens *D. pelopea* Billings

This shell is wrinkled, as shown by concentric grooves on casts of the interior, and these could not possibly erode away. Also the color is universally white, in strong contrast to the dark shells of an associated crania. And there may be some other differences. I have not a specimen of *D. pelopea* with which to compare.

From the Lingulasma bed, Berne and Mantorville, Dodge county, and the Blue (2d) bed at Minneapolis.

LEPTAENA MINNESOTENSIS n. sp.

Plate IV, figures 24 and 25.

Compare *L. sericea* Sowerby.

Shell small, length of largest specimen seen 8 mm., breadth 13 mm. on the hinge line, which is the greatest extension of the shell. Dorsal valve concave following the convexity of the ventral valve. Surface marked by fine radiae as in case of *L. sericea* Sowerby. No concentric lines. The specimens figured are the largest out of two hundred from ten localities in Ramsey, Goodhue and Fillmore counties. In general appearance and even in internal structure these agree closely with *L. sericea* Sowerby. I have a number of the last named, from the Stictopora and Fucoid beds in Minnesota, and they agree in every particular with the first figures of *L. sericea* in Paleontology of New York, Vol. I. With these L. minnesotensis may easily be confused unless attention be paid to a few particulars. Specimens of *L. minnesotensis* are uniformly smaller have no concentric lines (?), are more strongly curved. That they are not immature forms is shown by the thick shell and heavy visceral area, thicker and heavier if anything than in the mature forms of *L. sericea* Sowerby. *L. sericea* (as identified in Minnesota) and *L. minnesotensis* are never associated in the same strata so far as known. The former stops in the fucoid bed while the latter appears in the Zygospira bed, and continues up into the Camarella bed. There are some small differences of detail on the interior markings.

Common in the Zygospira bed and throughout to the Camarella bed, where exposed in Minnesota.

LEPTAENA PRAECOSIS n. sp.

Plate IV, figures 26, 27 and 28.

Compare *L. transversalis* Sowerby.

Shell small, very convex, length 9 mm. or less; breadth nearly twice that, hinge line as long as possible. Area on the convex valve very large with a triangular deltidium. No concentric lines. Interior not known.

This species agrees closely with *L. transversalis* Sowerby, but never attains the large size figured in the Palæontology of New York. The form of the shell is quite invariable.

Common in the Maquoketa shales of the Cincinnati group, wherever exposed in Fillmore county, Minn.

LEPTAENA RECEDENS n. sp.

Plate IV, figures 29, 30, 31 and 32.

Compare L. *transversalis* Sowerby.

Length 10 mm., about one-half the breadth; rather thick. Hinge line sometimes greater than represented in the figures. Surface marked by fine radiæ with a few coarser ones. No concentric lines on uninjured shells. Ventral valve usually with a broad sinus. This form is larger than *L. praecosis* n. sp. and is more convex anteriorly while the latter is most strongly convex posteriorly. The dorsal valve is less convex than that of *L. transversalis* Sowerby. Common in the limestone of the Cincinnati group in Fillmore county, near Spring Valley.

LEPTAENA SAXEA n. sp.

Plate IV, figures 33, 34 and 35.

Length and breadth 15 and 22 mm. respectively; cardinal angles about 85 degrees. Ventral valve moderately convex; dorsal valve slightly concave. Surface marked by two heavy concentric lines, besides the usual radiating lines. Visceral area on the dorsal valve slightly depressed and divided by four high radiating processes, the two central ones being somewhat the larger. Interior of the ventral valve like that of *L. recedens.*

From the limestone of the Cincinnati group, near the top, town of Bristol, Fillmore county, Minn.

ORTHIS CORPULENTA n. sp.

Plate V, figures 8, 9 and 10.

Compare *O. testudinaria* Dalman vars. *Meeki and Multisecta.*

Shell circular, diameter 20 mm; hinge line equal to two-thirds the greatest width. Ventral valve strongly convex, and with a sharp incurved beak; surface near the beak of either valve is marked by about fifteen radiating plications which bifurcate or implicate about three times before reaching the mesial line. Concentric growth lines several or many. Dorsal valve convex with a broad indefinite sinus. Rarely both valves are equally convex, the shell globular and the hinge area concealed. Immature specimens have the general outline of *O. multisecta* but are less plicated, and have a narrower hinge line. *O. meeki* is distinguished from *O. corpulenta* by its less rotund form and larger, angular sinus and median ridge. This is the largest form like *O. testudinaria* Dalman, yet seen; specimens are often larger than the ones figured.

From the shales and limestone of the Cincinnati group, Fillmore county, Minn. Specimens of the same species from Kentucky have been seen.

ORTHIS MACRIOR n. sp.

Plate V, figures 5, 6 and 7.

Compare *O. emacerata* Hall.

Shell semicircular, hinge line 20 mm. or less; length 15 mm. or less. Ventral valve convex between the hinge line and mesial line, most strongly so along the median ridge; slope from this median ridge to the lateral margins plane or slightly convex; beak small, extended.

Dorsal valve plane but for a somewhat acute sinus which extends and expands from the beak (of the dorsal valve) to the mesial line. The surface ornamentation consists of fine, unequal radiating lines that bifurcate three or four times, and of rounded inconspicuous growth lines.

From the upper part of the Cincinnati group in Fillmore county, Minn. I have a scarcely distinguishable form from Butler county, O., also.

This species and the previous one might be considered as varieties of *O. testudinaria* Dalman somewhat as are the forms in the Cincinnati group of Ohio. I did at first think the last described species an extreme form of *O. emacerata* Hall. Mr. Meek in his note on *O. emacerata* Hall expresses such an idea concerning what is probably this form.* But after looking over carefully the material collected last summer at Cincinnati, O., I doubt the correctness of my first impression.

Orthis multisecta Meek, and *O. meeki* Miller are not represented in Minnesota, and indeed the strata where the former should appear are probably wanting. Even in the immature specimens of *O. corpulenta* the acute cardinal angles and deep sinus of the Ohio specimens are wanting. *O. corpulenta* seems to agree much more nearly with the form of *O. testudinaria,* found in the Galena formation of Minnesota, and differs from this last mainly in size, and a few details on the interior, *i. e.*, the muscle scars are more nearly equal and more elongate in the former. This Galena form extends down from the Lingulasma bed to the Stictopora bed (which perhaps equals Black River formation of New York). It agrees closely in external form with the New York species from the Trenton, but is perhaps smaller. Whether *O. corpulenta* or the following described or some other is nearest *O. testudinaria* Dalman, I am at a loss to say.

ORTHIS ROGATA n. sp. or var.

Plate v, figures 1, 2, 3 and 4.

Compare *O. testudinaria* Dalman.

Shell small, subcircular, width of a largest specimen 12 mm., length 11 mm.; depth often equal to one-half the length. Hinge line equal to two-thirds or three-fourths of the greatest width. Ventral valve strongly and evenly convex (except near the mesial line on antiquated specimens where the curvature may be abrupt.) Beak small, sharp and curved; area small. Dorsal valve plane or convex with little or no sinus. Surface ornamentation as on *O. corpulenta,* but proportionately finer. The anterior pair of muscle scars on the dorsal valve are much the larger.

The specimen figured is the largest out of several thousand, and is from the Orthisina bed at Berne, Dodge county, Minn.

ORTHIS TERSUS, n. sp.

Plate v, figures 11, 12 and 13.

Compare *O. elegantula* Hall, and *O. hybrida* Sowerby.

Shells transversely elliptical, broadest towards the anterior; length of an average specimen 13 mm., breadth 15 mm., depth greatest just back of the umbo. Dorsal valve gently convex with a narrow furrow like sinus extending to, or nearly to, the anterior margin. Ventral valve strongly convex about the umbo, but less so toward the margin. No indi-

*Palæontology of Ohio, Vol. I, p. 110.

cations of a median ridge except near the beak. Beak extended and recurved. Area mostly on the ventral valve.

The specimens figured were collected from the Cincinnati group, at Wilmington, Ill. Two specimens only have been found in Fillmore county, Minn., towards the top of the limestone formation of the Cincinnati group.

The relation between this species and *O. corpulenta,* described above, is close; but smaller size, absence of cardinal angles, proportionately larger muscle scars, acute mesial angle and radiately striated internal surface are marks of the former. Compared with *O. hybrida,* Sowerby, it is broader, less equivalve, has a less incurved beak, besides some internal differences.

ORTHIS MINNESOTENSIS n. sp.

Plate V, figures 14, 15, 16 and 17.

Compare *O. pectinella* Hall, *O. subquadrata* Hall, and *O. iphigenia* Billings.

Shell broadly oval transversely; hinge line less than the greatest width, which is about 15 to 20 mm. Dorsal valve convex, ornamented by about twenty radiating plications on the umbo which bifurcate or implicate once or twice before reaching the mesial line; one or two run out on the hinge line on either side. Beak of the dorsal valve short, slightly incurved. Ventral a little convex, more strongly so near the beak, which is short, but a little curved. Area of the ventral valve broad, with the deltidium extending to the beak.

This species agrees in size and general form with *O. pectinella,* Conrad. Immature specimens are scarcely distinguishable, since in form and size the two are very like. But mature specimens differ radically in the manner of the plications.

From the Fucoid bed upwards into the Camarella bed; very generally distributed in Minnesota.

ORTHIS PETRAE n. sp.

Plate V, figures 18, 19, 20 and 21.

Shell subquadrate, with rounded corners. Length about 15 mm., breadth 20 mm. Dorsal valve convex, marked by fifteen to twenty radiating plications near the beak; of these central ones continue simple to the anterior margin, while those ending on the lateral margins bifurcate once or twice; broad indefinite sinus on the dorsal valve, small fold on the ventral. Ventral valve slightly convex, plicated like the dorsal. Derivation a proper name.

Found in the limestone of the Cincinnati group, at Spring Valley, and elsewhere in Fillmore county, Minn.

PRODUCTELLA MINNEAPOLIS n. sp.

Plate IV, figures 11 and 12.

Shell small, length 13 mm.; breadth 12 mm., greatest in front of the middle. Ventral valves only seen; these are convex, symmetrically rounded, the curvature from the beak to the opposite point on the mesial line being a gentle coil. Hinge less than the greatest width, and slopes back from the beak on either side. No cardinal area is shown by the specimens in hand, but either there is a large area or the dorsal valve is a pentagonal in outline. The surface is ornamented by pits arranged in concentric and radiating rows crowded on the posterior surface, alternating with smooth concentric bands on the anterior slope. Casts of the interior pitted likewise. The smooth bands are marked only by rounded growth lines.

Rare; in the crystalline strata at the bottom of the Stictoporella bed at Minneapolis.

RHYNCHONELLA MINNESOTENSIS n. sp.

Plate IV, figures 21, 22 and 23.

Compare *R. increbescens* Hall and *R. orientalis* Billings.

Shell variable in size, length of mature specimens 10 to 15 mm., breadth 12 to 18 mm., depth usually about one-half of the length, but specimens are often anteriorly globose. From 15 to 25 plications on the ventral valve, one to eight of which may fall in the sinus but more often there are three, four or five. Always one more on the fold of the dorsal valve. Plications rarely bifurcate. Sinus extends about two-thirds the distance to the beak. No elevated concentric striæ. Beak moderately recurved as in *R. increbescens* Hall, as identified in the Fucoid bed and upwards. There are undoubted transitional forms between this species and *R. increbescens,* on both sides of the line between the Stictopora bed and the Fucoid bed. But the greater breadth, greater curvature along either valve from the beak to the opposite point on the mesial line, broader or less acute radiæ, lack of elevated concentric lines and less asperated appearance readily distinguished *R. minnesotensis.*

In relation to *R orientalis* Billings, identified in the Buff limestone, there are many apparent intermediate forms recurring among *R. minnesotensis,* but the deeper sinus, larger size and more numerous plications distinguish the last named species.

Found everywhere in Minnesota in the Blue limestone and to the top of the Stictopora bed.

RHYNCHONELLA SANCTA n. sp.

Plate IV, figures 19 and 20.

Shell transversely elliptical, depressed, length 13 mm., width 17 mm., depth 7 mm. Thirteen broad radiating plications on the ventral valve, and fourteen on the dorsal. Sinus on the ventral valve, contains three plications; four plications on the fold on the dorsal valve. Beak curved. From the umbo on the dorsal valve, along the fold to the mesial line, scarcely curved. No concentric lines except one or two growth lines which seem to be accidental. Intermediate forms between this species and *R. increbescens* Hall, with which it is associated, are rather more numerous than specimens of *R. sancta,* but the striking differences and wide distribution of both, make it seem improbable that they are even varieties of the same species.

From the Orthisina (?) bed at Saint Paul and in Goodhue county.

SKENIDIUM ANTHONENSIS n. sp.

Plate IV, figure 7.

Very small, length of ventral valve 3 mm. or less, length of dorsal 2 mm., breadth 5 mm. Area mostly on the ventral valve, large, plane, nearly equal in dimension to the dorsal valve and at right angles to it. Deltidium very large, extending to the beak on both valves. Surface of the ventral valve plicated by 26 simple radiæ, two pair of which arise from the beak and include one shorter pair between them. The others arise from between the beak and the extremities of the area. Beak acute, not produced. A median fold extending from the beak to the mesial line includes about six radiæ, is nicely rounded, and has a corresponding sinus on the dorsal valve, and an emargination of the mesial line. Plications on the dorsal same as on the ventral surface.

From the Buff limestone, near the Falls of Saint Anthony at Minneapolis, associated with *Zygospira aquila* n. sp.

STROPHOMENA HALLI n. sp.

Plate IV, figures 36, 37 and 38.

Shell delicate, semicircular, width about 25 mm., length 15 mm. Ventral valve strongly convex near the beak, concave thence to the umbo where it suddenly turns and curves up to the mesial line. Curvature of the dorsal valve follows that of the ventral. Surface of both valves marked by fine radiating lines with about 25 or 30 heavier ones. The concave part of the ventral valve and corresponding convex part of the dorsal valve are undulated somewhat like confused cross waves. This marking extends to the interior, *i e.* the whole shell undulates. No concentric lines common. Area on the ventral valve unusually large for a strophomena, and has a large triangular deltidium.

Named in honor of Prof. C. W. Hall of the State University, to whose collection the first specimens seen belong. The specimens figured are from the Stictopora bed, Saint Paul. Rare.

STROPHOMENA INQUASSA n. sp.

Plate V, figures 22, 23 and 24.

Shell subcircular, length 25 mm., breadth 30 mm., hinge line equal to or less than the greatest width. Ventral valve strongly and evenly convex; (shells that are injured during growth, bend abruptly back at the line of injury, and the slope from thence to the mesial line is direct). Dorsal valve deeply concave. Area on the ventral valve broad; deltidium large. Surface radially marked like *S. alternata* Conrad. On the ventral side between the beak and each cardinal angle are from five to eight short, indistinct folds, oblique with reference to the median line.

The shell is thick and the internal markings are heavy. In these two respects as well as in having a shorter, broader hinge area and a more convex valve, it differs from *S. alternata* Conrad., to which it is closely related. The ventral valve is sometimes a little more convex near the centre like *S. camerata* Conrad. In some points it strongly resembles *S. ponderosa* from the top of the hills at Cincinnati, O., and I am inclined to look upon it as closer allied to that form than to *S. alternata* Conrad of the Trenton formation.

The specimen figured is from the Stictopora bed, at Saint Paul, Minn., but the species probably occurs in higher beds also.

STREPTORHYNCHUS SUBSULCATUM n. sp.

Plate IV, figure 39.

Compare *S. sulcatum* Verneul.

Shell semicircular, length of a large specimen 12 mm., breadth 15 mm. Both valves gently convex. Mature specimens have a short sinus on the ventral valve, a fold on the dorsal and usually a rounding out of the anterior margin. Interior unknown.

Compared with *S. sulcatum* Verneul, as figured by Mr. Meek; the only differences noted are a narrower area, shorter sinus, greater length and finer radiate markings and more equally convex valves. The relation of this form to *S. sulcatum* and *S. sinuatum*, in view of Mr. Meek's observations on the two last mentioned species, (Pal. Ohio, Vol. 1, p. 88) is interesting, since the coarser plicated species occur at an elevation intermediate between the other two.

From the Orthisina bed, Saint Paul, and in Goodhue county.

ZYGOSPIRA AQUILA n. sp.

Plate IV, figures 15, 16, 17 and 18.

Shell small; length (of a large specimen) 6 mm.; breadth a little less; depth 3 mm. Ventral valve convex, with a broad median ridge; beak sharp, long, curved in continuation of the convexity of the valve, and perforated. Dorsal valve more evenly convex, shorter and more circular. Surface smooth and brown in color. Plications several, extending part way to the beak. The outward appearance led me to think this a Camarella, but sections show an internal process similar so far as I have been able to observe, to that of Zygospira modesta. A thick section of the ventral valve cutting the beak of the dorsal valve is figured to indicate the position of the process. From other sections there appear to be spiral coils anterior to the part shown in the figure, situated in the dorsal valve mainly, and with the apices together.

Found in the Buff limestone at Minneapolis; also about the same horizon in Olmsted and Fillmore counties.

CARINAROPSIS DELETA n. sp.

Plate VI, figures 5 and 6.

Shell small, consists of one or two coils in the same plane, very rapidly enlarging so that the last half coil constitutes nearly the whole shell. Aperture elliptical, entire. Surface (on casts) concentrically marked, but not clearly. The minute coil is seldom preserved and the general form is then that of a metoptoma, but without a subtruncated margin, and marked often by a groove made by the penultimate volution, below the false beek. The figures are of a siliceous cast of a specimen somewhat under medium size. Good specimens are rare.

From the Stictopora bed at Minneapolis and in Goodhue county.

CARINAROPSIS (or BELLEROPHON) PHALERA n. sp.

Plate VI, figures 14, 15, and 16.

Shell of about two whorls in the same place;—the last one expands so rapidly as to give a patelliform outline. About one and one-half volutions exposed. Casts show indistinct radiating folds on the dorsal surface; crossed by concentric undulations (on one specimen). Dorsally and laterally subangulated, but only the dorsal carina continues to the margin of the aperture. Ventral surface grooved. Aperture circular, diameter 3 cm., truncated or emarginated anteriorly. Rare. From the Stictopora bed at Saint Paul.

CONCHOPELTIS (or METOPTOMA) OBTUSA n. sp.

Plate VI, figure 17.

Compare *C. minnesotensis* Walcott.

Shell large, patelliform, or subconical, apex eccentric, apical angle 110 degrees. Aperture subcircular, about three times as wide as the shell is high. Cast marked by four or five concentric furrows and by numerous elevated radiating lines, from 15 to 20 in one centimeter. Rare. From the Stictopora bed at Minneapolis.

FUSISPIRA (?) SPICULA n. sp.

Plate VI, figures 10 and 11.

Of this shell only one imperfect interior cast is known. This shows that the apical angle was about 12 degrees; sutures probably not visible on the exterior of the shell; transversely marked by fine lines that run obliquely back; aperture subquadrate, oblique, narrowest next the suture; shell delicate.

Found by Prof C. W. Hall in the Trenton shales (in the Stictopora bed) at Minneapolis.

HOLOPEA (?) PERUNDOSA n. sp.

Plate VI, figures 12 and 13.

Shell large, coiled into two or three rapidly enlarging volutions. Apical angle 180°. Suture deep. Umbilicus large. Casts of interiors only known. These are transversely marked by fine growth lines; and by large nodulose undulations on the upper and outer surface, that are continuous with or alternate with like undulations on the lower surface. A transverse section, parallel to the above mentioned markings, is oval with the apex at the outer lower margin.

This species agrees with *H. pyrene* Billings, so far as known, in every respect except that the latter is described as having an elevated spire which this species has not. Rare.

Found in the Orthisina bed at Kenyon, Goodhue county, Minn.

METOPTOMA EXPLANATA n. sp.

Plate VI, figures 7 and 8.

Shell oval, broadest anterior to the middle, low, very rapidly expanding from the apex to the aperture, apex small, acute, nearly straight, and directed posteriorly. Anterior slope long, 18 mm., posterior slope short, 5 mm. Shell thin and with no surface ornamentation. The specimen figured is from the Blue limestone at Minneapolis. This species very closely resembles *M. perovalis* Whitf., from the same horizon at Beloit, Wisconsin, but on the two specimens in hand no truncation of the posterior margin is apparent.

PLEUROTOMARIA CLIVOSA n. sp.

Plate VI, figure 9.

Compare *R. sponsa* Billings.

Shell small, conical, apical angle 75 degrees; length 12 mm., breadth 10 mm.; consists of about five volutions turreted one above the other. Carinated; one carina marks the limit of the umbilicus and is obtusely rounded; a second, below the middle on the outer volution and concealed below suture line in the first volutions, is acutely rounded; a third carina is on the outer extremity of each whorl and is angular. From the suture above each volution the surface rounds out broadly but becomes concave towards the main carina; the narrow band between this and the next carina (or the suture) is concave; from the last named to the umbilical carina the surface, in general outline, is convex, but is slightly undulated making two broad indistinct carina. Transversely marked by growth lines which curve obliquely back from the suture to the main carina and thence undulate obliquely forward to the umbilicus. Umbilicus small. Aperture vertically subelliptical, obliquely subquadrate, with the lower outer wall of the penultimate volution forming the upper inner boundary of the aperture. Lip (?). Shell thick. From the Stictopora bed at Minneapolis.

TRYBLIDIUM EXSERTUM n. sp.

Plate VI, figures 3 and 4.

Shell high and curved, forming about one-third of a volution; gradually expanding to near the aperture which (as shown on an interior cast) is suddenly expanded. The interior cast is marked by fine radiating lines two or more to 1 mm. These are shown on casts of the exterior to have been narrow acute bifurcating elevations, also marked by less acute and finer concentric lines. Aperture oval, much narrowed under the beak and with an unbroken margin. Length of the aperture 30 mm., breadth 25 mm. The muscle scars are not distinct on the cast, but there appears to be a row of about 24 passing around the shell from 2 to 5 mm. above the lip of the aperture. From the (2d) Blue limestone at Minneapolis.

TRYBLIDIUM VALIDUM n. sp.

Plate VI, figures 1 and 2.

Interior cast elliptical in outline, subtruncate posteriorly; somewhat acutely rounded anteriorly. Length and breadth of the aperture and the height of the cast are as 8, 6 and 3. Greatest elevation central. Beak of half the elevation, obtuse, and near the posterior margin. Surface marked by several concentric varices of growth. No radiating marks are visible on the cast. Two large round muscle scars have been made out and indications of a third are present, all on the same side.

The specimen figured is from the Orthisina bed at Kenyon, Goodhue county, Minn.

CYPRICARDITES LUCULENTUS n. sp.

Plate VI, figures 25 and 26.

Shell about 35 mm. long, and about same in width; convexity about 20 mm. Hinge nearly straight, anterior margin rounded above and then nearly straight from thence to a point on the ventral margin directly below the beaks. Thence the curvature is stronger up to the hinge. The beaks are oppressed and coiled in and forward; the umbones are large, and have a strong convexity that extends to the ventral and posterior margin. In front and back of this convexity the surface is depressed, or a little concave.

The muscle scars are large, the anterior one is situated close to the hinge and the anterior margin; the posterior scar is the larger, is close to the palial line, and about half its diameter below the hinge. Cardinal teeth two; the lateral teeth have not been clearly made out, but are probably small and few, ligament external. Casts have an elevated ridge extending from the beak towards the ventral margin.

From the Limestone of the Cincinnati group, town of Bristol, Fillmore county, Minnesota.

CYPRICARDITES MINNESOTENSIS n. sp.

Plate VI, figure 21.

Form ovate with the apex at the antero-dorsal margin; length 30 mm., breadth 25 mm.; convexity moderate and uniform. Beak small, acute, incurved, with two small cardinal teeth and two larger curved postero-lateral teeth. Two muscle scars; the anterior one small and close to the margin; posterior scar large, indistinctly outlined, remote from the hinge and from the posterior margin. Palial line simple and deep. The specimen figured is a cast of a left valve. Rare.

From the crystalline slabs of the Stictoporella bed at Minneapolis.

CYPRICARDITES TRIANGULARIS n. sp.

Plate VI, figure 23.

Compare *Cypricardites* (*Ambonychia*) *obtusa* Hall.

Cast small, narrow anteriorly. Hinge straight and about two-thirds as long as the cast. The anterior margin is slightly curving and forms an angle of 75 degrees with the hinge line. The posterior and ventral margins together form a semicircle, with a diameter equal to the width of the shell. Beaks anterior, nearly straight, flattened laterally, directed forward, and projecting. Anterior muscle scar large and reniform. Posterior scar smaller and less distinct. Palial line simple and very marked. From posterior to the beak there runs a bold ridge about two-thirds the distance to the anterior ventral margin of the cast.

From the Orthisina beds at Saint Paul, Minnesota.

The above described species is closely related to *Cypricardites obtusa* Hall. Indeed, in the description of *C. obtusa* mention is made of a specimen, from northwestern Wisconsin, that has a ridge on the cast, and that may be identical with the specimen described here. The shell figured by Mr. Billings as *Ctenodonta* (*Ambonychia*) *obtusa* Hall, in general outline at least agrees with the one that I have figured.

But from the original description and figure, I am unable to decide whether the above described or the following species is most nearly allied to *C. obtusa* Hall.

CYPRICARDITES VICINUS n. sp.

Plate VI, figure 22.

Shell large and smooth as shown by casts of the interior and of the exterior. Hinge long and straight. The anterior margin makes an angle of 90° with the hinge: it is quite continuous with the ventral margin. The ventral and posterior margins form rather more than a semi-ellipse. Beaks anterior, scarcely incurved; umbones evenly rounded but high. Shell thickest just back of the umbones. Cardinal teeth two or three, set obliquely to the hinge line, and parallel to the three oblique posterior teeth. The anterior muscle scar is deep, small and reniform; the posterior scar is larger but often not outlined. Palial line distinct.

From the Blue limestone at Minneapolis.

This species differs from the last described in being very much larger, more elongate, and in having rounded incurved beaks and smoothly rounded surface. It may be, however, an earlier form of the same species. But no evidence to that effect is known to me, except their great resemblance.

TELLINOMYA CANDENS n. sp.

Plate VI, figures 24.

Shell very small, length 7 mm., breadth 4 to 5 mm., moderately convex. Surface smooth(?). Beaks anterior, small, oppressed, and coiled inward and a little forward. Umbones prominent, hinge a little curved, ventral margin arcuate and continuous with the anterior margin, the anterior margin curves more sharply up to the hinge line, posterior rounded. Casts show two distinct muscle scars at the extremities of the hinge, and a simple palial line. No cardinal teeth could be discovered. This species is very common, but good specimens are rare.

The specimens figured are from the Stictopora bed, at Minneapolis.

TELLINOMYA (or NUCULA) LEPIDA n. sp.

Plate VI, figures 18, 19 and 20.

Compare *Tellinomya* (*Ctenodonta*) *astartaeformis* *Salter*.

Shell small, length 25 mm., breadth 25 mm., surface smooth but three or four varices of growth, beaks subcentral high, small, oppressed, closely curved in and backward. Hinge long, extending from under the beaks downwards toward the anterior and the posterior extremities. Ligament interior, in a shallow pit under the beaks. Anterior portion of the hinge marked on the inner surface by twenty teeth alternating with pits for the reception of the teeth of the other valve; posterior portion likewise ornamented with twelve teeth and sockets, muscle scars two, large, deep and situated at the anterior and posterior extremities of the hinge, near the longitudinal extremities of the valve. Palial line simple.

This species is closely related to *T. astartaeformis* Salter, but differs in having a well marked lunette on the posterior cardinal slope and a longer narrower area of the same kind on the anterior cardinal slope. Since muscle scars are neither described nor figured with *T. astartaeformis* Salter, it is probable that the presence of deep scars is another distinguishing mark for *T. lepida.*

From the middle and upper part of lime stone of the Cincinnati group, near Spring Valley and Granger, Fillmore county.

About sixty very perfect free valves have been found and are among the exchange material in the department of Geology of the University of Minnesota.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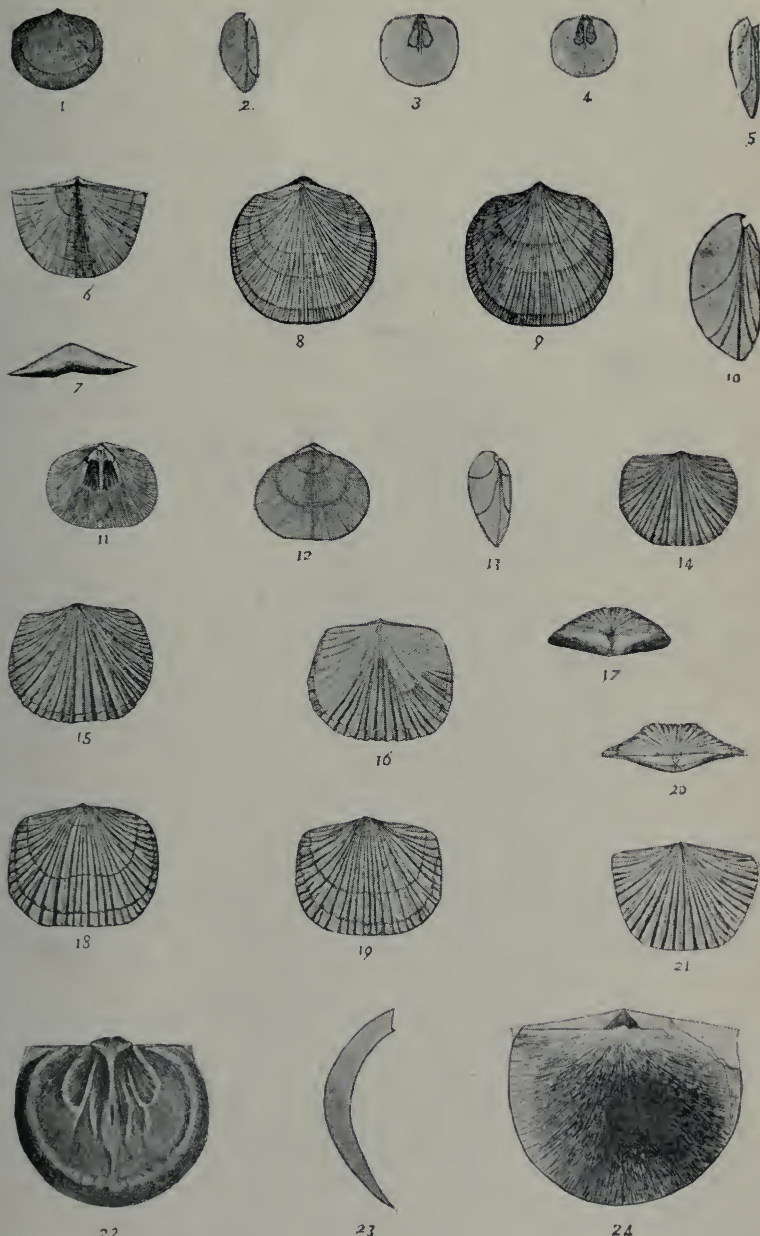
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LOWER SILURIAN. NAMES OF FOSSILS IDENTIFIED.	Buff l'stone.	1st Blue.	2nd Blue.	Stictoporella.	Stictopora.	Fucoid.	Zygospira.	Orthisina.	Camarella.	Lingulasma.	Maclurea.	Maquoketa.	Wykoff lower	Wykoff upper.
BRACHIOPODA.														
Camarella bernensis n. sp.									*					
" hemiplicata Hall									*					
" owatonensis n. sp									*					
Crania halli n. sp					*									
" granulosa N. H. Winchell	*													
" setigera Hall					*	*								
" trentonensis Hall	*		*		*				*					
Discina concordensis n. sp.			*						*	*				
Leptaena minnesotensis n. sp.							*	*	*					
" praecosis n. sp												*		
" recedens n. sp.													*	
" saxea n. sp														*
" sericea Sowerby	*			*	*	*								
Lingula elderi Whitfield		*	*	*									*	
" reciniformis (?) Hall								*						
Lingulasma schucherti (?) Ulrich.										*				
Linguella iowensis Owen		*	*						*	*				
Orthis bellarugosa Conrad			*		*				*	*				
" biforata Schlotheim								*	*	*				
" corpulenta n. sp.												*	*	*
" deflecta Conrad	*	*	*											
" kankakensis McChesney													*	
" macrior n. sp.													*	*
" minnesotensis n. sp.						*	*	*						
" pectinella Emmons						*	*							
" perveta Conrad	*	*	*	*										
" petrae n. sp													*	*
" plicatella Hall								*	*					
" rogata n. sp.					*	*	*	*	*	*				
" subaequata Conrad					*	*								
" subquadrata Hall													*	
" tricenaria Conrad	*	*	*	*	*	*	*	*						
Orthisina americana Whitfield								*						
Pholidops trentonensis (?) Hall							*	*						
Productella minneapolis n. sp.				*										
Rhynchonella ainsliei N. H. W.				*	*									
" capax Conrad													*	*
" increbescens Hall						*	*	*						
" minnesotensis n. sp.		*	*	*	*									
" orientalis Billings	*													
" sancta n. sp.								*						
Skenedium anthonensis n. sp.	*													
Streptorhynchus convexum Owen			*		*	*								
" filitextum Hall	*	*	*	*	*	*		*						
" subsulcatum n. sp.							*	*						
" trilobatum Owen									*	*		*	*	
" wisconsensis Whitfield													*	
Strophomena alternata Conrad					?	*	*	*	*	?				
" camarata Conrad					*	*			*	*		?	?	
" inquassa n. sp.					*									

	Buff.	1. Blue.	2. Blue.	Stict'l.	Stict'r.	Fucoid.	Zygos.	Orth's'a.	Camar.	L'lasma.	Maclur.	Maquo.	Wyk. l.	Wyk. up.
Strophomena halli n. sp.	..	..	..	..	*	..	..	..	..	..	..	..	..	..
" minnesotensis N. H.W.	*	*	*	..	..	..	..	..	..	..	..	..	..	..
" tenuistriata Sowerby	*	*	*	..	..	..	..	..	..	*	..	*	*	..
Zygospira aquila n. sp.	*	*	*	..	..	..	..	..	..	..	..	..	..	..
" recurvirostris Hall	..	..	*	*	*	*	*	*	*	?	..	..	..	..
GASTEROPODA.														
Bellerophon bilobatus Sowerby	..	..	..	..	*	..	*	*	*	..	..	..	*	*
Bucania bidorsata Hall	..	..	*	..	*	..	..	*	..	..	..	..	..	..
" buelli Whitfield	..	..	?	..	..	..	..	*	..	..	..	..	..	..
" punctifrons Emmons	..	..	?	..	..	..	..	*	..	*	..	..	..	..
Carinaropsis deleta n. sp.	..	..	..	..	*	*	..	..	..	..	..	..	..	..
" phalera n. sp.	..	..	..	..	*	..	..	..	..	..	..	..	..	..
Conchopeltis obtusa n. sp.	..	..	..	..	*	..	..	..	..	..	..	..	..	..
Cyclonema montrealense Billings	..	..	..	..	*	..	..	..	..	..	..	..	..	..
" percarinatum Hall	..	..	..	..	*	..	..	*	..	..	..	..	..	..
" semicarinatum Salter	..	..	..	..	*	..	..	..	..	..	..	..	..	..
Fusispira elongata Hall	..	..	..	..	..	..	..	*	*	..	*	..	..	..
" spicula n. sp.	..	..	..	..	*	..	..	..	..	..	..	..	..	..
" ventricosa Hall	..	..	..	..	..	..	..	..	*	..	*	..	..	..
Holopea obliqua Hall	..	..	..	..	*	..	..	..	..	..	..	..	..	..
" paludiniformis Hall	..	..	*	..	..	..	*	..	..	..	..	..	..	..
" perundosa n. sp.	..	..	..	..	..	..	..	*	..	..	..	..	..	..
" symmetrica Hall	..	..	..	..	*	..	..	..	..	..	..	..	..	..
Helicotoma planulata Salter	..	..	*	*	..	..	..	..	..	..	..	..	..	..
Maclurea bigsbyi Hall	..	..	*	..	..	..	..	..	..	..	..	..	..	..
" cuneata Whitf	..	..	..	..	..	..	..	..	..	..	*	..	?	..
Metoptoma billingsi Walcott	..	..	*	..	..	..	..	..	..	..	..	..	..	..
" explanata n. sp.	..	..	*	..	..	..	..	..	..	..	..	..	..	..
Murchisonia alexandra Billings	..	..	..	..	..	..	..	*	..	..	..	..	..	..
" bellicincta Hall	..	..	..	..	..	..	..	*	..	..	..	..	..	?
" gracilis Hall	..	..	*	*	*	..	..	*	..	..	..	..	..	*
" major Hall	..	..	..	..	..	..	..	..	..	..	*	..	..	..
" milleri Hall	..	..	*	..	*	*	..	*	..	..	..	..	..	*
" ventricosus Hall	..	..	*	*	..	..	..	..	..	..	..	..	..	..
" tricarinata Hall	..	..	*	..	*	..	..	..	..	..	..	..	..	..
Pleurotomaria clivosa n. sp.	..	..	..	..	*	..	..	..	..	..	..	..	..	..
" subconica Hall	?	..	*	*	*	*	..	..	..	..	..	..	..	..
Raphistoma lenticulare Emmons	..	..	*	*	*	..	..	*	..	..	*	..	..	..
" nasoni Hall	..	..	*	..	..	..	..	..	..	..	..	..	..	..
Subulites elongatus Emmons	..	..	*	..	*	*	..	*	..	..	..	..	..	..
Trochonema beachi Whitfield	..	..	..	..	..	..	..	*	..	..	..	..	..	..
" beloitense Whitfield	..	..	*	..	*	..	..	..	..	..	..	..	..	..
" umbelicatum Hall	..	..	*	..	*	..	..	*	..	..	..	..	..	..
Tryblidium exsetus n. sp.	..	..	*	..	..	..	..	..	..	..	..	..	..	..
" validus n. sp.	..	..	..	..	..	..	..	*	..	..	..	..	..	..
LAMELLIBRANCHIATA.														
Ambonychia attenuata Hall	*	..	*	..	..	..	..	..	..	..	..	..	..	..
Cypricardites canadensis Billings	..	..	..	..	..	..	..	*	..	..	..	..	..	..
" luculentus n. sp.	..	..	..	..	..	..	..	..	..	..	..	..	..	*
" minnesotensis n. sp.	..	..	..	*	..	..	..	..	..	..	..	..	..	..

	Buff.	1. Blue.	2. Blue.	Stict'l.	Stict'r.	Fucoid.	Zygos.	Orth's'a.	Camar.	L'lasma.	Maclur.	Maquo.	Wyk. l.	Wyk. up.
Cypricardites niota Hall	..	..	..	..	*	..	..	..	..	..	..	..	..	..
" rectirostris Hall	*	..	*	..	..	..	..	..	..	..	..	..	..	..
" rotundatus Hall	..	..	?	..	*	..	..	..	..	..	..	..	..	..
" subtruncatus Hall	..	..	..	..	*	..	..	..	..	..	..	..	..	..
" triangularis n. sp.	..	..	..	..	..	..	..	*	..	..	..	..	..	..
" vicinus n. sp.	..	..	*	..	..	..	..	..	..	..	..	..	..	..
" ventricosus Hall	..	..	..	..	?	..	..	..	..	..	..	..	..	..
Modiolopsis faba Emmons	..	..	..	..	*	*	..	..	..	..	..	..	..	..
" meyeri Billings	*	..	..	..	*	*	..	..	..	..	..	..	..	..
" modiolaris Hall	..	..	..	..	..	..	..	..	..	..	*	..	*	*
" plana Hall	..	..	*	..	*	..	..	..	..	..	..	..	..	..
" rectiformis Worthen	..	..	..	..	..	..	*	..	..	..	..	..	..	..
Pterinea demissa Hall	..	..	..	..	..	..	..	..	..	..	..	..	*	..
Tellinomya astartaeformis Salter	..	..	..	*	..	..	..	*	..	..	..	..	..	..
" candens n. sp.	..	..	*	..	*	..	..	?	..	..	..	..	..	..
" lepida n. sp.	..	..	..	..	..	..	..	..	..	..	..	..	*	*
" levata Hall	..	..	..	..	*	..	..	..	..	..	..	..	..	..
" nasuta Hall	..	..	*	..	..	..	..	..	..	..	..	..	..	..
" ventricosa	..	..	*	..	*	..	..	..	..	..	..	..	..	..
Whitella compressa Ulrich	..	..	..	..	*	..	..	..	..	..	..	..	..	..

Cyclonema semicarinatum Salter:—The specimens here identified have a small umbilicus but in other respects they are as described and figured by Mr. Salter. (Canadian Organic Remains, Decade I.)

Holopea perundosa n. sp.—This species has been put among the holopea mainly because of its supposed relation to *H. pyrene* Billings.

Modiolopsis meyeri Billings.—The specimens in hand may be *M. superba* Hall.

Tellinomya candens n. sp. has been referred to that genus although the characteristic hinge teeth have not been made out. Perhaps the species belongs more properly to some other genus, as Orthonetella S. A. Miller.

Crania granulosa N. H. Winchell.—Two specimens only have been found, with the characteristic granulose surface. I am not decided as to whether it is a distinct species or not, although I have satisfied myself that the granulose surface is incidental to decomposition of small shells in the magnesian limestones and shales. Small gastropods and lamellibranchs frequently have the same marking. But in the brachiopoda it is known to me only in these two specimens and may indicate some specific character.

Streptorhynchus convexum Owen (1840) is distinguished from *S. filitexum* Hall (1847) by having more nearly the exterior markings of *Stropomena alternata* Con., by a triangular outline, thicker shell, greater convexity, broader hinge proportionally, and smaller size. They are nearly always associated. They are sufficiently distinct for separation although no one characteristic serves as a criterion.

December 8th, 1891.

Contributions from the Chemical Laboratory of The University of Minnesota.

ANALYSIS OF A SAMPLE OF MANKATO CEMENT ROCK—*W. C. Smith*

Insoluble in HCl., 19.22 per cent.

Composition of insol. part:

Silica, SiO_2,	13.30 per cent.
Alumina Al_2O_3,	3.87 " "
Peroxide of iron Fe_2O_3,	trace
Lime CaO,	"
Magnesia, MgO,	"
Loss,	2.05 per cent.
	19.22

Composition of part soluble in HCl.

Calcium carbonate $CaCO_3$,	48.74 per cent.
Magnesium carbonate $MgCO_3$	29.27 " "
Peroxide of iron, Fe_2O_3	1.52 " "
Alumina, Al_2, O_3,	.30 " "
Potassium oxide, K_2O,	.26 " "
Sodium oxide, Na_2O,	.25 " "
Phosphoric anhydride, P_2O_5	.14 " "
Silica, SiO_2	.09 " "
	80.57

April 8th, 1890.

ANALYSIS OF A MARL FROM NEAR GLADSTONE, MICH.—*Peter Christianson.*

Calcium carbonate	96.96.
Magnesium carbonate	1.68.
Calcium combined with silica	.015.
Magnesium combined with silica	.010.
Silica	.401.
Ferric oxide	.257.
Alumina	.668.

Traces of potash, soda, phosphoric acid and organic matter.

This marl forms a bed, having an area of over 100 acres and a depth of from 2 to 14 feet. It occurs near the northwest shore of lake Michigan, about seven miles from the head of Little Bay de Noc, on the west side of White Fish river. As a rule it is covered with a thin layer of vegetable mold, but at some places it appears at the surface.

April 8, 1890.

ANALYSIS OF A SAMPLE OF WATER FROM "THE GIANT SPRING," MONTANA.—*J. A. Dodge.*

(1.) General characteristics: water perfectly clear, bright and colorless; odorless and palatable.

(2.) Mineral analysis:

Calcium sulphate,	241. parts per million.
Calcium carbonate,	75. " " "
Magnesium carbonate,	86. " " "
Sodium chloride,	9.5 " " "
Potassium salts,	traces.
Lithium salts,	traces.
Total,	411.5 parts per million.

(3.) Organic analysis:

Free ammonia,	0.01 parts per million.
Albuminoid ammonia,	none.
Nitrates,	none.
Nitrites,	none.
Permanganate test,	very slight reduction.

The residue from evaporation of this water on a large watch glass showed remarkable whiteness and purity. Rhombohedral crystals of calcite or dolomite were visible to the unaided eye. With a microscope crystals of gypsum were plainly seen, showing twin and stellar forms.

May 5th, 1891.

ANALYSIS OF A SAMPLE OF WATER FROM AN ARTESIAN WELL AT DEVIL'S LAKE, NORTH DAKOTA.—*J. A. Dodge.*

1. General characteristics:
   Colorless, odorless; taste brackish
   Reaction alkaline.
2. Mineral analysis:

Sodium sulphate,	1623. parts per million.
Sodium choride,	1483. " " "
Sodium carbonate,	705. " " "
Potassium carbonate,	79. " " "
Lithium carbonate	11.5 " " "
Magnesium carbonate,	17.3 " " "
Calcium carbonate,	26.8 " " "
Ferrous carbonate,	0.5. " " "
Silica,	9.6. " " "
Borates,	traces.
Bromides,	traces.
Total,	3955.7 parts per million.

The depth of this well was stated at about 1500 feet. The strata passed through were as follows: Black soil two feet, blue clay 18 feet, bluish shale 1,400 feet, conglomerate, three feet. Immediately below this shale a small flow of water was reached. The drill then passed into quicksand nearly white and very fine. This was penetrated about 15 feet. The sand came up the pipe with the water. The pressure of outflow is light, but a stream about two inches in diameter constantly flows.

May 5, 1891.

ANALYSES OF SEVEN SAMPLES OF EFFLORESCENCE FOUND ON RED PRESSED BRICK.—*C. F. Sidener.*

SAMPLE No. 1.—From College of Mechanic Arts building State University, Minneapolis, Minn.

Sodium sulphate,	90.1	per cent.
Calcium sulphate,	1.4	"
Water,	8.5	"
	100.0	

Location—damp.
Coating—thick

SAMPLE No. 2.—From Union Station, Saint Paul, Minn.

Magnesium sulphate,	78.57	per cent.
Magnesium carbonate,	4.64	"
Water,	16.79	"
	100.00	

Location—damp.
Coating—thick

SAMPLE No. 3.—From brick wall at northeast corner of Court house block, Saint Paul, Minn.

Magnesium sulphate,	21.42	per cent.
Potassium sulphate,	15.68	"
Sodium sulphate,	57.37	"
Sodium carbonate,	2.14	"
Water,	3.21	"
	99.82	

Location—damp.
Coating—thick

Sample No. 4.—From Nos. 141 and 143 Lyndale Ave. North, Minneapolis, Minn.

Calcium sulphate—mainly.
Magnesium sulphate—trace.
Sodium sulphate—trace.
Location—damp.
Coating—medium
Mortar—red.
Backing—red brick, laid in red mortar.

Sample No. 5.—From corner of 5th Ave. and 14th St. South, Minneapolis, Minnesota.

Calcium sulphate—mainly.
Magnesium sulphate—considerable.
Sodium sulphate—trace.
Location—damp.
Coating—thick.
Mortar—red.
Backing—red brick, laid in red mortar.

Sample No. 6.—From Union Station, Minneapolis, Minn.

Magnesium sulphate—mainly.
Sodium sulphate—trace.
Location—damp.
Coating—very thick.
Mortar—red.
Backing—yellow brick, laid in white mortar.

Sample No. 7.—From a brick left exposed to the action of the atmosphere for about six months.

Magnesium sulphate—mainly.
Sodium sulphate—trace.
Location—dry.
Coating—very thin.

May 5th, 1891.

A PRE-HISTORIC INDIAN VILLAGE.—*F. W. Pettigrew.*

There are about Sioux Falls, South Dakota, numerous indications of former Indian villages, belonging to that class of aborigines familiarly known as the "mound builders." These villages were located along the Sioux river covering a distance of fifteen miles north of Sioux Falls, and twelve miles southeast, occupying for the most part, some high point of prairie overlooking the surrounding country for many miles around. The confluence of small creeks, or on the opposite side of the river in a semi-inaccessible location such as a people would naturally select for a fortress, seemed to be the favorite location.

For the most part, these village sites which are marked by irregular groups of mounds of earth varying in hight from one to ten feet are of interest only to the archæologist, there being altogether of these mounds about three hundred and seventy-five. Many of them have been defaced by the plow, and others by the spade and shovel in the hands of unskillful relic hunters, who at different times since the country has been settled by whites, have dug them over, thus making the work of scientific investigation difficult. It was not until the season of 1889 that the writer made a careful examination of the different localities, and for the first time brought to public notice the location of these villages, the most prominent and interesting of which is located ten miles southeast of Sioux Falls, on the east side of the Sioux river, on Sec. 25, T. 100, R. 49 at the river crossing of the B., C. R. & N. R. R., at the mouth of Spring Creek, that comes in from the east, and opposite Nine Mile creek, that comes in from the west. The river valley at this place is narrow, not more than one-half mile wide, the bluffs on either side are high, and in many places rise abruptly. The village was located on prairie bench which bears N. E. and S. W. and extends for two miles. The accompanying diagram [See Fig. 1, Pl. VII.] shows a portion of the village containing about twenty acres just north of the railroad track on the land owned by Mr. Peterson; fortunately this is the original prairie sod and has been undisturbed except where the mounds have been dug into in search for relics. On this account, this is the most interesting portion of the village which extends across the adjoining forty acres on the northeast belonging to a Mr. Iverson, to Spring Creek, thence across, covering about fifty acres belonging to a Mr.

Nelson. These last two pieces have been plowed over and the stones which composed the "Hut circles" have been picked up and carried away. To the southwest across the railroad track, the fields have all been plowed over, yet, for a mile, scattered here and there, are the mounds plainly to be seen, and every year as the fields are plowed over, a fresh lot of stone implements, such as mauls or hammers, axes and grinding stones are brought to the surface. On the tract owned by Mr. Peterson, near the railroad track, earthworks are plainly traceable, enclosing about ten acres; inside of the circle stretches a trench in places two feet deep, with breast-works made on the outside, and about the same in height. At the north side of this circle and composing a part of the embankment, is a mound about thirty feet across, and four feet high. Several years ago this mound was opened, and a skeleton of a man seven feet in length was taken out. Mr. Peterson says there must have been a president buried there. To the east, about eighty rods are the hills, which are steep and high. On the summit of the two highest, which hold a commanding position, overlooking the country for many miles, are seven mounds, where the faithful sentinels or members of their families were buried. Several years ago, Mr. Iverson says, two of these mounds were dug into and several skeletons of human beings were found, also two stone axes. Recent excavations in the same mounds have revealed nothing except a few bones.

To the northwest of the village, about one mile, the bluffs are very steep, and hard to climb. On the summit, at the highest point of a ridge which bears northwest and southeast, we come to some more mounds. The first one is, or was, sixty feet across and five feet high; extending along the ridge are twenty-one more smaller mounds. The first one and four others were opened by me and proved very interesting. A person standing upon this ridge, can see in all directions for miles away. The view of the winding river, skirted with timber, and the undulating prairie, affording an unobstructed vision for miles in all directions, is truly a handsome picture. These two high points were where the scouts and sentinels were stationed with their families, and kept faithful watch both by night and by day, and if game should be seen, appropriate signals were given, and if the enemy should appear, timely warning was also sent to the villagers below. A deep worn pathway leads direct from these mounds down the hillside to the river, evidently made by the faithful women and slaves carrying wood and water to their lodges on the hill.

THE VILLAGE.

To obtain a correct diagram of the village, [consult again figure I, Pl. VII.] I divided the land into squares of one hundred feet and by measurement was able correctly to place the hut rings and mounds upon the plat. There are seventy-six of these circles and twenty-seven mounds. The circles are made of stones varying in size from one foot to two feet in diameter, and were placed around the outside of their houses to hold the skins in place. This was a permanent village and contained many people. The houses were built with a view to a winter as well as a summer residence the doorways facing uniformly to the southeast; the stones forming the rings are now half buried, the soil having accumulated about them to the depth of eight inches. There seems to have been no great degree of regularity in laying out the village. The smaller circles would indicate the lodges, while the four oblong circles, the council chambers, and places for holding winter sports.

THE MOUND BUILDERS.

Who were the mound builders is a question that has been often asked. It is generally conceded that they were a race who once inhabited the United States but were supplanted by the present race of American Indians, who now know nothing of them. Recent investigations, however, are convincing, and the best informed now believe that they were but the forefathers of present races, and that by changes in mortuary customs, and moving about from place to place, they are unable even to maintain traditions of their ancestors. The mounds were but the burial places of the dead, the largest ones not necessarily indicating a great chief, for more than one skeleton is often found in the same mound. There is a tradition among the Omahas, Ponkas, Osages and Kansas, that many hundred years ago, their tribes and several other cognate tribes traveled down the Ohio river to its mouth and separated on reaching the Mississippi, and that some went up the river and some went down. The above named tribes were the ones that went up the Mississippi. At the mouth of the Osage river, the Kansas separated, and the Omahas, Ponkas and Iowas proceeded by degrees through Missouri, Iowa and Minnesota till they reached the neighborhood of the Red Pipestone quarry; thence they journeyed toward the Big Sioux river, where they made a fort. They remained in that country a long time. Game abounded. By and by the Dakotas made war upon the three tribes and many Omahas were killed by them, so at last the three tribes went west and southwest to a lake near the head of Choteau creek, now known as lake Andes, there they cut the sacred pole. It is claimed by the Omahas that it is two hundred years since the sacred pole was cut. Tradition also says that they built dirt lodges wherever they went, and lived in them. In vain have I searched for any evidence of dirt lodges. There are no traces of them in this locality, and it is quite plain to my mind that there never were any. The earthworks above described may be the fort alluded to in the story; it was undoubtedly the work of the same people who lived in the village, and built the mounds, and built the fort at the same time.

Several years ago I examined the ancient diggings at the great Red Pipestone quarry, also at subsequent times have noticed that the accumulation of vegetable mould in the pits as well as on the rubbish heaps, denote great age; the sod and vegetable mould is of the same thickness as that which covers the mounds in the village.

The picture writing cut into the smooth weather-worn surface of overlying quartzite at the great Red Pipestone quarry exhibits many curious and grotesque forms among which can be traced the turtle, fox, skunk and bear of which tradition tells us nothing, nor can any of the present races of Indians enlighten us upon that subject. The peculiar dry moss that grows so slowly upon smooth rock surfaces which has so persistently spread itself over and upon these picture writings, would undoubtedly require the same lapse of time that it would require to form the vegetable mould upon the mounds, in the pits and on the rubbish heaps.

Whatever and whoever these people were, that quarried the pipestone, made the pictures on the rocks, built the mounds and made the fort, I am unable to say; but I do believe it was all done by one class of people at about the same time, and that they were the mound builders from the Ohio or their kindred tribes.

MOUND EXCAVATIONS.

I opened one mound which was forty-five feet in diameter and four feet high, composed of coarse gravel and clay; after removing the south half, came upon a human skeleton six feet two inches in length, in a good state of preservation. This body was buried face upward, full length stretched out, feet pointing about twelve degrees east of south; head was raised about three inches higher than feet; hands were placed over abdomen, so that the bones of right thumb dropped between second and third vertebræ of the spine. A necklace of light blue glass beads was around the neck, so thoroughly decomposed that but three of them were taken out entire. I was able to save the whole skeleton except a few bones of the feet. The skeleton was seven feet east from center of mound, and was evidently a male of about forty-five years of age. A few ashes to the left of the body, some broken pottery and some animal bones notably of the buffalo and wolf, were all the mound contained.

Another mound contained a skeleton, face upward stretched out at full length, feet pointing south forty-five degrees east. The skull was near the center of mound and was well preserved; most of the other bones were badly decayed. One stone hammer a few pieces of broken pottery and ashes were found.

I opened a mound fifty feet in diameter, six feet high, and found after working one whole day with team, plow and scraper, one stone hammer, broken pottery, numerous indications of fire-places, and ashes and animal bones.

Another which was sixty feet across and five feet high, had been opened partially in 1886, and one full length skeleton removed and sent to Clinton, Iowa. I found on more full excavation at different depths, from two to four feet from top of mound, parts of several skeletons of both male and female and children, also bones and teeth of animals, clam shells, vertebræ of fishes, small copper serpent, [Fig. 11, Pl. VII.] ceremonial stone [Fig. 12], and hair beads.

In another mound copper bracelets encircled the ulna and radius of the left arm of probably a full grown female; also copper beads around the neck.

There is no evidence of cannibalism in any of the mounds opened; neither are there any indications of cremation. Some of the mounds contain decayed bark which had been used to cover the body at time of burial. A list of some of the articles found either on the village site, or in the mounds is as follows: Three stone axes, three celts, two buffing stones made of coarse sand-stone, two ground sand-stone arrow shaft straighteners, three pipes made of catlinite; two copper serpents; thirteen copper beads; one copper bracelet; one bead of catlinite; one bead from shell; four bone hair beads; one pipestone slab on which is engraved a bird; several small grooved stones for war clubs; a great number of grinding stones and stone hammers; fragments of pottery; one bone stilleto; one iron knife; five cut stones called nut holders; one pair grooved sandstone, use not determined.

MORTUARY CUSTOMS AND RELIGIOUS WORSHIP.

But very few relics are ever found in the mounds or otherwise to denote religious worship, and in this respect the village has yielded up more than an average amount, and after careful examination of the mounds and other evidences we would be justified in arriving at the conclusion that these people were sun worshippers. There has been so many hundred mounds opened in the United States and skeletons found facing the east, the south and the west, and never to the north; some buried sitting and some at full length.

The theory I would advance is that at the hour of the day when the body was placed for burial, should the person be raised to his feet he would face the sun; thus, if burial took place in the morning, the person must face the east, and if at eleven o'clock, as was undoubtedly the case with the full length skeleton, then the person being brought to his feet would face the sun, a few degrees east of south, and the recurring days and seasons would bring the sun to occupy the same position in the heavens on that day when the body should be called forth to meet the great giver of life and warmth to receive its new lease of life.

The lodges in the village seem to be in groups. Probably families or "gens" thus arranged themselves and whenever a death occurred in a family after the body was prepared for burial, a place was selected but a few feet from the lodge, and the body placed upon the ground; a fire was built beside the body over which was cooked the feast, which was to be partaken of by the friends and relatives of the deceased during the long ceremony which was to follow. The mound was built by casting earth upon the body, covering it, and the fire, and the remainder of the feast, and such implements as were the favorite of the individual who died. When the ceremony was over the mound would be round and oval on top, when another member of the same family died, the body would be placed on top of the same mound, or to one side and ceremony repeated as before. Several persons might be buried in the same mound at the same time, as in battle, since parts of fifteen skeletons were found in one small mound. All Indian tribes have many religious rites or ceremonies commonly called dances, and in conferring the several medicine degrees, the different medicine stones [see Fig. 9] and ceremonial stones [Figs. 3 and 12] would all come of use in driving out evil spirits which are supposed to exist in the body of deceased persons.

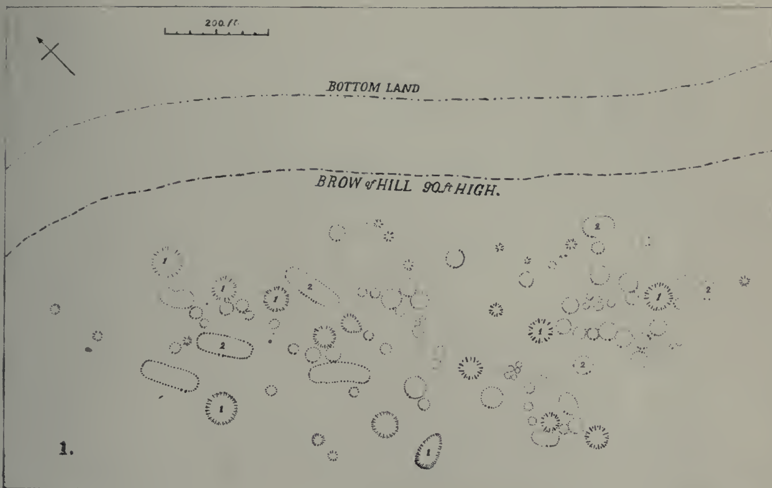
PIPES.

The discoidal pipes of peculiar pattern are made of catlinite. The village has furnished three, and there is but one other so far known, and that was found in Kentucky. A cast may be seen of it at the National Museum in Washington. Figure 10 will represent the largest one of the three, and may be regarded as the "peace pipe" and the disk, or face of the pipe in which the stem was inserted, as emblematic of the sun.

COPPER SERPENTS.

The two copper serpents found in the mound on the ridge to the northwest of the village; the third spadeful of earth brought the larger one to the surface; the other was two feet from the top of mound. Figure 11.

Before the advent of the whites the Indians knew nothing about smelting or fusing metals, and all copper implements, and ornaments were pounded out. The smaller serpent three and one half inches long, was first made into a sheet and rolled up, then bent. The larger one, seven inches in length, was a wire drawn out and bent to represent a moving serpent, about one eighth of an inch at one end bent around to represent a head. In looking upon this simple emblem which cannot be made of any use in supplying the necessities of life, we must search further for the meaning of it, as we know that among savages, every article has its useful purpose, and the natural conclusion is, that unless intended for utility or ornament, they must be connected with some form of religious worship. Can it be that they regarded the serpent as emblematic of one of the deities? If so then we must look for some simple natural cause, the most probable of which would be a comparison of the wriggling motion of the serpent to the zigzag appearance of the lightning, thereby accepting the



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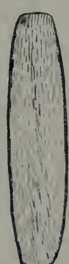

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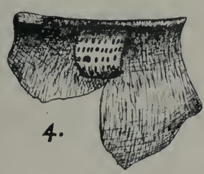

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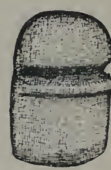

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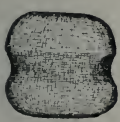

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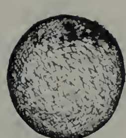

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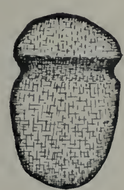

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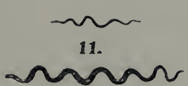

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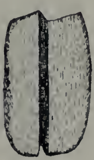

13.

15.

10.

1 ft.

serpent as a Totem of the god of rain. This is matter of speculation, but would not seem to be altogether unreasonable, when we take into consideration the mythology of all other barbarous tribes.

The people of this silent city were peaceful and depended largely upon agricultural pursuits for a livelihood; selecting their location for a village with a view to natural barriers, placing their sentinels on the commanding places on the top of bluffs, and building a fort for a place of last resort, when forced to retreat by the enemy. The great quantity of grinding stones and stone hammers found upon the ground would all tend to show that they were not a war-like people. The villages being located on high ground so far from water, it was necessary to have some means of carrying water, which was done in earthen vessels. These vessels were of so frail a nature, and were so frequently broken, that it is quite probable, the majority of the women of the tribe were well up in the ceramaic art.

Fragments of pottery are found everywhere, but no whole vessels; the fragments show that the clay was mixed with coarse sand or pounded shells and dried in the sun. Some pieces exhibit cord markings; other pieces were ornamented with a sharp stick or bone, and is not unlike Indian pottery generally.

Much more could be said about this Indian village, a minute description of the various excavations having been omitted. It is hoped, that as years roll by, enough light will be shed upon the past, to give us a clearer conception of the origin of these as well as other tribes of American Indians.

THE GROWTH-PERIODICITY OF THE POTATO TUBER.—

Conway MacMillan.

While a vast amount of research has been expended upon the physiology of tubers, bulbs, corms and fleshy roots, it is not clear that any extended observations have ever been made upon the method of growth of such an organ as the potato tuber. It is a well known fact that the growth in length of upright stems and various aerial organs is not regular, but exhibits a marked daily periodicity, the time of greatest average growth being not far from three o'clock in the morning, and most stems show a clearly marked diurnal period, unless this period is modified or obliterated by etiolation, suffocation, anæsthesia, or some other abnormal condition. Upon this subject since the researches of Baranetski and Pfeffer much attention has been bestowed, and we know that besides the daily periodicity there is a grand period of growth for each organ of the plant, that some organs reach the grand period of growth more rapidly or continue in it longer proportionately than other organs or similar organs in other species or in the same species under different outward conditions. The growth in length of any organ therefore is not regular, but it is to be graphically represented as a wavy curve with an ascending portion, a climacteric portion and a descending portion. In all of the parts of this great area, the climax of which represents the grand period of growth, one must notice the rhythmic pulsations due to the daily growth period, and more or less synchronous with the alternating periods of light and darkness, of higher and lower temperature, of less and of greater oxidation.

Seasonal rhythms in the growth of girth of organs is well known in the ordinary woody stems of Dicotyledons and Gymnosperms when the increasing tensions of later months reduce the rate of growth below the rate of the earlier months. This periodicity is a more simple and readily explained form than those periodicities which have been alluded to. It is found principally in organs provided with a cambium cylinder and a relatively inextensible bark and is referred to merely by way of illustration. While the potato tuber which is to be considered has a cambium area, it can scarcely be said to have a cortical area at all analogous to that of the erect tree trunk. We shall not find the tuber, protected as it is, and growing during a single season, affected by the conditions of alternate freezing and thawing, wind-disturbing, and so forth, which have so much to do with seasonal periodicity of growth in girth of woody stems.

A few months ago the writer was struck with the entire absence of investigations into the manner of growth of tubers, and gave more attention, forthwith, to devising a method by which the gap in our knowledge of tuber-physiology might be filled, in part. After due deliberation a method was formulated and applied, with but imperfect results at first; but as experience became wider the imperfections were gradually remedied. In all of the experiments Mr. C. P. Lommen, student in biology, at the University of Minnesota, gave much assistance in setting up apparatus, and by two or three helpful suggestions concerning certain technical difficulties which presented themselves in the course of our investigations. The method of research first adopted by us is described somewhat in detail in the *Botanical Gazette,* May, 1891; but upon this method certain improvements have been made. The apparatus used was the Baranetski self-registering auxanometer with electric-clock attachment, manufactured by Albrecht of Tubingen. At first both wheels of the apparatus were not employed but afterwards it was found that the two wheels could be combined in such a way as to multiply the tracings tenfold, and in our later experiments the wheel attached to the tuber-thread does not bear the tracing-needle but carries another thread on its large circumference which runs to the small circumference of the tracing-wheel. By this means hourly registrations were obtained instead of three-hour registrations as by the first method.

To recapitulate the method finally adopted as developed: A potato plant grown in a box from which one end had been removed was selected and carried to the experimenting room. With due care a tuber was exposed, and under it, resting upon the bottom of the box, a wooden block was placed in such a way that downward pressure would not disturb the position of the tuber. The rootstock umbilicus was protected from desiccation or injury during these processes of blocking up. Next a wooden-jacket consisting of two squares of cigar box material held together by a number of slightly stretched rubber bands was fitted over the tuber, in such a way that one square of the cigar box wood lay upon the block below and the other was parallel with it, but on the opposite side of the tuber. To the center of this upper square a screw was fixed and to this screw a silver wire was tied—since thread was rotted by the soil—and this wire after the whole apparatus of block and jacket was covered with soil, came to the surface of the soil under the first wheel of the auxanometer. An inch or two above the ground a twisted linen thread which gave better friction on the wheel was attached to the silver wire, and this twisted thread was passed over the small circumference of the first wheel and drawn taut by a weight of about forty grams. Passing from the large circumference of the first wheel to the small circumference of the second was a linen thread equally weighted at each end and over the large circumference of the second wheel was passed the thread bearing the tracing needle at one end and a small counterpoise at the other. The tracing needle was brought up against the smoked cylinder of the registering apparatus. This rested upon a clock-work in which a rachet-wheel was caught by a lever attached by a spring and bearing at the opposite end an armature near the poles of a small electro-magnet. Connected with the electro-magnet was a battery, but interpolated in the circuit was the electric clock so adjusted that every hour the circuit was closed for a few seconds. During the closure of the circuit the electro-magnet attracted the armature, overcoming the tension of the spring and releasing one cog of the ratchet wheel. By this means the cylinder attached to the clock-work turned about 1-16 of an inch, with the hands of the watch, and the tracing needle made a horizontal mark upon the smoked paper covering the cylinder. The opening of the circuit as the hands passed the hour released the armature, allowed the spring to push back the lever and stopped the cylinder clock-work until the next hour when a similar horizontal mark was made. During the hours, then, any expansion in the potato-tuber would loosen the string attached to the jacket. Pulling against this the weights would turn the first wheel. This would turn the second wheel and the indication of growth 100 times magnified, but in proper ratio would appear as vertical tracings upon the smoked cylinder. This brief description of the Baranetski apparatus is given that the exact method of research may be apparent.

The first experiments upon the growing tuber, made in accordance with the method described in the *Botanical Gazette*, were satisfactory in so far that they demonstrated the availability of the Baranetski apparatus for the purpose for which it was employed. In one of the early experiments a trace of periodic growth was distinguished, but it did not seem to be sufficient to base any confident assertion of periodicity upon. The first experiment continued two weeks. During this time the needle kept falling and at the close of the experiment was about half an inch below the level of the beginning. In the second experiment certain drops in the tracings, usually in the early morning, were noticed, but I have come to believe that these were not true growth-tracings but due to changes in temperature of the soil, the strings and the atmosphere with consequent shortenings and expansions. Against such accidental and confusing records as these it was constantly necessary to guard. In general the conclusions from experiments with the single wheel were conservatively stated as follows:

(a) The apparatus as set up indicates growth, by cylinder tracings.

(b) A possible trace of periodicity in the growth might have manifested itself.

Further than this we did not feel at liberty to go, under the conditions of the experiment.

Desiring to obtain more perfect results and to solve the question of the manner of growth of the tuber, the improved method of setting of the apparatus described above was developed, and the first experiment gave very favorable and luminous results.

The experiment began with a tuber about ¾ inch in diameter. At this time the top of the plant had begun to die from the attack of a blight. After attachment the registering needle gave two or three sharp drops owing to the stretching of strings and general getting-into-equilibrium of the apparatus. After this stage was passed the needle began dropping very gradually. This gradual descent was continued from 8 o'clock in the evening until about 8 o'clock in the morning. At this time the drop ceased and horizontal tracings continued until about 1:30 p. m., when a short abrupt drop was registered, followed by a longer drop, then by one shorter than the second but longer than the first, next by one longer than any, closely succeeded by another long one. After this the registrations were short and the regular gradual fall until 8 a. m. began. Here again the horizontal mark began and continued until 2 p. m., when a second drop began, on a somewhat smaller scale than the one registered the first day. The total extent of the second day's maximum between 2 p. m. and 8 p. m., was about one-half that of the first day's maximum. The third day the same tracings continued—only the tracings of the maximum were very much reduced—not more than one-quarter, in total length, of the second day's tracings. The fourth day's tracings were like those of the second day in all particulars, and those of the fifth day likewise, except that the tracings showed a less maximum growth. The sixth day was peculiar. During this day no appreciable drop in the tracings was detected. The explanation of this cessation is not offered. It may be said, however, that the death of the top was now about complete so far as the leaves and secondary branches were concerned. Only in the lower part of the main stem was living, green tissue still to be found. During the whole twenty-four hours little divergence of the tracings from the horizontal could be seen, but during the succeeding twelve hours a slight drop began. At 7 a. m. of the seventh day a decided drop began continuing until 11 a. m. There then succeeded a period of gradual dropping which disappeared about 3 p. m. Another drop took place in the evening from 6 to 9 p. m. The eighth day began with a drop at 7. a. m., continuing until 11, when three hours of horizontal marks followed. At 2 p. m. a five-hour drop began, and continued as a gradual depression, until 10 a. m. At 7 a. m. another abrupt drop took place, terminating at 11:30 a. m. At 3 p. m. a gradual drop lasting until 8 p. m. followed. During succeeding days the same rhythm continued, only the drops became slighter and slighter. Finally the needle ceased to trace. The explanation of these very curious maxima and minima in the growth of the tuber is a complicated matter. It can be given as yet only conjecturally. Before passing to any such conjectures, it may be well to give the conclusions arrived at in the experiment described above:

(a) The increase in diameter of the potato-tuber is not regular but is rhythmic.

(b) Maxima of growth are not of long duration, and are followed by periods of slower growth or of entire absence of growth.

(c) Maxima of growth may occur either once or twice and perhaps oftener during twenty-four hours.

(d) The maxima of some days are greater absolute maxima than those of other days. This indicates a grand period for the tuber.

(e) Regular periodicity in the tuber continues after the periodicity of the aerial stem is lost.

(f) Connected with profound changes of condition in the aerial stem changes in the periodicity of the tuber may be noted.

(g) There is some connection between the periodic growth of the tuber and the periodic growth of the aerial stem. What this connection is does not appear.

(h) There is also, it is probable, an *independent* periodicity in the growth of the potato-tuber which is obscured and modified by the secondary *induced* periodicity which is connected with the aerial-stem conditions and mode of growth.

With reference now to the conjectural explanation of the periodic growth of the potato-tuber, very little can be expected at this stage of the investigation. Whether like embryonic plants of *Hedera,* with their heliotropic irritability, the potato-tuber retains somehow, in hereditary fashion, its above-ground periodicity and thus gives hint of the time when its precursors were exposed to rhythmic alternation of light and darkness, is entirely an open question. On the other hand it is equally uncertain whether the induced periodicity is due to one or many causes. Some of the lines of research are indicated below and it is hoped that they will be followed to their rational conclusion.

(1) The rhythm of assimilation in the above-ground stem may affect the growth of the below-ground tuber. The synthesis of carbohydrates is a diurnal affair. From these carbohydrates the substance of the tuber is formed. Thus the rhythm above might induce a rhythm below.

(2) The conversion of plastic materials into reserve materials is characteristic of an organ like the tuber. This conversion depends upon the activity of certain ferments which are results of destructive and constructive metabolic changes in the shoot-area. These metabolic changes are connected with the respiration-function and this is a periodic or rhythmic function.

(3) The growth of the above-ground stem is strongly periodic and demands, in any plant, the same kind of material which would be supplied to a growing tuber. This drain upon the plastic-material in one direction might induce a corresponding dearth of it in another so that the periodic growth of the above-ground stem might induce a periodic growth in the below-ground tuber.

(4) The asynchronous grand-periods of growth of the different above-ground organs might be reflected in an irregular and erratic periodicity in the below-ground tuber.

(5) Combinations of these various conditions and a modification of them all by the independent rhythm of the tuber itself would have to be considered, and only by the most elaborate and extended researches could the proximate causes for the observed tuber-periodicity be detected.

In closing this contribution to the physiology of tubers one word by way of note may be added. It is possible to apply auxanometer methods to root-stocks by uncovering the root-stock attaching a silver thread, running it horizontally to the open side of the box passing over a horizontal roller and upward and finally adding the linen (or silken) thread which runs on the small circumference of the first wheel. Or in this case one wheel alone could doubtless be used. This study of underground stems, as in the grass root-stock, the potato rhizome or any other underground stem, would throw some light upon the tuber and its method of growth. A comparison of underground organs should be made along this line.

May 5, 1891.

PRELIMINARY NOTES ON THE EPINASTY AND HYPONASTY OF RAPHAINUS COTYLEDONS.—*E. P. Sheldon.*

In presenting this evening some of the phases of our present knowledge regarding the various positions assumed by dorsiventral organs during their period of growth and development, I think I can do little better than to give a short outline of the views held by prominent botanists on this point, and follow somewhat the course of development of such views as outlined by Sydney H. Vines, in his article on Epinasty and Hyponasty.*

First in importance are the views of De Vries.†

Here we have the first recognition of the fact that the growth of the two sides of a dorsiventral organ is not equal. There may be some growth on both sides of such an organ, but when the growth of the upper side preponderates over the growth of the lower organ it is said to be in a state of epinasty. When the reverse is true it is said to be in a state of hyponasty.

De Vries does not agree with Frank‡ in regard to the cause of the position of such members.

Instead of explaining their position by peculiar forms of geotropic and heliotropic irritability, he considers them as a resultant of the various forms of epinasty, hyponasty, and negative or positive heliotropism or geotropism. The observation of Sachs§ on

*Annals of Botany. Aug., 1889.

†De Vries: Arb. d. bot. Inst. in Würzburg, I, 1874.

‡Frank: Die natürliche wagerichte Richtung von Pflanzentheilen Leipzig, 1870.

§Sachs: Arb. d. bot. Inst. in Würzburg, II, 1879.

the thallus of *Marchantia* are directly in this line, and tend to uphold the position of De Vries. The observations of Darwin¶ have shown us that dorsiventral organs tend to place themselves at right angles to the direction of the light rays, and further that the phenomena of epinasty and hyponasty are to be considered as a modified form of circumnutation. One of the most important contributions to our knowledge of the subject is that of Detmer.**

By means of a series of observations in which dorsiventral organs were subject to varying intensities of illumination, Detmer comes to the conclusion that the position assumed by such are due not to the *photonic,* but to the *paratonic* action of light; and therefore instead of a condition of epinasty, it is in reality one of "photo-epinasty."

Coming now to the observations of Vines†† we find that he states the primary object of his experiments to be:

(1) "To ascertain whether epinasty and hyponasty are spontaneous movements, or are induced by light or other causes as stated by Detmer; and (2) whether the curvatures of dorsiventral members which have hitherto been ascribed to negative geotropism, are or are not due to this cause." He repeats the experiments of Detmer with the cotyledons of *Cucurbita* seedlings and with the primordial leaves of *Phaseolus,* and comes to the conclusion that "the effect of light is not '*paratonic,*' as Detmer would have it to be, but it is '*phototonic;*'" or in other words, that epinastic growth can take place in darkness.

It will be noted that these conclusions render the term "photo-epinasty" of Detmer useless.

To further establish his position, Vines notices that in seedlings of *Helianthus, Dahlia, Fuchsia,* and *Urtica,* epinasty is stimulated by the absence of light rather than bv its presence.

Continuing his experiments with *Plantago media* and *Taraxacum officinale,* he finds that specimens of these plants kept in darkness for 72 hours become decidedly hyponastic, and this happens whether the plant was placed in its normal position, or rotated on the clinostat. From this he comes to his second conclusion viz: that "Dorsiventral members are not negatively geo-

¶F. Darwin: Journal Linnean Society, XVIII, London, 1881. See also "Movements of Plants," 1880.

**Detmer: Bot. Zeitg, 1882.

††Vines, l. c.

tropic." Early last spring Professor MacMillan of the University brought a plant of *Solanum tuberosum* from the greenhouse and placed it upon a desk in his lecture room. The plant while in the greenhouse was under the influence of strong illumination. In the lecture room it had only diffuse light. In the course of 24 hours a remarkable change took place in the position of the leaves. Instead of being horizontal or slightly epinastic as they were under normal conditions, they were curled downwards so that the tips touched the stem. At the same time transverse epinastic curvatures had taken place.††

This seemed to show that the absence of light of a certain degree of intensity tends to promote epinastic curvatures. It was a realization of this peculiar state of our knowledge regarding epinasty and hyponasty that led Professor MacMillan to suggest to me the advisability of selecting some normally epinastic dorsiventral organ and subjecting it to varying degrees of intensity of light, as well as to varying intensities of light from different directions. Not only was a study of the action of light upon such an organ suggested, but also of all other natural conditions which might influence epinastic or hyponastic growth.

For this purpose the cotyledons of *Raphanus sativa* have been chosen. So far as I have been able to determine, no continuous observations have been made upon the epinastic and hyponastic curvatures of these normally epinastic organs.

The experiments were conducted in the University greenhouse, and the temperature in all cases was approximately the same, varying from a minimum of 60°-65° Fahr. by night, to a maximum of 75°-80° by day.

The seeds were planted Dec. 20th, in four-inch flower-pot saucers, and were constantly kept at the same degree of moisture. Before proceeding to a consideration of the phenomena observed it might be well to note in regard to the germinating seed of *Raphanus,* that in all cases when the cotyledons break from the seed-coats they are folded together, the lower and larger cotyledon always being strongly hyponastic, while the smaller and inner cotyledon is always strongly epinastic.

Two groups of cultures were made:

A. Those grown under normal conditions from the first.

B. Those grown under special conditions from the first.

††MacMillan: Botanical Gazette, Vol. xv, p. 121.

A.

NORMAL CONDITIONS.

For purposes of comparison let us first note the growth of the organs selected when exposed to ordinary conditions of strong illumination on a shelf in plant-house.

After 24 hours. Seeds swollen, but cotyledons not leaving seed coats so that no observations could be taken.

After 48 hours. Cotyledons have left the seed coat. The lower and larger are strongly hyponastic, fiwhile the inner and upper ares trongly epinastic. Slightly turned downward.

After 72 hours. Upper cotyledons slightly hyponastic, both now being curved outwards: *i. e.* both hyponastic. Not separated.

After 96 hours. Cotyledons separated, owing to the epinastic curvature of the hypocotyls. Strongly epinastic, upright.

After 120 hours. Cotyledons epinastic, separated. Plants 1 inch high.

It is interesting to note with regard to these that if one observes them early in the morning they are nearly always slightly hyponastic, especially if the weather is dark or cloudy. Later in the day, (*i. e.* 9 to 10 o'clock) they are found to be epinastic. The organs with which we have to do are evidently very irritable.

B.

SPECIAL CONDITIONS.

The special conditions may now be followed in the order of experimentation.

1. *Diffuse daylight.*—This was secured by selecting a convenient place under the shelves of the plant-house, sheltered from the rays of the sun and the reflection from the glass roof.

After 48 hours. The same phenomena are to be noted as in A, but less vigorous; cotyledons less opened, turned downward.

After 72 hours. Curvature less than in A. Cotyledons parallel, turned downward.

After 92 hours. Cotyledons most of them upright and parallel. The upper has overcome its epinasty and become slightly hyponastic, while the lower is still slightly hyponastic. Sometimes slightly epinastic, often straight.

After 96 hours. Cotyledons hyponastic. Not separated.

After 120 hours. Cotyledons hyponastic. Not separated.

After 144 hours. Cotyledons hyponastic. Separated

After 168 hours. Cotyledons hyponastic. Unchanged.

2. *Total Darkness.*—Using boxes placed one within the other

and lined with tin and tar felt, so as to preclude all possibility of the entrance of light.

After 48 hours. Same curvatures as in A, but cotyledons not opened as much. Strongly etiolated.

After 72 hours. Cotyledons hyponastic. Not separated, turned downwards.

After 92 hours. Cotyledons hyponastic, upright. Not separated.

After 96 hours. Cotyledons hyponastic. Slightly separating.

After 116 hours. Cotyledons strongly hyponastic. Slightly separating.

After 140 hours. Cotyledons strongly hyponastic. Unchanged.

3. *Faint illumination.*—Made by placing the saucers under square frames, covered with shades of cloth.

After 48 hours. Cotyledons separating (opening) upper epinastic, lower hyponastic, turned downwards.

After 72 hours. Upper cotyledons epinastic, lower hyponastic. The tendency is toward parallelism of the cotyledons.

After 96 hours. Cotyledons hyponastic. As compared with No. 1, (Diffuse light) they are more so at this age.

After 120 hours. Cotyledons hyponastic. Not separating.

After 144 hours. Cotyledons hyponastic. Not separating.

After 168 hours. Cotyledons hyponastic. Separating. Upper cotyledon with shorter pedicel, lower with longer.

After 192 hours. Cotyledons hyponastic. Separating.

4. *Illumination from the side.*—Produced by placing saucers at the back of low boxes with one side wanting, and exposing open side toward strongest light direction, *i. e.*, the path of the sun. In this manner we get light coming mainly from the one direction, and by placing the seedlings so that illumination may be directed toward the side of the cotyledons we may study this condition. Light here is necessarily somewhat diffuse. By arranging a mirror strong illumination may be secured.

After 48 hours. Upper cotyledons epinastic, lower hyponastic.

After 72 hours. Cotyledons turned downward. Upper epinastic, lower hyponastic. It is to be noted that the upper cotyledons are presented toward the direction of the incident light rays.

Three saucersful placed in opposite direction, *i. e.*, with lower cotyledons toward light direction.

After 96 hours. The result has been that those so placed have turned around, and persist in presenting their upper cotyledons toward the light. Cotyledons hyponastic.

After 120 hours. Those turned yesterday so as to have side illumination, have turned around and persist in presenting their faces to the incident light rays. Hyponastic.

5. *Strong illumination from end* (*toward notch between cotyledons*). Planted under same conditions as No. 4.

After 48 hours. Upper cotyledons epinastic, lower hyponastic.

After 72 hours. Same as No. 4. A number of plants so placed as to throw direction of light rays toward notch between cotyledons.

After 96 hours. Cotyledons hyponastic. Those placed so as to throw illumination toward notch between cotyledons have closed. More may now be so placed.

After 120 hours. Cotyledons all strongly hyponastic. Separating, owing to the epinastic curvature of the hypocotyls. They have all turned so that the light is directed toward the notch.

6. Exposed for 12 hours to total darkness, 6 to strong illumination, 18 to total darkness, and 12 to diffuse daylight, (repeat.)

These were planted Dec. 20th, 6 p. m.

After 12 hours. Put in strong illumination.

After 18 hours. Put in dark. Germinating.

After 36 hours. Put in diffuse light.

After 48 hours. Put in dark. Same phenomena of curvature as in A.

After 60 hours. Put in strong illumination. Upper cotyledons epinastic, lower hyponastic.

After 66 hours. Put in dark. Cotyledons strongly epinastic. In many cases they are parallel. The epinasty of the upper cotyledon being lessened, with tendency toward hyponastic curvature. The upper cotyledon does not become hyponastic, but does become less epinastic until the lower cotyledon overcomes its hyponastic curvature.

After 84 hours. Put in diffuse light. Cotyledons hyponastic, upright, separating, owing doubtless to the epinastic curvature of the hypocotyls.

After 96 hours. Put in dark. Cotyledons hyponastic, but less so than 12 hours ago.

After 108 hours. Put in strong illumination. Cotyledons hyponastic.

After 114 hours. Put in dark. Cotyledons hyponastic, but less so than 6 hours ago.

After 132 hours. Put in diffuse light. Cotyledons epinastic.

After 144 hours. Put in dark. Cotyledons present a very peculiar appearance. They are still slightly epinastic, but the edges are curled upwards, showing tendency toward hyponasty.

After 156 hours. Put in strong illumination. Cotyledons epinastic with edges curled upward.

After 162 hours. Cotyledons epinastic, with edges not curled upwards.

The plants were now put in total darkness, and kept in this condition for ten days. Observations were made at 12 M. on each day, but in all cases they were strongly epinastic. Some of these were repeatedly exposed first to light then to darkness, but this produced no further curvatures.

7. Exposed for 12 hours to dark, 12 hours to diffuse light, 18 to dark, 6 to strong light, 12 to dark, 6 to strong light, 6 to diffuse light, 12 to dark, 6 to diffuse light, 18 to dark, and 12 to strong light. (*Repeat*). These also were planted Dec. 20th, 6 p. m.

After 12 hours. Put in diffuse light. Seeds swollen and sending out roots, but not opened enough to see different curvatures. This seems to be the most favorable condition for germination.

After 24 hours. Put in dark.

After 42 hours. Put in strong illumination. Upper cotyledons epinastic, lower hyponastic.

After 48 hours. Put in dark.

After 60 hours. Put in strong illumination. Cotyledons barely opened, showing no tendency to curvature which might separate the cotyledons.

After 66 hours. Put in diffuse light. Cotyledons separated. The epinasty of the upper has become less apparent, as has the hyponasty of the lower, turned downwards.

After 72 hours. Put in dark.

After 84 hours. Put in diffuse light. Cotyledons slightly epinastic, upright.

After 90 hours. Put in dark. Cotyledons hyponastic. Not separated.

After 108 hours. Put in strong illumination. Cotyledons hyponastic. Not separated.

After 114 hours. Cotyledons hyponastic, but less so than 6 hours ago. Not separating.

After 120 hours. Put in dark. Cotyledons slightly epinastic. Separating.

After 132 hours. Put in diffuse light. Cotyledons epinastic. Separated.

After 144 hours. Put in dark. Epinastic.

After 162 hours. Put in strong illumination. Cotyledons slightly hyponastic.

After 168 hours. Put in dark. Cotyledons hyponastic but less so than 6 hours ago.

After 180 hours. Put in strong illumination. Cotyledons slightly hyponastic.

After 186 hours. Cotyledons epinastic.

To summarize these results we find that the cotyledons of *Raphanus sativa* are always epinastic when grown under normal conditions of light, temperature and moisture. Considering the temperature and moisture the same in all cases, we find in respect to these organs, that when grown under a condition of total darkness, diffuse or faint light, they are always hyponastic. When grown in total darkness the cotyledons are very sensitive to the influence of light.

In the case of one trayful, 72 hours old, which was exposed to diffuse light while taking notes, the cotyledons curved perceptibly, so that they were but slightly hyponastic. It is to be noted also that after 96 HOURS in the dark, epinastic curvature of the hypocotyls took place, thereby separating the cotyledons.

The illumination in the case of the light coming from only one direction must be toward the notch between the cotyledons.

Before the cotyledons are 96 hours old, however, they will close if illumination is directed toward the notch. This may be assigned to hyponastic curvature of the hypocotyls.

It might seem as if this is a wise protection for the tender epicotyl. With this is to be correlated the fact that in total darkness a certain period of time elapses before epinastic curvature of the hypocotyl takes place.

When we consider the cultures in which the organs under consideration were exposed to varying conditions, as in Nos. 6 and 7, we find that a broad field of investigation opens out before us. Let us first look carefully at No. 6.

After 66 hours we find that by 18 hours exposure to total darkness the cotyledons become changed from a strongly epinastic to a hyponastic condition. This seems to show that the absence of light in this case is favorable to a hyponastic position.

After 108 hours, the cotyledons being at that time hyponastic, they were placed in strong illumination for 6 hours. At the end of this period they were placed in dark for 12 hours, then in diffuse light. Not until this latter change took place did the cotyledons show any marked epinastic curvature. This, and the peculiar appearance of the cotyledons in the two succeeding states have led me to think that we have here a manifestation of a latent period of growth with respect to epinastic curvature. It is peculiar that when this epinastic condition was obtained the absence or presence of light should have no further effect on the cotyledons.

With respect to No. 7, it is only necessary to point to the difference in the results. In the latter we have without doubt a set of changes which instead of tending towards fixation of position, tend in exactly the opposite way, *i. e.* toward extreme irritability. It has now become apparent that what is needed is accurate permutations of these conditions, varying the time to secure results which explain the phenomena noted in this paper.

That the influence of light upon dorsiventral organs which produces epinastic or hyponastic growth is dependent on the intensity of light-vibrations is beyond a doubt. To determine the intensity of vibrations required to produce a given curvature, and to solve some of the problems indicated by these notes is the object of further experiments being conducted at the University. A series of permutations are now under way and an effort will be made to cover as much of the debated ground as possible.

February 3, 1891.

ARTESIAN WELLS IN NORTH AND SOUTH DAKOTA.—
By Warren Upham.

On the broad fertile plain called the Red river valley, which was the bed of the glacial lake Agassiz, many artesian wells have been obtained within the thick drift sheet, deriving their supply of water from porous beds or veins of sand and gravel beneath and frequently between deposits of bowlder clay or till. The depths of these wells vary from 40 to about 250 feet, and the height to which the water is capable of rising is often only a few feet and seldom more than 25 to 50 feet. Hundreds of these flowing wells, commonly one to two inches in diameter of pipe, are in use on farms, at grain elevators, and for the supply of towns, on both the Minnesota and North Dakota sides of the Red river. Some tracts of considerable area, however, fail to find artesian water, but even these generally encounter water-bearing layers at depths corresponding with those of the artesian wells, from which water rises nearly to the surface.

The narrow areas that may be sometimes occupied by the sand and gravel layers yielding artesian water, or the thin and in some places entirely deficient condition of these layers, is illustrated by the different depths at which a flow of water was first encountered by four wells in the village of Grandin, North Dakota. These wells are on an area only about 50 rods in extent, and their several depths are 105 feet, 158 feet, 187 feet, and 248 feet. Either the upper water-bearing beds here are narrow, like a stream course, so that they were not found by the deeper wells, or, if they exist as sheets of great width as well as length, they are in some parts thinned out, allowing the impervious till above to rest on that below. But in the direction from which the water supply is received, these gravel and sand veins or beds must have a great extent and descend from levels higher than the surface of the central part of the Red river valley, where the artesian wells are situated. At least this must be the case where the water is fresh or only very slightly saline, as at Grandin and in all the southern part of the valley as far northward as to the vicinity of Crookston in Minnesota, and Blanchard in North Dakota, and in a large district of Manitoba including Winnipeg and the Mennonite reserve east of the Red river.

North of Crookston and Blanchard to the international boundary, and in the south edge of Manitoba, the water of these wells, almost without exception, is distinctly saline and alkaline. It seems very probable that the water-bearing beds of that large portion of the Red river valley differ widely in the origin of their water supply from the foregoing. Instead of deriving their water, like the fresh artesian wells, from the rainfall upon higher parts of the drift surface contiguous to the Red river valley, there seems to be good reason for believing that the brackish water is mainly from the basal sandstone of the Cretaceous series, coming through that sandstone from its outcrops on the flanks of the Rocky mountains and Black hills, and permeating upward into the drift of the Red river valley from areas where this sandstone is the underlying bed-rock.

Deep artesian wells of somewhat saline and alkaline water, like that of the part of the Red river valley just described, are obtained on a belt that extends across North and South Dakota from Devil's lake to Yankton and Vermillion, including the greater part of the James river basin. Wherever borings along this belt have penetrated to the Dakota sandstone, the lowest formation of the Cretaceous series in the upper Missouri region, artesian water has been found. Probably as many as a hundred wells have been bored, their depths ranging from 900 to 1,550 feet, except in the southern part of the James and Vermillion valleys, where many wells are only 600 to 750 feet deep, and a few, the farthest southeast, are between 300 and 400 feet in depth. These wells are mostly five or six inches in diameter, and their strong pressure, commonly from 50 to 175 pounds per square inch at the surface, makes them valuable not only for fire-hydrants, but also to furnish power for manufacturing purposes. Several wells have been bored at Aberdeen, and three years ago, in 1887, fifteen wells were in use in Yankton. The pressure of the wells in Yankton is sufficient to raise the water 129 feet, and in numerous places along the middle portion of the James river valley, as Huron, Redfield and Aberdeen, the pressure corresponds to a rise of more than 400 feet above the surface.

The sections of these deep wells in North Dakota and on the high land between the James and Missouri rivers in South Dakota, include, beneath the drift, the Fort Pierre, Niobrara, and Fort Benton divisions of the Cretaceous series; but along the lower part of the James river and on the Vermillion erosion during the Tertiary era removed the upper portion of these beds, leaving only the Fort Benton shales or a part of that formation over the Dakota sandstone.

At Devil's lake, where an artesian well was bored last year, about six feet above the depot, or 1,470 feet above the sea, the section was as follows:

Section of well at Devil's Lake.

Glacial drift, till as on the surface................	25 feet.
Dark shale, nearly alike through its whole thickness, including the Fort Pierre and Fort Benton formations, with no noticeable calcareous beds at the intermediate Niobrara horizon................	1,403 feet.
Gravel, of granitic pebbles up to a half inch in diameter, firmly cemented with nodular pyrite.......	3 feet.
Dakota sandstone, or rather a bed of lose sand, very fine, white or light gray, the base of which was not reached..............................	80 feet.
Total	1,511 feet.

From the sandstone, at the depth of 1,470 feet, artesian water came up with a rush, but sand soon filled the pipe so that the supply became small. It is from this level that the present flow comes, through narrow slits cut in the pipe. The boring was continued forty feet deeper, but no such strong flow was obtained below. In July, 1889, when the well was completed, it supplied 1,800 barrels of water in 24 hours, or about 40 gallons per minute, the diameter of the pipe being 8 inches, reduced to 3½ inches in the lower portion. The stream flowing away was then turbid with the exceedingly fine particles of sand brought up from the bottom.

The Jamestown well, bored in the winter of 1886-7, about eight feet below the depot, or 1,400 above the sea, went through a similar section of about 1,400 feet of shales, with no distinctly different portion to indicate the place of the Niobrara formation. The same nearly uniform section has also been found to a depth of 1,350 feet at Deloraine in Manitoba, close northwest of the Turtle mountain, as I am informed by Mr. J. B. Tyrrell, of the Geological Survey of Canada. At that depth, which was bored last year, there still lacked about 300 feet of reaching the sea level, from which the Devil's lake artesian water rises.

For the greater part of my notes of the artesian wells of South Dakota, also of Ellendale and Oakes, in North Dakota, I am indebted to *Resources of Dakota,* published by the territorial Commissioner of Immigration in 1887, and to recent correspondence with Prof. G. E. Culver, of the University of South Dakota, and with Prof. C. W. Hall, of the University of Minnesota. These data, with those obtained by me at Devil's lake and Jamestown, I have placed in tabular form for convenient comparison, showing (1 and 2) the distances of the localities north and west from the mouth of the Big Sioux river at the southeast corner of South Dakota; (3) depths of the wells; (4) their pressure at the surface, wherever it has been obtainable, in pounds per square inch; (5) the corresponding height or head to which the water would rise above the surface; (6) the altitude, with reference to the sea level, of the source of the artesian water in the Dakota sandstone; (7) the altitude of the surface; and (8) the height of the computed head of water above the sea.

Artesian wells deriving water from the Dakota sandstone in North and South Dakota.

LOCALITY.	Distances in miles on latitude and longitude from the South-east corner of South Dakota.		Depth in feet.	Pressure at surface in pounds per sq. inch.	Head in feet above surface computed from pressure.	Altitudes in feet above the sea.		
	North.	West.				Source of water in upper part of Dakota sandstone.	Surface, railroad at station.	Head computed from pressure.
Devil's Lake	390	119	1511			0	1464	
Jamestown	305	110	1476	95	219	−76	1408	1619
Oakes	252	80	944			378	1322	
Ellendale	243	101	1087	125	288	362	1449	1737
Britton	228	72	1004			350	1354	
Columbia	216	92	965	175	404	339	1304	1708
Andover	202	72	1070	90	208	406	1476	1684
Groton	204	82	960	187*	432	344	1304	1734
Aberdeen	206	101	908	175	404	392	1300	1704
Ipswich	204	127	1270	70	162	200	1530	1692
Mellette	186	101	900			400	1300	
Ashton	174	101	915	50*	115	381	1296	1411
Doland	167	81	950			405	1355	
Redfield	166	103	900	175	404	395	1295	1699
Faulkton	176	132	1210			363	1573	
Hitchcock	148	97	950	175	404	389	1339	1743
Huron	130	88	863	175	404	424	1287	1691
Miller	140	126	1148	125	283	439	1587	1875
Highmore	141	148	1552	25	58	338	1890	1948
Harold	141	163	1453			348	1801	
Woonsocket	108	91	750	153	353	558	1308	1661
Letcher	97	85	600			700	1300	
Mitchell	84	79	600			701	1301	
Plankinton	85	102	760			778	1523	
Kimball	87	126	1068			720	1788	
Vermillion	20	24	865	15	35	785	1150	1185
Meckling	23	31	338			818	1156	
Yankton	27	46	610	56	129	586	1196	1325
Tyndall	34	71	730			688	1418	
Ft Randall	38	106	600	4	104	660	1260†	1364

*The pressure reported at Ashton is 100 or 125 pounds less than would be expected in proportion with other localities; and at Groton it is somewhat more. The discrepancy of the latter, however, is no greater than may be due to superior permeability of the water-bearing stratum.

†Approximate altitude of high water of the Missouri river at Fort Randall.

The flow of water from the Dakota sandstone at Devil's lake is found exactly at the sea level, but the top of the sandstone formation is 39 feet higher. At Jamestown the flow rises from a depth of 76 feet below the sea level, indicating that the top of the Dakota sandstone there sinks slightly lower than at Devil's lake. Along the distance of eighty-five miles from north to south between these points, its level is probably nearly constant; and boring at intervening towns, as New Rockford and Carrington, will doubtless find artesian water at or slightly below the sea level. Farther south, the top of the sandstone and its water supply are found throughout a large district of South Dakota and the south edge of North Dakota, at a plane 250 to 450 feet above the sea. Continuing still southward, from Woonsocket to the Missouri river, the water-bearing stratum rises to altitudes from 558 feet to 818 feet above the sea, the highest levels being at Meckling and Vermillion, the most southeastern localities of this list.

The same southeastward ascent of the Dakota sandstone reaches to its outcrops on the southwest side of the Missouri in Dakota county, Nebraska, whence its name is derived, opposite to the southeast corner of South Dakota. There and at other extensive outcrops in western Iowa and eastern Nebraska, having approximately the same elevations as the surface at Vermillion and Yankton, the water coursing through this sandstone finds outlet in springs; and these avenues of discharge explain the gradual reduction of the altitude of the head of the water above the sea level, as the series of wells is followed from north to south and from west to east. Somewhat uniform altitudes of 1,619 to 1,743 feet are recorded as the heights to which water would rise in pipes for all the wells, where pressure is reported, from Jamestown to Huron and Woonsocket, excepting those west of Huron, which will be considered later, and the well at Ashton, where the reported pressure is probably erroneous, lacking 100 pounds or more of its true amount. At Hitchcock the head of water has a computed altitude of 1,743 feet above the sea; eighteen miles to the south, at Huron, it is 1,691 feet; twenty-two miles further south, at Woonsocket, it is 1,661 feet; and eighty miles still farther south, at Yankton, it is only 1,325 feet.

Equally distinct gradients of the plane of water head are found descending from west to east on and near the latitudes of Huron and Yankton. Thus at Highmore, sixty miles west of

Huron, the head is 1,948 feet above the sea; at Miller it has declined 73 feet in a distance of twenty-two miles to the east; and in the thirty-eight miles thence to Huron it falls 184 feet more. Between Fort Randall and Yankton, in a distance of sixty miles from west to east, this plane descends at least forty feet, but the descent is more if the well at Fort Randall is at a considerable height above the Missouri river. In the next twenty-two miles eastward to Vermillion the descent is 140 feet. This feature of the artesian water supply is caused, as before stated, by its outlets through springs in outcrops of the Dakota sandstone, which begin thirty to forty miles southeast of Vermillion and extend thence southeast and south.

All of the eastern outcrops of the Dakota sandstone are lower than the upper portion of the James river basin and the wells farther west at Highmore and Harold. These outcrops therefore cannot be the sources from which the sandstone receives its artesian water, but, as we have seen, they are the avenues of its natural outflow. We must look instead to the western outcrops of this formation, where it skirts the Black Hills and exposes its upturned edges along the base of the Rocky mountain ranges, for the area upon which water is carried downward into the sandstone. Thence we know this stratum to be continuous beneath the plains to the James river valley, for there are no nearer nor other inlets from which the copious supply of the artesian wells can come. At a plane of greater or similar depth an artesian reservoir exists beneath much, if not all, of the country westward to the mountains. The gradients of the altitudes to which the water of wells is capable of rising along east to west lines in South Dakota, as at Huron, Miller, and at Highmore, are approximately the same as the average westward ascent of the country, demonstrating this western origin of the water supply, and indicating that such wells may be obtained upon an extensive region of the arid plains.

How far then can this artesian water be utilized for irrigation? Will it then be practicable to store the water in reservoirs for use in the season of growing crops, and especially during severe droughts, like that which so reduced or in some portions entirely cut off the crops in North and South Dakota last year? To this inquiry we may reply by computing the amount of water needed for irrigating a given space, as a quarter section of 160 acres, the usual area of a homestead. Allowing a depth of twelve inches of water for this use during the growing season, the year's supply of water from a well flowing 100 gallons per minute is required, without allowance being made for leakage or evaporation from the reservoir. The Devil's lake well would therefore irrigate only 64 acres, and the Jamestown well, flowing 375 gallons per minute will water less than a section one mile square. But each of these wells cost about $7,000, to which must be added the cost of the construction of reservoirs and irrigating ditches, placing the expense of such water supply far beyond its prospective value for ordinary agriculture.

An important objection, however, against the use of this water for irrigation seems to lie in its dissolved alkaline and saline matter, which must be left in the soil. After continued use in irrigation during many years the residuum from this water would quite certainly prove injurious to crops, so that the land would become worthless. Such results have attended irrigation with only very slightly alkaline water on the alluvial plains of the arid northwestern provinces of India. The proportion of sulphate of soda in streams flowing down from the Himalayan range and in canals taking water from them varies from 9 to 43 parts in a million, and the proportion of common salt is from 0.23 to 15 parts; yet under the dry climate of northwestern India the natural evaporation of so nearly pure water, and its use in irrigation have caused extensive tracts of land formerly productive to become barren.*

The analysis of the water of the Jamestown well, which, doubtless closely resembles that of all the wells obtaining their supply from the Dakota sandstone, is given by Prof. James A. Dodge, as follows:

Analysis of the mineral matter in the water of the artesian well at Jamestown, North Dakota.

	Parts per Million.	Grains per Gallon.
Silica	35.7	2.0823
Alumina	3.5	.2041
Carbonate of iron	2.2	.1283
Carbonate of lime	188.0	10,6743
Sulphate of lime	249.0	14.5241
Sulphate of magnesia	154.2	8.9944
Sulphate of soda	1139.4	66.3602
Sulphate of potash	81.5	4.7523
Chloride of sodium	369.1	21.5296
Phosphates	Traces.	....

* Medlicott and Blanford, Manual of the Geology of India, pp. 413-415.

The quantities of alkaline matter and salt are sufficient to give the water a brackish taste, rendering it unpalatable for drinking and unfit for ordinary domestic uses; but it is drank freely by cattle and horses, with no unfavorable effects. These dissolved mineral ingredients seem to have been derived from the Cretaceous shales, and probably in part from beds in the Dakota formation, with which the water has been in contact during its slow percolation hundreds of miles through the sandstone. They are the same in kind and similar in amount with the mineral matter of Devil's lake, concentrated by evaporation without outlet from the water of inflowing streams and springs, which bring very small amounts of these salts dissolved from the drift and Cretaceous shale of the adjoining country.

Much shale, gravel and detritus, rich in sulphates, are present in the glacial drift over nearly the entire Red river basin, and the percolating rain-water, found by the fresh artesian wells in the drift of the southern and northern ends of the Red river valley, has acquired minute quantities of alkaline and saline matter. But where its proportion is large, as in the brackish water of the wells from Crookston and Blanchard northward to the edge of Manitoba, it seems impossible that so remarkable a difference can be due to diversity in the material of the drift, or to longer time and better opportunity afforded to the water for such impregnation while percolating through porous beds or veins in the drift. The saline and alkaline artesian waters of the drift, gravel and sand along this central portion of the Red river valley therefore appear to be received mainly from the same Dakota sandstone which supplies the deep wells of the James river valley.

Several wells in the vicinity of Blanchard and Mayville, 375 to 404 feet in depth, pass through the drift and enter a very fine white sandstone, probably the Dakota formation, from which they obtain flows of brackish water. About a dozen miles east of Blanchard the drift was found to have a total thickness of 310 feet below which a boring went 107 feet into exceedingly fine white sandstone, finding, however, no artesian water, apparently because of the very close texture of the rock. The top of the sandstone in these wells is 650 to 575 feet above the sea. If it is the Dakota sandstone, as seems probable, it has an ascent of about 600 feet in 75 miles east from the meridian of Devil's lake and Jamestown, rising in its approach toward the Silurian, Cambrian and Archæan areas of Minnesota and Manitoba. It may be thus the bed-rock, on which the drift is deposited, beneath extensive tracts in the middle part and on the western border of the Red river valley, discharging there its alkaline and saline artesian water into the permeable beds of gravel and sand in the drift sheet, whence it rises in the brackish wells of that district.

Besides the classes or groups of artesian wells thus far considered, there remain to be mentioned numerous shallow flowing wells, from 20 to 168 feet deep, in the drift of the Vermillion river basin in South Dakota, reported by Prof. G. E. Culver, and two deep artesian wells in North Dakota at Tower City and Grafton. The wells in the vicinity of the Vermillion river are on an area unmarked by grand contrasts of elevation, though toward the north and northeast the surface gradually rises in the Coteau des Prairies. They seem to be comparable with the plentiful flowing wells or fountains along the Maple river in Blue Earth and Faribault counties, Minnesota.

The Tower City well, fifty miles east of Jamestown, is four feet lower than the depot, being 1,168 feet above the sea. Its depth is 670 feet, through drift, 163 feet; Cretaceous shales, with occasional beds of sandstone, 502 feet; and quicksand, into which the boring advanced only 5 feet. Salty and alkaline water outflows 9½ gallons per minute, and is capable of rising 33 feet above the surface. The scanty flow and low head of this well suggest that the water-bearing stratum may be enclosed within the Fort Benton shales; but its altitude, 500 feet above the sea level, accords with that of the sandstone reached by wells at Blanchard and Mayville, so that more probably it is the top of the Dakota formation. The plane of the head of water supplied from this formation would show a marked descent northeastward, as is thus indicated at Tower City and in less degree at Devil's Lake, in comparison with Jamestown and Ellendale, if there are abundant natural outlets of this artesian water along the Red river valley, as appears to be true, by springs rising through the drift. These brackish springs occur on many of the streams tributary to the Red river both in North Dakota and Minnesota, the most remarkable being on Forest and Park Rivers, which therefore were formerly called the Big and Little Salt rivers.

At Grafton, in the Red river valley on the Park river, the artesian well, 825 feet above the sea, is 915 feet deep, going through (1) drift, 298 feet; (2) limestone, apparently the Lower Magnesian formation of the Cambrian series in southern Minnesota, 137 feet; (3) white sandstone, referred to the Jordan formation of the same series, 65 feet, yielding a copious flow of brackish water; (4) reddish, blue, and gray shales, with some arenaceous or cherty and dolomitic beds, representing the Saint Lawrence formation of that series, 398 feet yielding a feeble flow of very salt water from its upper part; (5) sandstone, perhaps a trace of the Dresbach sandstone of southeastern Minnesota 5 feet, yielding a small flow of brine, which was analyzed by Prof. Henry Montgomery, of the University of North Dakota, and pronounced more saline than sea water; and (6) granite, as determined by Prof. N. S. Shaler from specimens of the borings, 12 feet. The water used from this well is taken from the top of the Jordan sandstone, at the depth of 438 feet. The diameter of the pipe is six inches, and the flow, according to three measurements in 1886 and 1887, during the first year after the completion of the well, was 800 gallons per minute. The reference of this section to the Cambrian series seems to be well determined by correlation with other wells penetrating Cambrian strata in this valley at Humboldt, Minnesota, and Rosenfeld, Manitoba, respectively about thirty-five and fifty-five miles farther north. At Rosenfeld, however, according to my interpretation of the section, the Cambrian series is overlain by 352 feet of Lower Silurian strata, which there are the bed-rocks first encountered below the drift. Not far west of Rosenfeld and south of Grafton, the Dakota sandstone, forming the base of the great Cretaceous series which is penetrated by the wells at Deloraine, Devil's Lake and Jamestown probably abuts, with horizontal or only slightly inclined stratification, upon the similarly almost horizontally bedded Silurian and Cambrian rocks.

June 10, 1890.

THE GEOLOGY OF THE ARTESIAN BASIN IN SOUTH DAKOTA.— *D. S. McCaslin.*

The artesian basin in South Dakota comprises an area variously estimated from 15,000 to 20,000 square miles. Its boundaries are not yet fully made out. It certainly extends from Yankton to Devil's Lake. Its eastern limits are marked by an irregular line running north and south, at a distance ranging from five to fifty miles east of the James river. Its western boundary is not yet defined. Its probable extension beyond the Missouri river is one of the strong conclusions of all the investigations, though it is doubtful if volume and pressure continue as great as we go toward the Black Hills. As yet no well has been put down west of the Missouri, except at Fort Randall which lies so far south and east that it has no practical bearing on the question of the western limit of the artesian basin.

The topography of this region is very simple. The James river lies in a broad valley of erosion from 50 to 60 miles wide, lying at an altitude above the sea ranging from 1,408 feet at Jamestown to 1,196 at Yankton. The railway track at Huron is 1,287. This would be about the average elevation of the valley through which flows the longest unnavigable stream in the world. From source to mouth, about 250 miles, yet its vermicular channel winds through more than 700 miles in persistent sinuosity. The present river is a mere trickle of the ancient flood that poured down this valley. The canal-like channel simply moves from side to side in a sluggish flow over an alluvial bed. Its banks vary from lacustral sedimentary deposits in Brown county, to bluffs of glacial drift, as in Beadle and Spink counties, till capped with modified drift in Beadle, Sullivan and Sanborn counties, the same covered with loess deposits as at Mitchell and southward. To the east or west of this river the altitude increases. At Arlington, about 45 miles east, it is 1,850 feet or 563 feet above level of Huron. At Highmore, about the same distance west, it is 1,890, or 603 feet higher than the James river. This outlines a great valley whose depression, by the way, bears no relation whatever to the artesian water. The water lies practically at the same level everywhere, as we shall see further on, and the differences of altitude only after the depth of the wells and not the deposit of the water. As I have intimated, the whole region is covered with drift deposits. But they are varied in character and distribution. They are not uniform, either in thickness or material or in order of deposit.

The earlier observations of Todd and others on the drift of South Dakota inclined to the conclusion that the Coteau region west of the James river was analogous to that lying east, between the Sioux valley and the James. The observers found the drift deposits very heavy in eastern South Dakota, sometimes as thick as 250 or 300 feet, with the usual order of glacial material: a base of quicksand, overlaid by blue clay, with unpolished fragments of rock; above that till with polished bowlders inclined to stratification; over this assorted or modified drift, sand or gravel, with flow and plunge structure; over this sometimes loess or other sedimentary deposits. It is still a question in glacial study whether the later drift lies above the loess in South Dakota. (Chamberlain, Geology of Wisconsin, volume III, page 395.) This is the typical drift section. It is freely illustrated in the eastern Coteau region, but in the western we have very different conditions. The order of the eastern glacial deposits was carried by analogy to the western Coteau region. There was a similarity in outline and elevation. It was an easy and natural conclusion that the structure of the formation was the same. The fact is there is a marked difference in the drift of the Missouri Coteau and that of eastern portions of the state. In the first place the western deposit is very light as compared with that of the east. Rarely has the drift been found over 100 feet thick west of the James river. On the highest elevations east the drift is heaviest. On the highest elevation west it is lightest. At Helland, Kingsbury county, near Arlington—the top of the Coteau—it is 310 feet thick. At Harold, west of Highmore, in the valley of Medicine creek, the drift shows a thickness of but 125 feet. This is the heaviest typical drift section I have observed west of the James river. Seventy feet of this is blue clay.

Yet east, and south, and north of Harold are much higher altitudes where the drift is very light. At the very top of the Ree Hills the chalk is simply capped with a light deposit of morainic bowlders, yellow clay and gravel, with no blue clay. The same thinness of this deposit appears at Wessington Springs, where the "Cement rock" crops out within a few feet of the summit, with only a few feet of sand and gravel overlying. This point is fully 2,000 feet above the sea. This is the general state of things west. The blue clay is frequently absent and the drift becomes only a thin sheet of bowlders and gravel. At Pierre it is very light, and at that particular point it does not cross the Missouri, though above and below it extends a few miles over on the reservation.

This observation on the real distribution of South Dakota drift will help us to see the position and relations of the underlying formations.

It shows us a heavy denudation of Cretaceous shales and chalks over all the Coteau region east of the James. If the "Cement rock" at the top of the Wessington Hills—2,000 feet above the sea—is Niobrara or Benton, either, its position shows a former wide extension eastward over all the region now where the drift lies directly on Pre-Cambrian rocks of either Algonkian or Laurentian age. It is a fact that the blue clays of this eastern portion are largely made up of disintegrated Cretaceous shales, and that this material below carries most of the fossil Baculites and Belemnites, while the upper morainic material carries quantities of diorite and syenite bowlders, with occasional slabs of limestone, many of them massive, and carrying characters of Silurian and Cambrian (?) fossils. One lying at the top of the Wessington Hills, 500 feet and more above the plain, will weigh more than 30 tons, and lies directly on a bed of fine ripple-marked sand. How a fact like that would have made the iceberg champions smile 10 or 20 years ago! We have got now where we can look at "both sides of the shield," and the berg of silver and the glacier of gold belong to the same scientific armor of truth.

We come now to the underlying geological section of the Artesian basin. The facts are fairly well made out. We know that the Pre-Cambrian rocks occupy wide areas beneath the heavy drift of the eastern Coteaus. Southward it is always Huronian quartzyte which crops out in force in all the lower Sioux valley, from Dell Rapids to Sioux Falls, westward in the Vermillion valley this same quartzyte appears at the surface. Outcrops are found in McCook and Turner counties, and also on Firesteel creek, near Mitchell. There is probably a heavier westward extension of this formation than was supposed. The fact is, all the borings show that both the granite and quartzite have a wider western area than was suspected. It is more than likely that the Dakota sandstone lies on quartzite or granite from Yankton to Jamestown and not on Jura-Triassic rocks.

Here are a few of the facts: at Vermillion quartzite was reached at 630 feet below the surface; at Mitchell, 645 feet (with light flow); at Plankinton, 760 feet (this lies west of James river); at Tyndall, 735 feet; at Scotland, 548 feet; at Vilas, 462 feet; at Iroquois, 1,098 feet (147 feet above Hume); at Hume, 802 feet; Aberdeen, 955 feet. (Stopped at hard bottom.) This last is either granite or quartzite, probably the former.

This wide projection of these formations westward is along the trend of the great Pre-Cambrian systems that stretch from Lake Superior across Minnesota, and far into southeastern South Dakota. Why is this idea not the key to the peculiar distribution of the drift in the Dakotas? If the theory of a series of centers of glaciation is true why may it not be that the ice mass moved from North Minnesota southwestward, rather than from the Turtle Mountain country or Lake Winnipeg? That would put the heavy moraine in the right place across the Dakotas, and account also for the Laurentian bowlders in the drift beyond the Missouri.

The next feature of the section of this basin is the Cretaceous, which system is represented by the Colorado group, consisting of the Pierre, Niobrara and Benton formations. These formations in descending order overlie and overlap the Dakota sandstone. This last named is a widespread deposit ranging from only a few feet to a hundred or more feet in thickness; it is persistent throughout the artesian region, and is the rock furnishing the tremendous flow of the wells.

A short study of this Cretaceous section will indicate the artesian conditions that prevail in this region.

If you start anywhere on the Pre-Cambrian border you will find these formations overlying granite or quartzite. Sometimes as a thin trace—a mere feather edge, as it were, of shale or chalk—but usually appearing in force as one approaches the James river valley. The only surface exposure of the Dakota sandstone is found in the extreme southeastern portion of the state, where it is seen to pass under the Benton shales. These shales and the Niobrara are both found to overlap the Dakota to a greater or less extent. The Benton shales are from 90 to 100 feet thick, and consist largely of "shales and laminated clays with some layers of very hard limestone all of a lead gray color." Beautiful nests and single crystals of selenite are found in them. Over this formation lies the Niobrara, known locally as "Chalk rock." It contains some "marly clays," and some "thick beds of a light, friable sandstone." It varies in thickness, being at Chamberlain probably about 200 feet.

Above the Niobrara comes the Pierre formation, a heavy deposit of dark, plastic "unctuous clays," with a few fossils, and those appearing in the upper and lower beds. It has a total thickness, according to Dr. Hayden, of 1000 feet, but probably not represented in any one section by more than 350 feet. In all the central and northern portions of the Artesian basin this deposit is passed through in boring the wells. It is absolutely impervious to water, yet when disintegrated it takes up water and forms a tough, sticky mud that makes a "Gumbo" flat the terror of the prairie-dweller.

This is the now fairly well determined section of the Artesian basin.

As one passes up the Missouri river these formations pass under each other with a very slight dip. If one follows this dip through to the head waters of the Missouri river he will find these same formations in outcrop on the slopes of the mountains, with a slight dip eastward and southward along the tributaries of the Missouri watershed. The Dakota sandstone is exposed in thousands of places. Observation and calculation have shown that the visible flow of the Missouri river does not represent by any means the volume of water that is gathered by the Missouri watershed. The position and character of the strata at the headwaters explain its disappearance, and the tremendous volume of over 200 artesian "gushers" shows that both the subterranean flow, and the surface streams have the same source. It is one of the most marked examples of a great river system attested by homogeneous geological conditions that the world furnishes. The inference is that the water beneath will flow as long as the water above, the artesian wells will go dry when the river does, and that will be when snow ceases to melt on the Rocky Mountains.

Now as to the wells themselves:

First, depth.—As I have said the local topography has nothing to do with wells except to modify the depth. The Dakota sandstone lies from 350 to 600 feet above sea level. Obviously wells in the higher localities must go deeper than those in the lower ones. It is found that the sandstone declines toward the north and west rather more than the surface of the country slopes south and west. The Dakota sandstone at Jamestown is 76 feet below sea level, and at Yankton 586 feet above; this shows that the artesian water runs up hill faster than the James river runs down hill. The wells will be found to deepen as you go north from Yankton. At Yankton they average about 628 feet; Woonsocket, 750 feet; Huron, 802 feet; Redfield, 900 feet; Aberdeen, 908 feet; Ellendale, 1,087 feet; Jamestown, 1,487 feet.

The Huron wells probably present as nearly a typical section as can be afforded in the Dakotas. They are all very similar, though, of course, the wells to the south do not penetrate some of the formations that spread over the interior of the two states. Absolute accuracy in description and depth is quite impossible.

The first artesian well sunk at Huron gave the following record:

	Feet.
Glacial drift of the usual composition of this deposit........	89
Bluish gray shale, very tough and becoming sticky when wet, undoubtedly of Pierre formation:....................	169
Sandstone and gray shale, which may provisionally be referred to the Niobrara...........................	200
Brown shale, associated with layers of gray marly shale in part; Benton in age............................	253
Friable, water-bearing sandstone.....................	80
Hard pan penetrated only...........................	10
Total	802

This is about as nearly as I can classify the strata passed through at Huron. Facts are hard to get, and well borers use terms very loosely. I verified this arrangement in other wells, notably at the Day-Harrison well, two miles and a half southwest. Aberdeen corresponds almost exactly, only the Pierre shales are heavier.

Second, the flow in all these wells is marvelous, so great as to awaken scientific incredulity so strong that the facts as first proclaimed were discredited entirely.

The first Huron well (now there are three or four more being sunk) flows 1,560 gallons per minute under a pressure of 120 pounds per square inch. Woonsocket has three wells, two within 1,800 feet of each other, each flowing 2,370 gallons per minute. A new one, three inches in diameter, one mile away flows 1,000 gallons per minute under a pressure of 120 pounds per square inch. These are a few examples where no less than 150 might be cited. More likely there are over 200 now flowing.

Third, the character of the water is notable. All the wells, with one or two exceptions, yield a clear and bright water. The exceptions are where there are some defects in the piping or where the water comes in contact with the shale at the bottom. In Groton such a condition ruined the well. A new and clear well is now flowing at that place. The water of the wells at Aberdeen has a slightly milky appearance at times, owing probably to a local sediment in the sandstone. Usually the flow is bright and sparkling. The temperature of the water varies from 68° to 70° Fahr., though at Miller and Harold it is 91° and 90°, respectively. In some of the wells the water is soft—as at Iroquois. Everywhere it is palatable and pleasant. Experience has proved it, with only a few exceptions, very healthful. The Jamestown well is an example of one yielding a brackish and saline water. But every well in South Dakota, so far as I am informed, furnishes water that can be used by man and beast.

This opens the question of utility. Its domestic use is already before us and has been sufficiently noted. Its mechanical use is also already established. In many towns and cities it affords the cheapest and best possible fire protection. The problem everywhere is to get hose that will withstand the pressure. Huron uses about 80 pounds pressure per square inch. For power it has been used in a practical way in driving printing presses—no less than three printing houses in Huron are using motors driven by one artesian well.

At Hitchcock a flour mill has been running for two years, driven by a three and one-half inch well—grinding 48 barrels of flour every day. "The natural pressure is so steady and regular that there was absolutely not the variation of a single revolution in 24 hours."

The new six-inch well at Woonsocket is driving a still larger mill by this time. The machinery having been put in place three or four weeks ago.

Lastly and finally, we will consider the use of artesian wells for irrigation. It is more and more becoming an accepted belief that this vast "sub-humid" region must have moisture by other than natural methods, or never be successful as an agricultural country. The rainfall is insufficient and unreliable, showing at Huron, 23.65 inches, at Fort Sully, 16.33 inches per annum. The semi-arid character of the climate appears in various peculiarities of animal and plant life. In this region are two or three species of cactus, such plants as "*Lygodesmia-juncea,*" and others with much contracted foliage show what the lack of humidity can accomplish. Then the fauna has shown some dictinctly desert types; the prairie marmot, or dog, is a desert type, and so is the gray plover; the "sand piper," and other birds, are nature's hints as to what the permanent conditions are likely to be.

The soil is everywhere good, from two to four feet of black organic mould occurs, and all it wants is moisture. If the subsoil is saturated well in fall or spring a crop is assured, at least in the wheat bearing belt of the states.

The heavy snowfall of 1881 had this effect; in fact it was felt for four or five seasons. They were years of plenty in the Dakotas. Another effect of irrigation would be the prevention of the hot winds. Artesian water would fill basins that are now dry, and so modify the winds by moisture.

Lake Byron and Lake Preston would be enlarged, and scores and hundreds of these, some greater and others smaller, would be formed. The effect of having these lakes all filled with water and bordered with trees, would be to eliminate practically all danger from the hot winds. It is perfectly feasible to accomplish all these results. There is no longer any doubt about it. The thing has been done, and a yet more extensive application of artesian water will be achieved in the season now approaching.

Two or three scientific bugbears have been effectually disposed of. One is probable lack of water. The water is proved to be there in a practically inexhaustible supply. It has flowed persistently everywhere year after year since 1883. The proximity of new wells has not affected either volume or pressure in any perceptible way. The cost of the wells has been reduced to a reasonable sum. A good well has been put down at Woonsocket for $900. Scores of them will go down this spring at a cost of from $500 to $800. New machinery is now being patented which will revolutionize artesian well boring. The practical results of all experiments have been perfectly satisfactory. The water does not injure either soil or vegetation. It is used constantly on the lawns about scores of residences, in Huron, Aberdeen, Redfield and Mitchell. It can be applied directly to the crops whenever needed. But ordinary agriculture in Dakota requires simply an overflow of the land in the spring or fall, and with a saturated sub-soil, and the air moistened by a multitude of artificial lakes, the wide fields of South Dakota will wave with wonderful harvests year after year.

The Melville law just in force authorizing the bonding of townships for the purpose of putting down artesian wells is being received with great favor, and will furnish the funds to start the streams of a lasting prosperity in this vigorous young commonwealth

April 7, 1891.

SOURCES OF THE CONSTITUENTS OF MINNESOTA SOILS.

By C. W. Hall.

CONTENTS.

The soil is the superficial portion of the unconsolidated surface material of the globe; it is the line of contact between the solid portion—the rocks—of the earth's crust and the liquid or gaseous portion—the air and the water. It is, therefore, the zone of chemical activity and represents that era of profound change, under which rocks break in pieces and re-form under new physical conditions and chemical composition; under which water is absorbed by the rocks or, unabsorbed, becomes loaded with every conceivable chemical element and compound as it passes on in its devious wanderings.

The Formation of Soils. Touching the formation of soils two things may be noted: (1) The soil is made of debris of weathered and comminuted rocks mingled with the remains of plants; (2) Since the composition of vegetation is always nearly the same, the varying conditions of soils must depend upon two things, the proportion of vegetable remains in the vegeto-mineral mixture and the variation of the rock constituents out of whose decomposition the mineral portion is obtained. Vegetation in its decomposition plays rather a chemical than a geological part. In the course of years, large quantities of vegetable matter are broken down and are subjected to the various processes of decay. In some instances peat is formed; in others, the vegetable matter is mingled with mineral to such an extent that it becomes a carbonaceous rock.

Mineral matters in the mixture usually take the leading place and are of prime importance in considering the character of soil. The two extremes of infertility in soils are clear, comminuted quartz, kaolin and calcite,—that is, sandstone, clay and limestone, —on the one hand, and clean vegetable mold on the other; and all the stages of fertility lie between these extremes, where the sandstone, shale or the limestone, and mold are judiciously mingled and associated with proper proportions of alumina and the alkalies.

The process of rock alteration.—The process by which the chemical condition of rocks is changed so that they may become constituents of soils is rock alteration, and this is one of the most constant processes in nature. It is going on wherever water and air can come in contact with the rocks; so it is not only along the comminuted surface that is exposed to the sunshine, where we call it weathering, but along the deep fissures which extend for many feet—even miles—through the rocks in vertical and horizontal directions. The processes by which alteration is effected vary under different conditions. This change is effected in warm and humid climates chiefly by waters of a comparatively high temperature, in climates that are warm and dry, by sunshine and sudden changes of temperature; in cold climates, by moisture and freezing. But with these forces, others naturally come into play; for instance, the erosion of rain water is necessary to remove the loosened material, so that which lies below and still fresh, may come within the influence of weathering agencies; or the wind, blowing through high arid regions with great violence, carrying clouds of dust, constantly lays bare the surface of underlying rocks and burrowing animals of many types constantly bring to the surface quantities of fresh earth.

The layers of soil sections.—In any normal soil section there are three layers, (1) the soil; (2) the sub-soil; (3) the underlying rock. The soil is filled with the roots and rootlets of plants, and the burrows of insects and worms. Plants are constant constituents of soils. Numerous fungi and plants of many a low type abound.

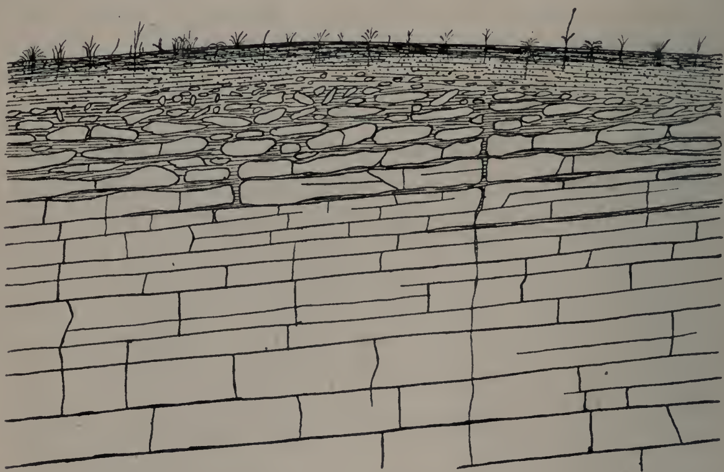

Figure 1. The decomposition of limestone and the foundation and accumulation of soil. This is representative of areas in Southeastern Minnesota. Drawn by F. W. Sardeson.

The sub-soil is a broken-up layer consisting of pebbles large and small, some crumbling and others fresh, around which are pushing their crooked ways the roots of trees and strong herbs. In color this layer is like the rock beneath; and while in general characters it touches on the rock below, in other characters it is closely related to the soil above. A loam, a clay, a sand, or a gravel bed beneath a cultivated field is sure to make its imprint upon the crop raised. The reason for this is not far to seek; it lies within the observation and every-day experience of every one. Water will disappear by the barrel in sand and gravel; while it will lie until it dries up when the bottom of the pool is clay or mud.

The underlying rock is compact and firm, never fresh and unshattered, and never yielding to the urgent demands of the growing trees for root space or support, unless it has first yielded to the action of water and the crustal movements of a changing globe. The varying proportions of the soil to the sub-soil, and the sub-soil to the underlying rock are often noted. They lie in the varying conditions under which soils are formed and retained

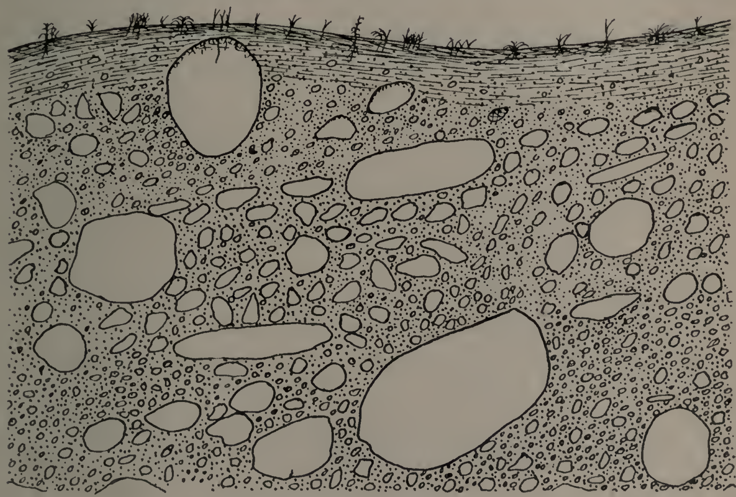

Figure 2. The decomposition of glacial drift, till, and the formation of soil. This is the type of rock alteration and soil building most extensive in Minnesota. Drawn by F. W. Sardeson.

in place. Upon hillsides there is a constant transport of material towards the bottom. If the slope be gentle, this transport is slow, and in any case it is the finest particles that are carried farthest. This movement while slow and insignificant in itself, is of moment since it forms the record of a slow and almost imperceptible geological change affecting a whole region. This change suggests another fact within observation: a given type of plant growth will continue to live generation after generation upon the same place. This is the case because the peculiar food constituents which are favorable to the growth and maturity of this particular species are continually loosened and separated from the rocks in which they lie, and in the course of time they are comminuted by temperature changes and rain water at so slow a rate as to furnish plants food at about the same rate as they exhaust it by assimilating it. The great diversity of composition and physical characters which soils present are really primary traits and they depend to a great degree on the nature of the rocks beneath the surface and the topographical features of the country in which they are found. Other traits are secondary; briefly enumerated, they are due:—to depositions of vegetable and animal matter; to the action of moles, worms, insects; to the growth of roots of trees; the wind which, in leveling countries, moves great masses of the finer soil, and to those slow but unceasing chemical activities which transform entire rock formations and extend over the continental areas of the globe.

Darwin fifty years ago noted the peculiar creeping of soils by which lower layers would seem to change places with upper ones, and this apparently without the aid of worms or moles. This phenomenon is probably explained by the capillary action possible through the pressure of water. Underground waters also equalize the temperature of soils to a most remarkable degree, a fact of great moment in the steady growth of crops in a changing climate like ours.

The work of the sea in the forming of soils.—While it is not necessary to call attention to those soils formed directly by the sea, still we note that indirectly the work of the sea in the building of all soils is an imposing one. The beginning of this work lies in those silent and ceaseless ages in which the contents of the vast oceanic basins were brought into one compound after another, and at the close of many transformations—some of which transformations are made in the tissues of plants and animals and others in the vast abysmal precipitations by which alumina, iron, silica, and the alkalies,—are packed down on the bed of the sea. Thus the waters of the sea play no insignificant part in soil building, although it is a very indirect one.

The part of plants in soil formation. Plants are builders of soils; such is not always their office. They are also destructive in their action, disintegrating rocks by keeping the surface moist, —water being a medium of chemical action, and in itself a universal solvent. Plant decay furnishes an important source of organic acids. These acids in their action upon minerals and rocks are as vigorous as sulphuric or nitric acid of soils. Roots of plants—especially of trees and shrubs—pry off blocks of rock, separating them from the ledge and thus extend the rock surface over which corroding influences can work.

Effect of moisture in soils.—A practical note may be added touching the presence of moisture in soils: Cultivation varies that ingredient in all soils; experiment has shown this. The Michigan Agricultural College during the past few years, has been conducting a series of experiments upon different kinds of soils, and the following result is reached: The steady loam soil that is cultivated has three per cent. more moisture than that which is merely raked; and that which is raked, has one per cent. more moisture than unworked soil. This is a strong argument put in a strong way in favor of industry and care on the part of the farmer who has planted his crop.

The chemical elements in soils.—Dr. T. Sterry Hunt calls attention to the providential fact that those substances which the waters percolating through the superficial rocks take out and carry away are the substances which plants do not want, and the very substances which the waters leave are those which plants want and must have in their growth. "Drainage waters of soils, " he says, "like that of most mineral springs contain only carbonates, chlorides and sulphates of lime and magnesia and soda, the ammonia, potash, phosphoric and silicic acids being retained by the soils."* Briefly stated, those elements out of which are made the salts so essential to growing plants is in part the air, but in larger part the porous rocks of the earth's superficial crust through which the waters percolate, and from which they dissolve some essential ingredients. The number of these elements is not large. They are all grouped together under the general name *foods.* Some are used directly, others indirectly; some perform one office in the plant economy, others another and widely different one; some can be used immediately by the plant protoplasm

* Chemical and geological essays, The Chemistry of Metamorphic rocks, 2nd ed., 1878, p. 22.

and others must be worked over in divers ways. All these changes direct and indirect, immediate and remote are necessary to convert chemical elements and compounds into protoplasmic food, that is, to assimilate them.

The essential food elements of plants.—There are twelve chemical elements which may be considered the essential foods of plants: Of these six occur in large amounts, viz: Carbon, oxygen, hydrogen, sulphur, phosphorus and nitrogen; and six others in small amounts, viz: Calcium, magnesium, iron, silicon, potassium and sodium. Let us now see what extent these food elements exist in Minnesota rocks and, proportionately, in the soils derived from them.

Quite as essential as the mineral matters or the average moisture in the soil are occasional showers of rain. Dry weather causes the soil and sub-soil to hold these constituents as solids, and in this condition plants cannot take them up; but let a shower fall and dissolve them and they are rapidly carried into the plant tissues and there assimilated. A hint at this condition is seen upon prairies in the almost white coating of magnesic and calcic salts that cover the dark loam in the dried out sloughs and swamps of nearly every portion of Minnesota. A shower of rain will cause this white coating to disappear, again to appear as soon as the rain has been absorbed by the earth or evaporated once more into the air.

Here is the reason for the phenomena often seen in dry weather of the lower and mature leaves of a plant shriveling and disappearing; the salts so essential to the growth of the new shoots and leaves of the plant are taken from the mature parts of the plant itself instead of from the soil, where they lie in the condition of salts on which it is impossible for the plant to feed.

The chemical composition of soils.—When soils are spoken of in their chemical relations to plants and plant food the chemical composition of soils should be understood that the capacity of soils to feed plants may be seen. When the sources of the constituents of soils are discussed the amount and character of these constituents should be known. So little work has thus far been done on the chemistry of Minnesota soils that the following table is made up of analyses drawn from the geological survey reports of Wisconsin. They are taken from Salisbury's table, vol. 1, p. 307, as fairly representative of similar soils of Minnesota.

I. Peaty Soil—characteristic of the bottom lands of eastern Wisconsin.

II. Prairie Loam—south central Wisconsin.

III. Siliceous red clay, Ashland. This is fairly representative of an extensive stretch of country in eastern Minnesota.

IV. Loamy soil, Douglas county, Wisconsin, characteristic of the higher ridges and rolling areas of eastern Minnesota.

V. Sandy soil from the barrens of Douglas county, identical in general characters with the sandy tracts of eastern central Minnesota.

	I	II	III	IV	V
Silica SiO_2	64.49	79.59	57.60	80.36	94.08
Alumina AlO_2	4.80	4.17	25.85	2.90	0.74
Ferric oxide F_2O_3	5.74	8.16	4.11	0.90	1.00
Manganic oxide Mn_2O_3	0.13	0.18	......	......	......
Lime CaO	1.60	1.30	3.58	0.68	0.64
Magnesia MgO	0.79	1.04	1.70	0.40	0.12
Soda Na_2O	0.51	0.49	......	......	......
Potash K_2O	0.14	0.10	......	......	......
Phosphoric acid P_2O_5	0.12	0.06	......	......	......
Carbonic acid CO_2	0.25	0.52	4.65	0.70	0.65
Sulphuric SO_3	0.08	0.03	......	......	......
Water H_2O	......	......	2.57	3.15	0.37
Organic matter	21.40	4.24	......	9.60	0.80
Totals	100.00	100.00	100.00	98.78	98.40

Soils classified.—Powell classifies soils in the following manner:

I. Endogenous,—those derived from the common rocks, and remaining in place. These vary greatly according to the rocks from which they are derived; but broadly stated we have three classes:

1. Sandstone soils;
2. Limestone soils;
3. Granitic soils.

II. Exogenous soils,—those derived from other surfaces than that of the common rock peculiar to the district in which they occur. Of these soils there are many sub-divisions, but so far as represented in Minnesota, they are,—

1. Alluvial soils, formed from depositions on flat plains by running waters;
2. Lacustrine soils, formed from depositions in lakes;
3. Drift soils, formed from depositions by glacial agencies.

This classification can be considered only in a general way since the entire state, save a small area in the southeastern corner has been overwhelmed by glacial ice and its soil and subsoil conditions completely altered. The material torn up and comminuted has been transported and redeposited in other localities, some near and some far. Thus the rocks have been brought into even closer relations to the processes of soil-making than could exist were the surface of the state that of a non-glaciated region. The intermingling of material affords soil material of remarkable versatility and strength; versatility because of the intermingling incident to glacial transportation, and strength because of the mixture of partially decomposed and fresh materials, insuring a slow and continuous decomposition of mineral matters and a facility for the extended growth of roots and underground stems and thereby the ceaseless forming of soil to an unusual depth. That there are many rock species in the constitution of the glacial drift the following tables will show.

The rocks that form Minnesota soils.—The underlying rocks of the state are:—

1. The acid crystalline rocks,—largely granitic and rich in silica.

2. The basic crystalline rocks,—diorites, diabases, gabbros, etc., or those usually poor in silica.

3. Sandstones and quartzites, consisting mostly of silica.

4. Calcareous shales, partly carbonates of lime and magnesia, partly silica and partly alumina, as leading constituents.

5. Carbonates,—rocks chiefly of organic origin and chiefly carbonates of lime, magnesia and iron.

The first group of rocks includes granites, gneisses and the so-called crystalline schists. All are very hard to break down into the condition of soil. It takes time and chemical action. The chemical substances in these rocks are silica, alumina, potash, soda, lime, magnesia, and the compounds of iron. Quartz and the feldspars are their chief constituents, followed by hornblende, biotite, etc.

They are the chief storehouses of the elements furnished to the soil by these rocks, and in their degradation, the chief resultant products are quartz, sand and kaolin, with chloritic minerals in proportion to the biotite present. The granitic rocks, when broken down on level tracts, make a very sterile and barren soil; where erosion can collect them into valleys, the soil becomes rich —when not too heavy. But then, the cost! Hundreds of acres are washed to build a single meadow; and these washed hillsides are pre-eminently the barren pastures of grazing districts.

The granitic rocks.—Granitic rocks are distributed very largely over the northern part of the state. Probably one-half of the area north of the line from Taylor's Falls to Anoka and thence directly westward to the state of South Dakota through New Ulm and Tracy is underlain, beneath the glacial drift, by these rocks. At many places when the granites come to the surface samples have been taken for study. Below are a few analyses made of granites and gneisses from representative localities:

I. Red hornblende biotite granite, St. Cloud, analysis by F. H. Crowell.

II. Gray hornblende biotite granite, St. Cloud, analysis by W. H. Willard.

III. Gray augite granitoid gneiss, La Framboises farm below old Fort Ridgely; analysis by A. O. Dinsmore.

IV. Medium colored hornblende biotite granite, St. Cloud; analysis by G. H. Hammond.

V. Red hornblende biotite granitoid gneiss, Ortonville; analysis by A. D. Meeds.

(This is the stone of which the City Hall and Court House in Minneapolis is built.)

VI. Augite gneiss, La Framboise's landing below Ft. Ridgely, Otto H. Folin.

	I	II	III	IV	V	VI	**Average**
Silica SiO_2	73.30	71.64	72.30	69.47	74.70	69.07	71.71
Alumina Al_2O_3	14.20	11.82	15.40	14.94	14.06	13.73	14.02½
Ferric oxide Fe_2O_6	5.40	3.94	3.10	4.07	*5.07	*2.87	4.07½
Lime CaO	3.00	1.41	3.75	1.60	1.73	3.70	2.53
Magnesia MgO	0.50	0.32	0.65	0.29	0.29	7.08	.52
Potash K_2O	1.40	2.49	......	4.56	1.83	2.33	2.10
Soda Na_2O	2.00	5.22	3.40	3.37	2.17	4.30	3.39
Water H_2O	0.30	0.88	2.00	.....	0.26	0.13	.59½
Totals	100.10	97.72	100.50	98.30	100.11	97.05	98.98

*Fe_2O_3 and FeO computed together.

The foregoing analyses were made from fresh material, in some instances broken from the lowest layers in the quarry. They thus represent not partially decomposed rock formations, but the actual condition of the freshest and least changed beds within the granitic group of Minnesota rocks. The soils originating directly from them are as varied in composition as are the rocks themselves; so they vary from a sandy soil on the one hand when the rock is mostly silica, to a clayey soil on the other, when alumina occupies the largest place in the chemical composition of the rocks.

Basic eruptive rocks.—The second group, or the basic eruptive rocks are important, first, because of their extent, for probably ten thousand square miles of the commonwealth is underlain by these; and secondly, because of their chemical qualities. They possess the same chemical constituents as the first class considered, but in quite different and more varying proportions. They contain less silica and more of the alkalies and alkaline earths, the real plant food than do those. For instance, the lime in a cubic mile of these rocks, if none of it were wasted or used in other ways, is sufficient to grow a crop of grass yielding two tons per acre for hundreds of years. When these rocks are weathered and the debris is gathered by erosion and transported into the meadows and valleys of the northern portion of the state, a soil of great richness is produced; grasses, sedges, shrubs and forest trees grow vigorously.

In area these eruptive rocks underlie about one-fourth of Minnesota to the north and west of the line just drawn from Taylor's Falls through Anoka, New Ulm and Tracy to South Dakota. The great field of volcanic activity was almost the entire tract north of Lake Superior in Minnesota. Thousands of square miles were overflowed by lava beds and the exudations of hundreds of dikes which welled up from the deep-seated plastic rocks. Cracks in the old rocks some of them of huge extent were made across the state to the south and southwest and filled with this plutonic matter. They can be seen today in almost every county where the granitic and gneissic rocks appear. The chemical composition of the basic eruptive rocks will appear from the following selected analyses, also made in the laboratories of the State University:

VII. Medium grained diabase, north shore Lake Superior; mean of five analyses; analysis by H. B. Greeley.

VIII. Thomsonite-bearing diabase, north shore Lake Superior; analysis by Prof. C. F. Sidener.

IX. Columnar diabase, Grand Marais, north shore Lake Superior; analysis by Professor C. F. Sidener.

X. Porphyritic quartz diabase, Saint Augusta, Stearns county; analysis by A. A. Finch.

XI. Peridotite, Minnesota river bottoms below Motley; analysis by A. D. Meeds. Bull. 157, U. S. Geol. Survey, Granites, granite gneisses, etc., of the Minnesota river valley, p. 113.

XII. Porphyritic gabbro schist, Granite Falls; analysis by E. J. Babcock. Bull. 157, U. S. Geol. Survey, p. 89.

XIII. Porphyritic diabase near the base of Caribou Peak, north shore Lake Superior; Professor C. F. Sidener.

XIV. Olivine gabbro, Sec. 19, T. 65, R. 9 W.; Dr. H. W. Stokes. Journal of Geology I, p. 712.*

XV. Normal gabbro, Sec. 35, T. 61, R. 12 W.; Dr. H. W. Stokes. Journal of Geology I, p. 712.*

	VII	VIII	IX	X	XI	XII	XIII	XIV	XV	Average
Silica, SiO_2	48.86	46.80	52.62	58.72	43.65	47.43	47.05	45.66	46.45	48.58
Alumina, Al_2O_3	12.99	15.21	15.75	16.53	6.81	23.66	32.03	16.44	21.30	17.84
Ferric Oxide, Fe_2O_3	20.42	13.13	15 83	9.56	21.10	13.06	2.01	0.68	0.81	13.33
Ferrous Oxide, FeO	....	....	....	....	....	....	....	13.80	9.57	
Lime, CaO	11.99	11.11	8.90	6.37	4.86	11.21	15.85	7.23	9.83	9.71
Magnesia, MgO	....	8.13	3.71	1.36	12.91	3.15	.15	11.57	7.90	5.43
Potash, K_2O	2.14	0.01	0.19	4.41	0.52	0.42	0.05	0.41	0.34	0.94
Soda, Na_2O	3.66	1.95	2.07	2.13	0.43	0.41	1.00	2.13	2.14	1.77
Titanic dioxide, TiO_2	....	....	....	....	....	....	....	0.92	1.19	....
Water, H_2O	1.46	2.79	1.81	0.81	*7.46	0.90	1.36	0.90	1.16	2.07
Total	101.52	99.13	100.88	99.71	98.86	100.24	99.50	†100.03	‡100.75	99.57

*CO_2 = 1.12 %. †Incl. NiO 0.16 and P_2O_5 0.05. ‡Incl. NiO 0.04 and P_2O_5 0.02.

Sandstones and quartzites.—The third group embraces typical sandstones and quartzites. These rocks do not lie in distinct and broad areas; they are rather in the form of narrow belts sandwiched in between the dolomitic rocks in the southeastern counties and the eruptive flows of northeastern Minnesota, save in the one expanse of quartzite which appears around New Ulm, thence southwest and across Cottonwood, Rock and Pipestone counties into South Dakota and Iowa. Attention is called to the high percentage of silica in these rocks.

XVI. Red quartzite, Pipestone; analysis by Professor J. A. Dodge.

XVII. Pink sandstone, Hinckley; analysis by Professor J. A. Dodge.

XVIII. White Saint Peter sandstone, Fort Snelling; analysis by Professor J. A. Dodge.

* Nos. XIV and XV were inserted in the reprinting of the Bulletin because of their typical character.

XIX. Light gray sandstone, Dresbach; analysis by Professor J. A. Dodge.

XX. Red sandstone, Fond du Lac, analysis by Professor J. A. Dodge.

XXI. White, friable sandstone, Jordan; analysis by Professor J. A. Dodge.

XXII. Gray slaty quartzite, Wauswaugoning bay, Lake Superior; Professor C. F. Sidener. Geol. & Nat. Hist. Survey Minnesota 13th an. rep. 1885, p. 100.

	XVI	XVII	XVIII	XIX	XX	XXI	XXII	Aver'ge
Silica Si_2	84.52	98.69	97.67	81.47	78.24	81.19	81.86	86.23
Alumina Al_2O_3	12.33	1.06	1.31	8.90	10.88	10.44	9.87	7.83
Ferric oxide Fe_2O_3	2.12	......	0.55	.....	3.83	.....	1.44	1.13
*Ca Carb. $CaCO_3$	0.55	0.75	0.74	3.38	1.69	1.00	0.82	1.28
†Mg Carb. $MgCO_3$	......	0.22	0.44	1.02	3.30	0.84	1.70	1.05
Potash K_2O	0.11	......	0.02	4.20	1.67	3.60	.45	1.43
Soda Na_2O	0.34	0.17	0.15	0.39	0.06	0.66	1.61	.48
Water H_2O	......	......	......	.....	.....	.....	1.43	.....
Total	99.97	100.69	100.88	97.37	99.67	97.73	101.54	99.43

*Recalculated from calcium oxide.
†Recalculated from magnesium oxide.

The soil qualities of sandstones and quartzites.—The sandstones and quartzites alone make a most barren soil; they are almost entirely destitute of the essentials of plant food. Almost entirely silica in their chemical composition, very nearly insoluble in water, hard and extremely obstinate in their physical character, they are most forbidding to all forms of vegetable life. Yet, in soils the contents of these rocks have their uses. Their *debris* does not pack into such an impervious mass as does clay, nor become crystalline and compact like the carbonates, but the grains lie loosely upon each other permitting free circulation of water, and in this way serving the double purpose of draining away the superfluous waters of level tracts,—preventing stagnation on the one hand, and on the other aiding in securing a supply of water from great depths through capillary action in time of drought. In the Gulf States there are large tracts of sandy soil. With the abundance of rain which annually falls in that section large crops are produced on land which in the upper Mississippi valley would be almost barren. In this state a sandy soil is not desirable for farming purposes. The sandy plains existing are due to the distribution of the disrupted sandstone and quartzite formations through the agency of the glaciers of the successive stages of the glacial invasion.

The calcareous and siliceous shales.—The fourth group is that of the calcareous and siliceous shales, partly Cambrian, partly Cretaceous and partly Glacial in age. While they are at the present time of no great extent, before the Glacial period they were probably spread over many square miles of Minnesota. They must have formed the underlying rocks over a considerable belt in southern Minnesota where the edges of the Cambrian rocks came to the surface, and to the west and northwest, where the Cretaceous—Fort Pierre shales of the Dakotas—extended into the state, a great extent of our territory must have been covered, possibly more than half the state. The soft and friable condition of these rocks caused them to be easily eroded by the ice which was pushed down from the north during the Glacial epoch.

The calcareous shales possess some peculiar, and for the agriculturist, valuable properties. Chemically, as will be seen, they contain in large measure some of the essential elements of plant food, and they are partially soluble; physically, they are not so heavy and compact as clays, they are easily broken up, allow roots to push into them, and they crumble and become finely pulverized under the action of sun and rain. The soil produced by them is not a heavy clay, but rather a mingled clay and sand,—and they will doubtless make, under some circumstances, an excellent loamy soil.

The siliceous shales contain a far less amount of soluble material than do the calcareous shales. There are two types of these shales in the state: those that stand intermediate between the dolomites and sandstones of the southeastern Minnesota succession and those which are directly or indirectly due to the ice of the Glacial period. The first type represents a rock originally very different from the existing one, the change being effected by combined solution, erosion and transportation. The existing condition may be regarded as a transition from a rock of quite diverse character towards a very clean bed of sandstone.

In the following table of analyses are included the decomposed granitic rocks which occur in several portions of the state. Along Birch Cooley, in the Minnesota river bottoms below Redwood Falls, at Granite Falls, and elsewhere, these rocks are an important soil constituent.

XXIII. Decomposed gneiss, Birch Cooley; analysis by A. D. Meeds.

XXIV. Siliceous clay, thought to be Cretaceous Mankato; Prof. S. R. Peckham. Geol. & Nat. Hist. Survey Minn., Am. Rep., 1880, p. 153.

XXV. Dark shaly bands Minneapolis building stone, Trenton limestone; Prof. W. A. Noyes.

XXVI. Contact clay between Shakopee limestone and Jordan sandstone, mouth of Blue Earth river; Professor C. F. Sidener. Geol. & Nat. Hist. Survey Minnesota, 11th An. Rep. 1884, p. 181.

XXVII. Stratum of easily crumbling calcareous rock above the building stone, Minneapolis, Minn., by H. V. Winchell.

	XXIII	XXIV	XXV	XXVI	XXVII	Average
Silica SiO_2	41.71	70.10	15.84	68.70	20.38	43.35
Alumina Al_2O_3	34.61	16.99	4.93	18.04	26.77	20.27
Ferric oxide Fe_2O_3	4.58	......	4.00	1.53	1.57	2.34
Ferrous oxide FeO	6.88	......	......	......	13.74	......
Lime CaO	1.16	......	......	1.24	0.70	......
Magnesia MgO	0.22	......	......	0.56	......	......
Soda Na_2O	0.11	......	......	0.24	......	......
Potash K_2O	Trace	10.69	......	5.28	......	......
Water H_2O	12.69	1.98	......	1.40	......	4.02
Sulphuric acid SO_3	......	0.23	......	......	......	......
Calcium carbonate $CaCO_3$	......	......	56.47	......	28.16	......
Magnesium carbonate $MgCO_3$	......	......	14.21	......	11.18	......
Organic matter	......	......	1.26	......	......	......
MgO with SiO_2	......	......	0.14	0.09	......	......
Total	101.96	99.99	96.86	97.08	102.50	......

The Carbonates.—The last group, or the carbonates, occupy a large area in southeastern Minnesota, and they probably underlie a considerable area of the Red river valley. At one time, I have no doubt, they covered the entire state as well as Wisconsin and the Dakotas to the right and left, and even Manitoba and Ontario on the north. They are crystalline and firm of texture, and they form an excellent building stone. In composition they contain carbonic acid, lime and magnesia, with small quantities of other plant foods. In the southeastern portion of the state, over some hundreds of square miles, these rocks are not covered by Glacial *debris;* for there we see a portion of the old Glacial island which lies largely in Wisconsin and Illinois—a tract of land over which the ice did not spread during the period when all the rest of the northwest was buried deep beneath the glacier. In this corner of the state, then, these carbonates by their decay have produced the surface soil; while by the breaking up of boulders in every other portion of the state they have done their work in soil building. But in the breaking up of these rocks into farming soils so much is soluble that only a small part remains behind for soil building, and this is largely the impurities of the rock, such as silica and alumina; while the other constituents, lime, magnesia, soda, sulphur and phosphorus remain behind in small quantities.

XXVIII. Compact dolomite, Dresbach; analysis by C. S. Chappel.

XXIX. Compact dolomite, Nininger; analysis by Mary E. Bassett.

XXX. Dolomite, bottom layer quarried at Mankato; analysis by C. L. Herron.

XXXI. Dolomite, buff-colored Kasota stone, Kasota; analysis by H. C. Carel.

XXXII. Dolomite, porous, Frontenac quarries; analysis by J. G. Cross and E. P. Sheldon.

XXXIII. The buff limestone, Minneapolis, analyzed as a whole; analysis by Professor J. A. Dodge.

XXXIV. The buff limestone, Minneapolis; analysis by W. A. Beach.

XXXV. "Galena limestone", Section 9, Spring Valley. Chemist unknown.

XXXVI. Mankato cement rock, Mankato, Minn.; analysis by W. C. Smith.

XXXVII. Frontenac dolomite, quarried extensively as a building stone, Frontenac, Minn.; analysis by E. P. Sheldon.

XXXVIII. Siliceous dolomite, Goodhue co.; analysis by G. A. N. King. Results as reported have been recalculated.

	XXVIII	XXIX	XXX	XXXI	XXXII	XXXIII	XXXIV	XXXV	XXXVI	XXXVII	XXXVIII	Average
Ca. carbonate, $CaCO_3$...	47.96	46.46	47.22	44.78	54.34	79.18	77.21	70.53	48.74	54.40	49.95	56.43
Mg. carbonate, $MgCO_3$.	44.45	48.92	37.50	34.26	41.00	6.38	3.91	23.49	29.27	41.63	40.41	31.94
Iron carbonate, $FeCO_3$..	1.41	....	0.73	0.59	0.79	....	....	....	....	0.90	....	4.11
Silica, SiO_2........	5.15	1.75	13.01	18.96	1.84	8.16	9.99	4.57	13.39	3.36	8.01	6.49
Alumina, Al_2O_3........	1.13	0.43	1 31	1.09	0.85	2.67	3.43	....	4.17	....	....	....
Ferric oxide, Fe_2O_3	....	....	....	....	....	2.43	2.69	0.73	1.52	1.11	0.31	1.60
Soda Na_2O........	....	....	....	....	....	trace	....	....	0.25	....	1.26	....
Potash K_2O........	....	....	....	....	....	trace	....	....	0.26	....	....	....
Water H_2O........	....	....	0.21	0.37	0.03	....	....	....	....	....	....	....
Lime CaO........	....	....	....	....	....	trace	....	....	....	0.12	0.13	....
Magnesia MgO........	....	....	....	....	....	0.04	....	....	....	....	....	....
Carbondioxide CO_2........	....	....	....	....	....	....	....	....	....	....	....	....
Organic matter........	....	....	....	....	....	0.80	....	....	0.14*	....	....	....
Totals........	99.30	97.56	99.98	100.05	98.94	99.66	99.14	99.32	97.74	101.61	100.07	....

* Phosphoric acid, P_2O_5.

Application and Summary. The foregoing analyses disclose rocks of a varied composition within the borders of the state. Were they the rock-floor which, directly beneath the workable soils were affording replenishment of the mineral substances of these soils, it would not be difficult to read the characters of the best crops in the tables of chemical constituents. But the work of the glacial period of geologic history must be given recognition. It is not alone that all the foregoing rocks have been covered by glacial drift in places to the depth of hundreds of feet by rock debris, but the very rocks themselves have been broken, torn up and scattered over wide areas.

What does occur, then, as soil-making material is the fragments of these rocks torn from the ledges and scattered broadcast over that glacial plain which the surface of the underlying rock-formations so plainly shows. True, much material derived from the underlying rocks within this state has been carried across the boundary to form the soil-material of neighboring states, while on the other hand no small amount brought from other regions has been deposited within the borders of this commonwealth. Its present occurrence is in the form of particles fine and coarse, which, by affording a large proportion of surface to bulk are rapidly disintegrating and yielding their chemical elements to be used as the food of growing plants.

If a further summary of this paper were written it would state: The term soil is defined. Soils are made by the mingling of rock-debris with the remains of organisms, chiefly plants, and its degree of fertility depends upon physical and chemical conditions combined. A soil fertile for one crop is not necessarily the best one for another type of plants. The chemical elements constituting the essential plant foods are few, yet these must be in such condition that the crops can readily secure them from the multitude of mixtures in which they occur. The rocks of Minnesota are classified under five groups; 1, acid crystallines; 2, basic crystallines; 3, sandstones and quartzites; 4, calcareous shales, and, 5, the carbonates. Among these, granitic rocks and basic eruptive, which occupy large areas beneath the drift in the northern and western portions of the state, furnish many important food elements, particularly alkalies and alkaline earths.

The sandstones and quartzites among the most barren soil producers have mingled with other substances their beneficent uses. The calcareous and siliceous shales spring from widely divergent geologic periods and bring to the making of soils somewhat different physical and chemical factors. Their influence is wholesome and strengthening. Finally the carbonates come before the eye in this chemical review. They yield, for soil making, carbonic acid, lime, magnesia and small quantities of other compounds. When the condition of a soil is reached, but a small percentage of these rocks is left, but this is a substantial part and enters into the constitution of the best soils of the state. They appear in full force in the southeastern corner of the state where stands a portion of that old glacial island, a tract over which the ice did not flow during the period when all the rest of the state was buried deep beneath the glacier.

December 8, 1891.

PLATE IV.

1, 2 and 3. Camarella owatonensis; showing ventral, dorsal and lateral views.

4, 5 and 6. Camarella bernensis; ventral, dorsal and lateral views.

7. Skenidium anthonensis x2; showing the cardinal area and deltidium, and ventral view of the same specimen.

8, 9, 10. Crania halli; (8) superimposed valves, lateral view, (9) interior ventral and (10) interior of dorsal valve.,

11, 12. Productella minneapolis; ventral valve and lateral view of the same.

13, 14. Discina concordensis; dorsal valve (partly exfoliated) and ventral valve.

15, 16, 17, 18. Zygospira (?) aquila x2; dorsal, ventral and lateral views, and (18) a section through the ventral valve of another specimen near the median line.

19 and 20. Rhynchonella sancta; anterior view and dorsal side showing one heavy concentric line.

21, 22 and 23. Rhynchonella minnesotensis; (21) ventral view of an average specimen; (22 and 23) dorsal and lateral of an antiquated individual.

24, 25. Leptæna minnesotensis; interior of a dorsal valve, a longitudinal section, and dorsal view of a large specimen.

26, 27, 28. Leptæna præcosis; dorsal and ventral views and longitudinal section of another specimen.

29, 30, 31, 32. Leptæna recedens; (29) ventral valve exterior, (30) interior of same, (31) interior of a dorsal valve with the cardinal processes broken off, and (32) longitudinal section.

33, 34, 35. Leptæna saxea; (33) longitudinal section, (34) dorsal view, and (35) interior of a dorsal valve.

36, 37, 38. Strophomena halli; exterior view from the concave side, (37) interior of a dorsal valve showing the triangular muscle scars, and (38) a longitudinal section.

39. Streptorhynchus subsulcatum; dorsal view.

PLATE V.

1, 2, 3, 4. Orthis rogata; (1) ventral view of a large specimen; (2) lateral profile, and (3 and 4) interior of two dorsal valves showing the muscle scars.

5, 6, 7. Orthis macrior; lateral, dorsal and anterior views.

8, 9, 10. Orthis corpulenta; dorsal, ventral and lateral views of an average mature specimen.

11, 12, 13. Orthis tersa; (14) interior of a dorsal valve; (12) dorsal view and (13) lateral view.

14, 15, 16, 17. Orthis minnesotensis; (14) ventral of an average specimen; (15, 16, and 17) ventral, dorsal and posterior views of a large individual.

18, 19, 20, 21. Orthis petrae; dorsal, ventral and posterior of an average specimen, and (21) dorsal of a younger (?) form.

22, 23, 24. Strophomena inquassa; interior of a dorsal valve, a longitudinal section and dorsal view, from three specimens.

PLATE VI.

1, 2. Tryblidium validum; dorsal and lateral views of a cast with the muscle scars emphasized on the latter figure.

3, 4. Tryblidium exsertum; lateral and dorsal views of an interior cast.

5, 6. Carinaropsis deleta; lateral profile and dorsal view.

7, 8. Metoptoma explanata; lateral and dorsal views.

9. Pleurotomaria clivosa; outline of a specimen with the direction of the concentric markings indicated.

10, 11. Fusispira spicula; (10) the specimens seen on a slab, and (11) reconstruction of the same.

12, 13. Holopea perundosa; apical view of a somewhat imperfect cast; transverse section of another specimen indicating the outline of the aperture.

14, 15, 16. Carinaropsis phalera; (14) outline of a cast, (15) longitudinal section with the lower part reconstructed from another specimen, and (16) transverse section near the highest elevation of another specimen.

17. Conchopeltis obtusa; interior cast in soft limestone.

18, 19, 20. Tellinomya lepida; (18, 19) interior and exterior of a left valve, and (20) posterior view.

21. Cypricardites minnesotensis.

22. Cypricardites vicinus; an interior cast reconstructed from another specimen on a slab so as to show the hinge and the outline of the exterior of the original shell.

23. Cypricardites triangularis; interior cast.

24. Tellinomya (?) candens; exterior and interior casts and dorsal view.

25, 26. Cypricardites luculentus.

PLATE VII.

1. Map of a Pre-historic Indian village.
2. Stone hammer (small).
3. Stone (2x8⅛ in.) probably used by medicine men in ceremonial.
4. Fragment of a water jar.
5. Double grooved stone ax.
6. Stone hammer.
7. Grinding stone.
8. Stone ax.
9. Medicine stone.
10. Peace pipe made of catlinite.
12. Copper serpents.
12. Ceremonial or monumental stone from a moung (grave).
13. Arrow shaft straightener of sandstone.
14. Flint spear point.
15. Bone stiletto.

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BULLETINS

OF THE

MINNESOTA ACADEMY OF SCIENCE

VOL. IV

1892 ---- 1910

INSTITUTED 1872

MINNEAPOLIS, MINN.

1910

CONTENTS

OFFICERS—1910

President	T. B. Walker
Vice-President	F. J. Wulling
Secretary	Harlow Gale
Corresponding Secretary	O. W. Oestlund
Curator	J. W. Franzen

TRUSTEES—1910

T. B. Walker, *Ex Officio.*
F. J. Wulling, *Ex Officio.*

Elected 1909—C. W. Hall; Term Expires 1912
Elected 1909—H. Gale; Term Expires 1912
Elected 1910—O. W. Oestlund; Term Expires 1913
Elected 1910—F. W. Sardeson; Term Expires 1913
Elected 1911—N. H. Winchell; Term Expires 1914
Elected 1911—E. C. Gale; Term Expires 1914.

PROCEEDINGS

OF THE

MINNESOTA ACADEMY OF NATURAL SCIENCES

VOLUME IV. BULLETIN I.

January 5, 1892.

ANNUAL MEETING.

Twelve persons present, with Vice President Nachtrieb in the chair.

The following reports of the retiring officers were read and placed on file:

Report of the Recording Secretary:

Report of the Treasurer:

Report of the Corresponding Secretary.

Treasurer Edw. C. Gale made the following financial statement:

Amount on hand at the last annual meeting	$122 92
Membership fees and election dues collected during the year	44 00
Total available for the year	$166 92
Paid to G. A. Clark for typewriting and duplicating	$ 9 50
" Frank White for services	10 00
" J. A. Schlener & Co., stationery	10 50
" N. W. Photo-Engraving Co	2 50
" L. Kimball Printing Co., on acct. of BULLETIN	112 00
Total paid out	$144 50
Balance on hand	$ 22 42

Corresponding Secretary C. S. Fellows reported the following additions to the library during the year 1891:

THE UNITED STATES.

Albany, N. Y.—New York State Library: Bulletins N. Y. State Museum, 2 to 10; Bulletin Legislative, No. 1; Bulletin Regents, Nos. 1 to 7; Bulletin State Library School, 1; Bulletin State Library additions, 1; Bulletin State Library Extension, 1; 73d Annual Report, Sept. 30th, 1890.

Baltimore, Md.—Maryland Academy of Sciences: Transactions, Vol. 1, pp. 1-68.

Johns Hopkins University: Circulars Nos. 69, 72, 74, 77, and Vol. x, Nos. 85 to 94.

Boston, Mass.—Massachusetts Horticultural Society: Transactions, 1889, Part 2, and 1888, Part 1; Schedule of Prizes for 1889 and for 1891.

Boston Society of Natural History: Proceedings, Vol. xxiii, Parts 3 and 4; and Vol. xxv, Parts 1 and 2.

American Academy of Arts and Sciences: Proceedings, Vol. xxv.

Buffalo, N. Y.—Buffalo Historical Society: Annual Reports, Jan. 8, 1889, and Jan. 13, 1891.

Cambridge, Mass.—Museum of Comparative Zoology: Annual Reports, 1890, 1891; Bulletins, Vol. xvi, Nos. 3, 4, 5, 10; Vol. xvii, Nos. 3, 4, 5; Vol. xx, Nos. 4 to 8, and xxi, Nos. 1 to 4.

Chapel Hill, N. C.—Elisha Mitchell Scientific Society; Journal, Vol. vi, Part 1; Vol. vii, Part 2; Vol. viii, Part 1.

Cincinnati, O.—Cincinnati Society of Natural History: Journal, Vol. xi, Part 4; Vol. xii, Part 1; Vol. xiv, Parts 1 and 2.

Historical and Philosophical Society: Annual Report for 1890.

Columbus, O.—Geological Survey of Ohio: First Annual Report of Third Survey.

Denison, O.—Denison University: Bulletin of Scientific Laboratory, Vol. iii and Vol. vi, Part 1.

Davenport, Ia.—Davenport Academy of Natural Sciences: Proceedings, Vol. v, Part 1 (pp. 1 to 184).

Denver, Colo.—Colorado Scientific Society: Proceedings, Vol. iii, Part 1.

Hartford, Conn.—Connecticut Historical Society: 250th Anniversary of adoption of First State Constitution.

Iowa City, Iowa.—State Historical Society of Iowa: Iowa Historical Record, Vol. v, and Vol. vii, Parts 2, 3 and 4.

Jefferson City, Mo.—Geological Survey of Missouri: Biennial Report and Bulletins 1 to 5.

Lansing, Mich.—State Agricultural College: 29th Annual Report, and General Index of Reports; Bulletins Nos. 43 to 48 and No. 70; First Report of Forestry Commission, 1887-8.

Lincoln, Neb.—University of Nebraska: University Studies, Vol. i, No. 2.

Little Rock, Ark.—Geological Survey of Arkansas: Annual Report, 1888, Vols. i, ii, iii.

Madison, Wis.—State Historical Society of Wisconsin: Proceedings of 36th and 38th Annual Meetings, 1889 and 1891.

Meriden, Conn.—Meriden Scientific Association: Transactions, Vol. III (1887-8) and Vol. IV (1889-90).

Middletown, Conn.—Wesleyan University: 18th and 20th Reports of Curator of Museum.

Milwaukee, Wis.—Wisconsin Natural History Society: Proceedings, 1889, pp. 191-231.

Public Museum of the City of Milwaukee: Annual Reports of Trustees, 1883 to 1891 (9 pamphlets); Final Report of Committee on Subscription to Ward Museum Fund, 1885.

Minneapolis, Minn.—University of Minnesota: Annual Report; Bulletin of Agricultural Experiment Station, Nos. 5 to 9 and 16 to 18.

Newark, N. J.—New Jersey Historical Society: Proceedings, Vol. x, No. 3; Vol. XXI, No. 2; New Jersey Archives, First Series, Vols. XIII, XIV; Biographical Sketch of Moses Bigelow.

Geological Survey of New Jersey: Annual Report of Survey, 1889, (and same in German language); Final Report, Vol. II, Parts 1 and 2.

Newport, R. I.—Newport Natural History Society: Proceedings, Document VII.

New York, N. Y.—New York Academy of Sciences: Transactions, Vol. VIII, Parts 1-8; and Vol. x, Parts 1, 2, 3, 4, 5, 6; Index to Vol. IX.

New York Microscopical Society: Journal, Vol. v, 1889, Nos. 1, 2, 3, 4; and Vol. VII, Nos. 2, 3, 4.

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American Museum of Natural History: Bulletin, Vol. II, No. 8; and Vol. III, pp. 41-116, and 123-194; Annual Report of Trustees, 1888-9 and 1890-1.

Philadelphia, Pa.—Academy of Natural Sciences: Proceedings, 1888, Part III; 1889, Parts I, II; 1890, Part III, and 1891, Part I.

Zoological Society of Philadelphia: 17th Annual Report, 1889, and 19th Report, 1891.

Second Geological Survey of Pennsylvania: Atlas of Southern Anthracite Coal Fields, Parts 3 and 4, AA; Atlas of West Middle Coal Fields, Part 3, AA; Atlas Northern Coal Fields, Part 6, AA, and Parts 3 and 4; South Mountain Sheets, C, 1, 2, 3, 4, and D, 1 to 6; Reports HH and HHH; Museum Catalogue, 3, OOO; Annual Report, 1887; Report of Progress, F, 3; Dictionary of Fossils, Vol. II, N to R; Dictionary of Fossils, Vol. III, S to Z.

Portland, Me.—Portland Society of Natural History: Proceedings of Annual Meeting, May 20th, 1889.

Catalogue of Birds.—N. C. Brown.

Poughkeepsie, N. Y.—Vassar Brothers' Institute: Transactions, Vol. V (1887 to 1890).

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Rollo, Mo.—Missouri School of Mines: Scientiæ Baccalaureus, Vol. 1, Part 3.

San Diego, Cal.—West American Scientist, C. R. Orcott: The Journal, 1889, No 43, May; 45, July; 46, August; 47, September; 48, October; 49, November.

San Francisco, Cal.—California Academy of Sciences: Proceedings, Series 2, Vol. I, Parts 1, 2; and Vol. III, Part 1.

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Saint Louis, Mo.—St. Louis Academy of Sciences: Transactions, Vol. V, Parts 1 and 2, and Total Eclipse of the Sun, Jan. 1, 1891.

Missouri Botanical Garden: Second Annual Report (for 1890).

Saint Paul, Minn.—Minnesota Historical Society: 6th Biennial Report, and Historical Collections; Vol. VI, Part 2.

Salem, Mass.—American Association for Advancement of Science, F. W. Putnam, Permanent Secretary: Proceedings, Vol. XXXVII, Meeting of 1888 at Cleveland; Proceedings, Vol. XXXIX, Meeting of 1891 at Washington.

Topeka, Kan.—Washburn College Laboratory of Natural History: Bulletin, Vol. II, No 9, January, 1889.

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St. Johns, N. B.—Natural History Society of New Brunswick: Bulletins Nos. 8 and 9, and Index to Bulletins 1 to 5.

St. Lo, France.—Société d'Agriculture, d'Archeologie et d'Histoire Naturelli de la Manche: Notices, Memoires et Documents, 9th Volume.

Semur, France.—Société des Sciences Historiques et Naturelles de Semur: Bulletin, 2d Series, No. 4, 1889.

Shanghai, China.—Royal Asiatic Society (China Branch); Journal, Vol. XXII, No. 6; and Vol. XXIII, Nos. 1, 2, 3.

Stavanger, Norway.—Stavanger Museum: Aarsberetning for 1890.

Strassburg, Germany.—Kom, für die Geologische Landes Untersuchung: Mittheilungen Band I, II and III, No. 1.

Sydney, N. S. Wales.—Geographical Survey of New South Wales: Memoirs of the Survey; Paleontology, No. 2 and No. 7; Records of the Survey, Vol. I, Parts 1 and 2, and Vol. II, Part 2; Annual Report of Department of Mines, 1890; Descriptive Catalog of Exhibits of Metals, Minerals, &c., to the Melbourne Cen. International Exhibition, 1888.

Royal Society of New South Wales: Journal and Proceedings, Vol. XXII, Parts 1 and 2; and Vol. XXIV, Parts 1 and 2.

Tokio, Japan.—Deutsche Gesellschaft für Natur und Volkerkunde Ostasiens: Mittheilungen, Heft 46.

Toronto, Canada.—Canadian Institute: Proceedings, 3d Series, Vol. VI, No. 2; Transactions, No. 1, Vol. I, Part 1; Transactions, No. 2, Vol. I, Part 2; Transactions, No. 3, Vol. II, Part 1; Report for 1887 and Maps; Fourth Annual Report, 1890-1.

Time Reckoning for the 20th Century.—Sanford Fleming.

Toulouse, France.—Acad. des Sciences, Inscriptions et Belles-Lettres de Toulouse: Memoirs, New Series, Tome II, 1890.

Townsvill, Australia.—Geological Survey of Queensland: Report of Annual Progress, 1889.

Chillagoe and Koorboora Mining Dists., from J. S. Jack, Author.

Turin, Italy.—R. Museo Zoologico di Torino: Bollettino, Vol. III, Nos. 49 to 52, and Plate No. 3; Vol. IV, Nos. 53 to 61 and Plate No. 1; Vol. V, Nos. 87 to 93, title and index; Vol. VI, Nos. 94 to 103.

Vienna, Austria.—Verein der Geographen an der K. K. Universität: Bericht u. d., XVI Vereinjahr.

Wiesbaden, Pruss.—Verein für Naturkunde: Jahrbücher, Jahr. 44.

The following officers were elected for the year:

President, - - - -	Henry F. Nachtrieb.
Vice-President, - - -	Thomas S. Roberts.
Recording Secretary, - -	Christopher W. Hall.
Treasurer, - - - -	Edward C. Gale.
Corresponding Secretary,	William H. Pratt.
Trustees for three years,	Louis F. Menage. S. P. Channell.

February 2, 1892.

Regular monthly meeting.

Fifteen persons present.

Prof. H. L. Osborn read a paper on "The rodentia in evolution; a preliminary study." [See paper A.]

A letter dated November 12, 1892, from Mr. D. C. Worcester, of the Menage Scientific Expedition to the Philippine Islands was then read by Secretary Hall. Following this, President Nachtrieb read the description of a new species belonging to the family Lemuroidea, sent by Mr. Worcester for prompt publication. An abstract of the description has been published in the *Zoologische Anzeiger.* No. 389, 1892.

The following were elected members. Prof. W. R. Appleby, Charles P. Berkey, and Arthur H. Elftman, all of the University of Minnesota.

March 8, 1892.

Twenty-three persons present.

The following papers were presented:

Notes on the genus *Laciniaria* in Minnesota, by E. P. Sheldon. [See paper B.]

The classification of the Metaphyta by Prof. Conway MacMillan.

[ABSTRACT.]

In this paper an attempt is made to indicate the dual nature of the species among higher plants, in which both sporophytic and gametophytic structures may be distinguished, upon the presence or absence of the sporophyte, plants are classified into *Gamophyta* and *Sporophyta* and the subdivisions of these groups are indicated. The futility of attempts to homologize, after the ordinary manner, higher plants with higher animals is pointed out and the proper course in the search after a basis for comparison between the two principal phyla of living things is suggested. The paper is published in full in Vol. XVII, pp. 108-113 of the *Botanical Gazette* (1892).

Current methods in botanical instruction by Professor MacMillan.

[ABSTRACT.]

The ordinary attitude of educators towards the science of botany is described and criticised. A plea is entered for the emancipation of botany from its bonds to medicine and the establishment of it, as physics or chemistry, upon a pure basis, where the *knowledge* of the plant rather than the

classification of the plant should be deemed important. The methods of botanical instruction, or what too often passes for it in American schools, colleges and universities, are discussed and the better developments in some particularly fortunate institutions are briefly chronicled. In conclusion the constructive work and influence of men like Draper or Bessey is considered and an effort is made to show the urgent need of a still more widespread reform. The paper is published in full in *Education*, March, 1892.

Preliminary notes on the influence of anæsthetics on plant transpiration, by Dr. A. Schneider.

[ABSTRACT.]

The paper gives a brief review and criticism of Jumelle's memoir on the same subject. Jumelle came to the couclusion that ether increases transpiration in the light, but decreases it in the dark. The increase in light is supposed to be due to the influence of ether on assimilation. Ether decreases assimilation and hence those rays of the sun which were engaged in assimilation are now utilized in "chlorophyllian transpiration." Lommen, in 1891, made a series of experiments which apparently verified Jumelle's conclusions.

Jumelle's as well as Lommen's experiments are insufficient because they used only parts of plants (leaves and branches), and in that they confounded *evaporation* and *transpiration.*

In the writer's experiments, a modified and improved Kohl transpiration apparatus was used which allowed the use of the entire plant, root and all. Various anaesthetics as ether, chloroform and amyl-nitrite were used. The effect of ether on protoplasmic movements in hair cells of *Primula sinensis*, *Petunia violacea*, and *Lycopersicum esculentum* was carefully noted. The influence of the various colors of the solar spectrum on transpiration under normal conditions and combined with the anaesthetics was then taken up and also the influence of anaesthetics with moisture. Finally a series of control experiments was made with leaflets of *Solanum tuberosum.*

The summing up of all the results obtained led to the following conclusions:

1. Ether retards protoplasmic action. Given in sufficient doses it kills protoplasm.
2. Ether *retards* transpiration by *retarding* assimilation.
3. Ether retards transpiration in both light and darkness, in fact, under all conditions.
4. The increased loss of water vapor by the anaestheticized vegetable tissue is due to the fact that the anaesthetic has modified the primordial utricle, thus allowing *evaporation* to take place, and not *transpiration.*
5. Periods of maximum transpiration and assimilation coincide.

James W. Swan, White Bear Beach, and Professor I. H. Orcutt, Brookings, South Dakota, were elected members.

April 5, 1892.

Twelve persons present.

The papers read were:

Notes on the Alpine characteristics of the flora of the Coteau des Prairies, by E. P. Sheldon. [See paper C.]

Some poisonous plants around Winona, Minnesota, with descriptions of their characters, by C. W. McCurdy, read by Professor Conway MacMillan.

[ABSTRACT.]

Attention is called to the poisonous properties of the following plants which are either native or introduced in the neighborhood of Winona, Minn.: *Actara spicata* Linn., *Aconitum napellus* Linn., *Ranunculus sceleratus* Linn., *Hellborus niger* Linn., *Rhus toxicodendron* Linn., *Rhus venenota* D. C., *Solanum nigrum* Linn., *Atropa belladonna* Linn., *Solanum dulcamara* Linn., *Hyoscyamus niger* Linn., *Datura stramonium* Linn., *Pastinaca sativa* Linn., *Conium maculatum* Linn., *Cicuta maculata* Linn., *Archemora rigida* D. C., *Aethusa cynapium* Linn., *Taxus baccata* Linn., *Kalmia augustifolia* Linn., *Symplocarpus fortidus* Nutt., *Arisaema triphyllum* Torr., *Digitalis purpurea* Linn., *Lobelia inflata* Linn., *Phytolacca decandra* Linn., *Urtica gracilis* Ait., *Andromedo mariana* Linn. The frequent occurrence of poisonous Agarics is also noted and it is recorded that the flesh of edible toadstools does not become discolored when broken, while that of the poisonous species quickly changes to a deep blue or purple color.

O. A. Stoneman was elected a member of the Academy.

May 3, 1892.

Eighteen persons present.

The papers presented were the following:

Motion and life by Professor L. W. Chaney.

Remarks on some recent investigations on Phagocytes; and the relation of Protozoa to disease, by Professor Henry F. Nachtrieb.

[ABSTRACT.]

Metchnikoff's recent valuable contributions to our knowledge of phagocytes were briefly reviewed and their importance pointed out.

The last edition of Pfeiffer's "Die Protozoen als Krankheiterreger" was briefly reviewed and compared to some of the earlier works on Bacteriology in that the subject was still in a rather chaotic condition and at the same time was full of promise. The subject undoubtedly is one of great importance. It is also one of great difficulty, possibly is surrounded by greater difficulties than Bacteriology was in its earlier days, since it is impossible at present to cultivate any of the various protozoa that are cell parasites

—that is, parasites within the individual cells of the body. More experiments, larger knowledge and improved technique may, however, soon remove this apparently insurmountable barrier.

Recent views concerning the embryo-sac of Angiosperms and the cells produced by it, by Professor Conway MacMillan.

[ABSTRACT.]

Current discussion concerning the homologies of the Metaspermic embryo-sac is somewhat clarified by recent papers of Guignard, Hartog, Bretland-Farmer, and others. The notion that the endosporic cells are not in the nature of a female gametophytic plant has been again argued by Guignard, upon the bases of his researches concerning the number of chromatomeres in the equatorial plane of vegetative and reproductive nuclei. This view has already, from other morphological evidence, been advanced by Warming, Vesque and Mann, but is, on the whole, not to be credited because of the distinct homologies with the embryo-sac of Archispermous plants, like Cycas, where the embryo-sac is clearly a megaspore, and on account of other and simple explanations of the number of nuclear segments in the definitive nucleus of the sac before the divisions of germination.

Considering the embryo-sac in all cases then, as a spore and not as a special spore-mother-cell, it becomes evident that the traditional explanation of the seven cells which are produced within it in the Metaspermæ is not far from the truth. They represent a degraded and symbiotic sexual plant, forming the female of the same generation as that in which the pollen-tube is the symbiotic male.

The older view that the antipodal cells represent the prothallium of the female plant is, however, not to be maintained, and in evidence the results of certain examinations of different pollen-tubes and embryo-sac contents were adduced. It will be found that in the case of *Narcissus*, *Cucurbita* and others, the staining of the second polar cell of the egg and that of the sperm nucleus is similar in all points, and that in structure, size and reactions to safranin, dahlia and other dyes, these nuclei are readily comparable. On the other hand, the antipodal cell that migrates to the top of the embryo-sac, where it finally fuses with the second polar cell of the egg, otherwise known as the micropylar endosperm-forming nucleus, is comparable more directly with the other micropylar cell which is universally recognized as having the character of an egg. In size, structure and chemism, these cells are similar. It therefore appears that the antipodal cells, as is determined by Hartog, upon a purely theoretical basis, are *experimentally* seen to have the character, not of prothallium, but of an archegonium, and the embryo-sacs of Metaspermæ are *universally characterized by the production of two eggs*. One of these is cross-fertilized by the sperm nucleus of the pollen-tube, and develops the embryo of the seed. The other is close-fertilized by the polar body of the micropylar egg and develops a dependent sporophytic plant, the endosperm, and this is destroyed, either during processes of seed-ripening or of seed germination, in both of which it comes into

competition with the more robust cross-fertilized sporophyte. It is apparent then that polyembryony is the rule among the Metaspermæ and that every seed, at some time in its life (with the possible exception of some orchids), bears within its coats two plants, only one of which has the strength to develop into an embryo and ultimately into a seedling and mature sporophytic structure.

It is maintained then, that the Metaspermæ are peculiarly characterized by persistent specific dimorphism of a high grade and this alone serves to limit them from all other living things. Each specific form consists of four potential individuals, where the dimorphism is at its height. These are (*a*) the male plant or pollen-tube, (*b*) the female plant or embryo-sac contents (and in the Metaspermæ the female is binovular), (*c*) the staminate, sporophytic plant of vegetative specialization, and (*d*) the pistillate, sporophytic plant—also of vegetative specialization.

S. P. Channell presented a beautiful piece of Sphalerite from Joplin, Mo., for which the secretary was directed to extend the thanks of the Academy.

The meeting adjourned until the second Tuesday in June instead of the first, as regularly, owing to the Republican National Convention.

June 14, 1892.

At this meeting there was no quorum, but Mr. Uly S. Grant presented a paper on "The stratigraphical position of the Ogishke Muncie conglomerate of northeastern Minnesota,"* of which the following is an

[ABSTRACT.]

A brief review of the first description of this great conglomerate is given, followed by a summary of the opinions of the geologists who have worked in this region, in regard to the relation of this formation to the surrounding rocks. The relation of the conglomerate to the rocks in its immediate vicinity, and especially to the Saganaga granite, was discussed and the following conclusions arrived at: The Ogishke Muncie conglomerate can no longer be correlated with the Animikie, as has often been done, for the two are separated by a great structural break and an immense erosion interval. The conglomerate grades, both along and across the strike, into rocks which have as yet not been separated from the Keewatin series. At present it seems best to regard the conglomerate as an upper member of the Keewatin.

October 4, 1892.

Twelve persons present.

The following program was heard:

*This paper is published in the American Geologist for July, 1892, pp. 4-10.

Notes on an excursion into northern Mexico.—A. D. Meeds.

[ABSTRACT.]

On October 4, 1891, the writer having been granted a leave of absence from the University of Minnesota, left Minneapolis for El Paso, Texas, where he joined Dr. Carl Lumholtz, the Norwegian explorer, who was about to continue his expedition in northern Mexico. The expedition* had started the previous year from Bisbee, Arizona, and at this time the party was near Casas Grandes, in northwestern Chihuahua, where they had spent the summer exploring the many ruins and mounds of the early inhabitants. A very valuable collection of pottery, utensils, etc., was made and sent to the American Museum of Natural History, New York, under whose auspices the expedition was undertaken.

The general object was to explore and study the prehistoric ruins, to make collections of animal and plant life, and of rocks and minerals, in order to advance our knowledge of an unmapped and little known territory. The region to be explored was in the inaccessible Sierra Madre mountains lying along the boundary between the states of Sonora and Chihuahua, in northern Mexico. These mountains from their ruggedness had been the lurking place of hostile bands of Indians, especially Apaches, who had terrorized the surrounding country, carrying death and destruction into the pueblos and driving all settlers out of the country. They had been masters of the region for many years and were only captured and dislodged by Gen. Crook in his famous campaign.

The early Spaniards had been through this country centuries before and had left traces in the way of abandoned smelters, mines, etc. The Mexicans told fabulous stories of this wonderful country. It had been reported and was believed by some scientific men, that a tribe of Cliff Dwellers still existed in their natural state, in the barrancas of this *terra incognita*.

Casas Grandes is about 150 miles directly south of Deming, N. M., where the explorers left the railroad, and about the same distance southwest of El Paso, Texas. It is on a river of the same name which flows through the sandy plain, enclosed on the east and west by mountains. The topography of the country is very similar to that of Texas and New Mexico, of which it is, in fact, a continuation. From this point the expedition traveled in a southerly direction, climbing immediately into the mountains and continuing along their crests the greater part of the time. These mountains vary from 6,000 to 9,000 feet high, and during the winter are covered with snow, the weather at this time being very similar to a mild Minnesota winter.

The party consisted of the leader, Dr. Carl Lumholtz, G. H. Taylor, topographer and photographer, C. V. Hartman, botanist, J. H. Locke, in charge of accounts, A. D. Meads, naturalist, and about a dozen Mexicans for general work.

Leaving Casas Grandes, about 4,500 feet above sea level, the region of the pines was reached, ranging from 6,000 to over 8,000 feet, and a few

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*See account of the Expedition in Scribner's Magazine, November, 1891.

days brought the party to the Mormon colony of Bacheco located in a small valley or plain in the mountains. This was the last settlement seen for about a month. Mount Chuhuichupa was passed, where Gen. Crook had captured the Apaches, and the great difficulties and dangers he must have encountered were here realized. Traveling was very difficult and slow and attended by great danger in the roughest part of the mountains. The fall of an animal down some steep cliff became a common occurrence. The scenery was full of grandeur. In the very heart of this region were passed the ruins of smelters built by the early Spaniards who had worked the mines at Guaynopa and other points which are now abandoned.

The party soon left this wild region, striking the town of Temosachie, on the main traveled trail to the mining district of Pinos Altos. The trails were fairly good through the mining towns of Pinos Altos and Jesus Maria, and various small pueblos on the road to Batopilas These pueblos were inhabited partly by Mexicans and partly by Indians, all very poor and possessing a very low order of intelligence. The Indians encountered were mostly Tarahumaras, who raise flocks of sheep and goats and cultivate small plats of land on the mountain slopes and in the valleys, and are usually honest and peaceful.

Before reaching Batopilas another extremely rough country was traversed in the Barranca de Cobre, where an English company is working an old mine. The cañon here is about 4,000 feet deep, and the trails are very steep and dangerous. Batopilas is about a week's journey from here and is situated on a river at the bottom of a deep cañon, about 2,500 feet above sea level. It is in the southwestern corner of Chihuahua, near the states of Julisco and Durango. It is one of the largest and richest mines in the state and is owned by Americans. At this point, which is in the neighborhood of 400 miles south of Deming, but in reaching which probably double that distance was traveled, the party was disbanded in May, 1892. Dr. Lumholtz decided that the main object of the expedition, the proof of the existence or non-existence of Cliff Dwellers, could be better accomplished by his traveling alone, obtaining Indian guides as he found it necessary. A full account of the expedition will probably be published in the Bulletin of the American Geograpical Society, New York, when Dr. Lumholtz finally completes his exploration. He contemplates publishing a book describing the people and country, with incidents of the expedition.

Observations on the collections of minute aquatic forms made by Messrs. Worcester and Bourns in the Philippine Islands, by Chas. S. Fellows.

[ABSTRACT.]

At the writer's suggestion, on their expedition to the Philippine Islands Messrs. Worcester and Bourns took with them apparatus especially designed for the collection and preservation of minute aquatic forms.

Unfortunately the apparatus was lost, and in the early part of their stay no collections of these forms were made.

After new apparatus was received they were enabled to collect and send eleven small gatherings, five of which were from fresh water and the remainder from brackish and salt water.

The collections were all made at and near Puerto Prinusa, Paragua (Palawan) during December, 1891, and February, 1892.

From the fresh water gathering were found one species of Ostracoda (undetermined); two of Cladocera, *Daphnella* and *Bosmina* (only two specimens of the former and one of the latter have as yet been recognized). There were found of the Copepoda, one species of *Cyclops* and one of *Diaptomus*, the latter new to science.

The salt water gathering yields one new genus, a calanid, and seven species of as many genera, as follows: *Ectinosoma, Amymone, Laophoute, Westwoodia, Harpacticus, Porcellidium* and *Lichomolgus*.

It is a curious circumstance that although the "Challenger" made no less than four gatherings at the Philippine Islands, one of which was in the harbor of Zeba where the above forms would likely be found, only one was then found, *Ectinosoma*, a single specimen of which was secured and that at Ascention Island.

Several species of Amphopods were found but have not as yet been studied.

The collections are now receiving a thorough examination and will be fully reported upon shortly. Only a few mature specimens have as yet been detected among the fresh water forms and a further supply of material is awaited that the forms may receive more thorough examination.

Secretary Hall gave an outline of recent news received from the Menage Scientific Expedition; also an account of the present state of the taxidermic work of Mr. Hobson.

The meeting was then adjourned to the second Tuesday instead of the first in November an account of election day.

November 13, 1892.

Twenty-one persons present.

Three papers were read:

Outlook for a cholera epidemic in 1893, by Dr. A. Schneider.

[ABSTRACT.]

In this paper the author criticises American carelessness and incompetence to cope with great epidemics. The first part of the paper was devoted to a short review of the history of various cholera epidemics since 1817, after which was given some of the evidence of the most prominent cholera bacteriologists as Koch, Hueppe, Fraenkel and others. Missionaries, ministers and other non-professionals are severely criticised for expressing erroneous opinions in regard to the prevention and treatment of cholera.

The main feature of the paper is the cholera outlook in 1893. Owing to the fact that cholera has already made its appearance and that it usually continues its ravages for several years it can be expected to make its appearance the coming year, especially if the weather be moist and warm. Knowing that cholera follows the routes of commerce and knowing that there will be an enormous increase of traffic and immigration on account of the Columbian World's Fair in Chicago, a cholera epidemic is thereby much more liable to occur. The cities near the St. Lawrence river, the great lakes, the Atlantic and Gulf of Mexico will be particularly exposed.

The writer does not attach any special importance to arresting immigration unless all commercial intercourse were also stopped and that would be more harmful than the epidemic itself. The plan suggested is to appoint thoroughly qualified national health officers with police authority to look after the sanitary conditions of every city in the Union. This should begin *now* and not after the cholera has made its appearance. Cholera can be easily prevented if proper precautions are taken, and even after it has made its appearance it is easily controlled under proper treatment.

A map accompanied the paper showing the probable routes and distribution of cholera in 1893.

This paper was discussed by Dr. E. S. Kelley, health officer of Minneapolis, and others.

The Saint Peter sandstone by F. W. Sardeson. [See Paper D.]

The Rum river valley as a botanical district, by E. P. Sheldon; read for the author, by C. A. Ballard. [See paper E.]

December 6, 1892.

Twenty persons were present.

Corresponding Secretary W. H. Pratt, presided.

The following program was carried out:

A review of some points in the history of microscopy, by Chas. P. Berkey.

The subject was treated for the most part historically. The object was to note the early inventions of lenses, and to trace the various subsequent important improvements in both simple magnifiers and in combinations up to the early part of the present century. A chart was used to illustrate the appearance and adjustment of Leeuwenhoek's simple microscopes. In conclusion the paper outlined some of the late improvements and called attention to the broadened usefulness of the instrument in the last fifty years.

The use of the microscope in the study of the plant lice. —O. W. Oestlund.

[ABSTRACT.]

Attention was called to the insufficiency of the characters generally used by entomologists for the distinction of species of the aphididæ as the number is constantly increasing. In the wings we have good characters for genera and higher groups, but usually of little use for species. The relative length of the joints of the antennæ are subject to too great variation to be much relied upon. A knowledge of the food-plant is not sufficient as exceptions are constantly being brought to light. Color is in all the larger genera, where specific characters are most needed, of little value. It therefore, in many cases, becomes necessary to seek for additional characters to those commonly given.

A study of mounted specimens under the microscope brings out several characters that promise to be of great value, at least for the more difficult genera, one of the most important of which are the *sensoria*, or small sense spots distributed over the surface of the antennæ, which have been found quite constant, both in size, number and distribution. A summary of the results of a study of the sensoria of the Minnesota species was given; a full account of which will appear in a final report on this family in the publications of the Geological and Natural History Survey of Minnesota.

A new locality for cobalt in Minnesota, by A. D. Meeds.

[ABSTRACT.]

While examining a sample of manganese ore from Monticello, Minn., indications of cobalt were noticed and further examination proved it to be present in small quantity. As cobalt had not been reported from Minnesota before, so far as known, a determination of the cobalt was made. The ore under examination was a bog ore and contained much organic matter. It was first ignited and the ash submitted to partial analysis, resulting as follows:

Manganese, Mn.,	35.70
Iron and Alumina, Al_2O_3, Fe_2O_3,	4.63
Cobalt Oxide, Co O,	0.71
Insoluble, Si O_2,	28.33

Cobalt in small quantity seems to be quite constant in its occurrence in bog manganese ores and its appearance here is not surprising.

Although a number of samples of manganese ore from Monticello have been examined, this is the only one so far that has shown any sign of cobalt.

This paper was discussed briefly by H. V. Winchell, who stated that recently obtained samples of pyrrhotite from the lower part of the Huronian series near Gunflint lake, T. 65, R. 4 W., had been found to contain traces of cobalt and about three per cent. of nickel. This is supposed to be at the same geological horizon as the Sudbury, Ont., nickel deposits.

The Fauna of the Magnesian Series of the northwestern states; with descriptions of new species by F. W. Sardeson. [See paper F.]

The structure, lithology and genesis of the Magnesian Series of the northwestern states, by C. W. Hall. [See paper G.]

Supt. Robert P. A. Nix, New Ulm, Minn., Prof. W. V.

Metcalf, Northfield, Minn., Prof. Philip Smith, Faribault, Minn., and Dr. Walter C. Hanscom, Minneapolis, were elected members.

Secretary Hall introduced the following resolution:

Resolved, That this Academy, always aiming to advance scientific knowledge and culture in the community, shall secure for the coming winter a series, three to six in number, of lectures from our members. These lectures will treat the subjects which they discuss in a somewhat more popular manner than our monthly programs are accustomed to do.

The resolution was unanimously carried, and President Nachtrieb and W. H. Pratt were directed to appoint a committee of three to secure the lecturers and arrange the meetings for the same.

January 3, 1893.

ANNUAL MEETING.

President Nachtrieb in the chair.

Sixteen persons present.

The report of the following officers were read:

Report of Recording Secretary Hall; the first part touching the scientific work of the Academy, was ordered filed, and the second part, giving the statement of dues and collections, was referred to the auditing committee.

The report of the Treasurer, E. C. Gale, was then read:

SUMMARY OF TREASURER'S REPORT FOR THE YEAR 1892.

1892.			
Jan. 5	By Balance from 1891		$17 42
Jan. 5,'92 to Jan. 3,'93	Collections of Annual dues through Prof. Hall		304 00
Feb. 22	R. J. Mendenhall, on life membership		10 00
Mch. 11	Bishop McGolrick, on life membership		50 00
Feb. 23	Judge Vanderburgh, for Cross Collection		10 00
Jan. 5,'93	T. B. Walker, for Menage Collection, taxidermy		390 00
	CONTRA.		
Feb. 4	To Cash to Kimball, for printing	$150 00	
Mch. 4	Cash to Rev. R. T. Cross, for collection	45 00	
Mch. 25	Certificate deposit, Permanent fund	60 00	
	N. W. Photogravure Co., for plates	43 25	
	J. Hobson, for taxidermist services	418 10	
	J. Hobson, for taxidermist supplies	27 42	
	Typewriting and office sundries	18 16	
	Express and Miscellaneous expenses	29 85	
	Deficit, balance due Treasury		10 36
		$791 78	$791 78

The report of the corresponding secretary was read. Mr. Pratt reported the number of additions from the United States to be 224; from foreign countries, 396; total, 620 titles, as follows:

THE UNITED STATES.

Albany, N. Y.—State Museum of N.Y.: Bulletin, Vol. I, No. 1; 44th Annual Report, Bound.

University of the State of New York: State Library Bulletin, No. 2; 104th Report of Regents, 3 parts, *Bound*—viz. No. 1, "Bulletins;" No. 2, "Colleges;" No. 3, "Academies."

Baltimore, Md.—Johns Hopkins University: University circulars, Vol. XI, Nos. 95 to 100.

Boston, Mass.—American Academy of Arts and Sciences: Proceedings, Vol XXVI, 1890-91.

Massachusetts Horticultural Society: Transactions, 1890, Part II; 1891, Parts I and II; 1892, Part I: Schedule of Prizes for 1892.

Marine Biological Laboratory: Annual Report, No. 4.

Boston Society of Civil Engineers: Committees Report on Weights and Measures.

Boston Society of Natural History: Proceedings, Vol. XXV.

Bridgeport, Conn—Bridgeport Scientific Society: List of Birds of Bridgeport.

Buffalo, N. Y.—Buffalo Historical Society: Annual Report, Jan. 1892.

Cambridge, Mass.—Museum of Comparative Zoology: Bulletin, Vol. XXII, Nos. 1, 2, 3, 4; Vol. XXIII, Nos. 1, 2, 3.

Harvard College: Report upon Athletics, June 1888.

Champaign, Ill.—Illinois State Laboratory of Natural History: Articles XI and XII of Vol. III: Article I of Vol. IV, and Bulletin, Vol. III.

Chicago, Ill.—Chicago Academy of Sciences: Bulletin, Vol. II, No. 1.

University of Chicago: Program of Course in Social Science, etc. "Some First Steps in Human Progress."

Chapel Hill, N. C.—Elisha Mitchell Scientific Society: Journal, Vol. VIII, Part 2.

Cincinnati, O.—Cincinnati Society of Natural History: Journal, Vol. XIV, Nos. 3, 4; Vol. XV, Nos. 1, 2.

Denver, Col.—Colorado Scientific Society: Proceedings, Vol. III, Part 3.

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Cherbourg, France.—Societe Nationale des Sciences Naturelles et Math: Memoires, Tome XXVII.

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Zurich, Switz.—Naturforschende Gesellschaft: Vierteljahrschrift, Jahrg. 36 (Heft 2, 3, 4) and 37 (Heft 1, 2).

The Academy then proceeded to the election of the following officers:

President, - - -	Henry L. Osborn.
Vice-President, - -	Conway MacMillan.
Recording Secretary,	Christopher W. Hall.
Treasurer, - - -	Edward C. Gale.
Corresponding Secretary,	William H. Pratt.
Trustees for three years,	W. H. Leonard. C. W. Hall.

The persons directed at the December meeting of the Academy [see page 19] to name a Committee to take in charge the organization of a course of lectures for the Academy, named the following as such committee: W. H. Leonard, C. S. Fellows and A. H. Brackett.

Professor MacMillan read a letter which the Academy had received from Dean C. Worcester, of the Philippine Islands expedition.

Secretary Hall recommended that the letters received by the Academy from the expedition be edited and printed in the next Bulletin. The recommendation was adopted.

The following were elected members of the Academy:

W. M. Quayle, 3132 Grand avenue, Minneapolis.

L. B. Avery, the Normal School, St. Cloud.

February 6, 1893.

Seventeen persons present.

The following program was presented:

The Adaptation of structure to fossorial habit in the Pocket Gopher, *Geomys bursarius*, President Osborn.

The paper was discussed by Messrs. C. S. Fellows, J. C. Bryant and H. S. Baker.

A letter from the Philippine Islands, written by Dean C. Worcester, was read by Mr. W. H. Pratt.

The lecture course of the Academy arranged for the third Tuesday of the months February, March, April and May, was announced.

W. D. Frost was elected a member.

February 21, 1893.

Dr. W. H. Leonard in the chair.

Ninety-five persons present.

The first lecture in the special course was given this evening by Dr. Charles N. Hewitt. Subject: Cholera and Common Sense.

March 21, 1893.

Professor MacMillan presided.

Thirty persons present.

The second lecture in the special course was given this evening by Professor Henry L. Osborn. Subject: Structure and habit among the Rodents.

April 18, 1893.

A hundred or more were in attendance.

The third lecture in the special lecture course was given by Professor MacMillan. Subject: The Mechanics of Heredity.

May 2, 1893.

Twenty-three persons present.

The program was as follows:

An Apophyllite Geode; by Charles P. Berkey.

The paper gave the results of an examination of some minerals collected by C. W. Hall near Grand Marais, Minnesota.

Complete chemical analyses were made of all the minerals of this geode, and also of the diabase rock in which they were found. Grand Marais is a new locality for Apophyllite, which occurs in well formed crystals combining the prism, pyramid and pinacoid, $_{\infty}P_{\infty}$, P, oP. The diabase is very much altered and bears secondary minerals in great abundance. A chemical analysis of the diabase shows:

Silica, Si, O_2,	55.40
Alumina, $Al_2 O_3$,	22.55
Iron protoxide, Fe O,	3.75
Iron sesquioxide, $Fe_2 O_3$,	14.67
Lime, Ca O,	1.41
Magnesia, Mg O,	0.74
Water, H_2O,	0.97
Total,	99.49

Analyses of the different minerals:

	Apophyllite	*Laumontite*	*Chlorite*
$Si\ O_2$	52.61	53.87	33.14
$Al_2\ O_3$	0.67	18.06	13.22
Fe O	....	....	12.19
$Fe_2\ O_3$	trace	0.88	24.20
Ca O	25.22	11.19	1.50
Mg O	0.17	0.45	3.49
K_2O	3.03	0.29	....
$Na_2\ O$	1.71	0.67	....
H_2O	16.17	13.18	12.34
Total	99.58	98.59	100.08

Calcite shows 99.85 per cent. $Ca\ CO_3$; insoluble 0.15 per cent.; $Mg\ CO_3$ a trace.

The analysis of the chloritic mineral is near to the composition of *Strigovite.*

The Pewabic Quartzite; by Arthur H. Elftman.

In this paper the results of a microscopic examination and field observations of a designated district in northeastern Minnesota was given. The rock to which the name Pewabic Quartzite has been given is placed by some geologists at the bottom of the Animike, by others in the lower Keweenawan. It is older than the Keweenawan because the basal gabbro of that formation cuts through and even encloses large blocks of the quartzite. The rock is not a quartzite, but essentially an aggregation of quartz, olivine, augite hornblende and magnetita. In the Birch lake region some of the so-called Pewabic Quartzite has been traced into the iron bearing member of the Animike. These results differ slightly from those of Professor W. S. Bayley, published in the 19th Annual Report of the Geological and Natural History Survey of Minnesota, pp. 193-210.

A Second Warning; Dr. Albert Schneider.

The author continued his studies on the spread of Asiatic cholera begun sometime ago. The Academy's attention had been once before called to the subject. (See Minutes for November, 1892, p. 308.)

Minneapolis, May 16, 1893.

The fourth and last lecture in the special lecture course was given by C. W. Hall.

Subject: The Formation and Deformation of Minnestoa lakes.

Thirty-eight persons were present.

June 6, 1893.

Commencement week at the University prevented attendance of many members, consequently no quorum.

September 7, 1893.

A special meeting of the Academy was held in the Public Library. President Osborn in the chair.

Eight members present.

The objects of the meeting were: 1. That the Academy be informed of the amount and condition of the material gathered by the Menage Scientific Expedition to the Philippine Islands; 2. That a statement might be made ot the progress of taxidermic work on said material; 3. That the financial condition of the Academy might be stated; and 4. That such action might be taken as should be thought wise in view of the present condition of the Academy's work.

1. Secretary Hall gave a brief statement concerning the condition of the material thus far received from the Menage Expedition to the Philippine Islands and what had been done towards preparing the material for permanent preservation.

2. He then gave a summary of the taxidermic work done by Mr. James Hobson, who entered the service of the Academy in May, 1892, and closed his work in June, 1893.

3. The Secretary then stated that the immediate financial needs of the Academy for payment of transportation charges, taxidermist's wages, etc., amounted to over five hundred and fifty dollars.

4. After some discussion and a careful review of the present membership of the Academy, it was moved and carried that a soliciting committee of ten or more members be appointed to make the effort to raise the money necessary for paying the transportation charges, wages, etc., now due and if possible to carry on the work of putting the Collections into the Academy's Museum, and in short to fulfill all the obligations the Academy is under through its acceptance of the material secured by the expedition. The committee was named as follows:

Wyman Elliott, chairman, Thomas Lowry, Clinton Morrison, Chas. A. Pillsbury, C. E. Vanderburgh, R. E. Grimshaw, Verdine Truesdale, C. C. Jones, Edw. C. Gale, C. J. Bartleson, President Osborn.

After the special business of the meeting the following was ordered:

1. That a field day be observed by the Academy sometime during September by an excursion to Taylors Falls if possible. H. W. Smith and C. W. Hall were appointed a committee to do what is necessary to make a suceessful day.

2. It was the unanimous opinion of all preseut that an annual meeting be held at some date between December 20, 1893, and Jan. 10, 1894 for the presentation of a program of papers and discussions by members of the Academy and others who might be invited. President Osborn was directed to name a Committee of arrangements for such a meeting.

November 7, 1893.

Eighteen persons present.

The first paper read was by Mr. F. W. Sardeson on the "Sources of the water supply of Saint Paul."

Mr. Sardeson presented two profiles drawn through the State, one up and down the Mississippi river and the other down the Minnesota river and across to Taylors Falls. He pointed out the faulting of the Paleozoic rocks through Ramsey and Washington counties.

The second paper was on the "Resonant cavities that modify the human voice," by Dean W. X. Sudduth.

Dean Sudduth's paper aroused considerable discussion participated in by several members of the Academy.

Miscellaneous business was then in order.

Secretary Hall related what had occurred concerning the Menage Expedition to the Philippine Islands, and stated in a general way what collections had arrived from that expedition since last May, summarizing as follows: The work of the expedition in the Philippine Islands closed May 8 but just before that date, Mr. D. C. Worcester was taken ill with fever and was obliged to leave his work and Mr. Bourns started for Borneo where he was to make collections for the purpose of comparing the faunal conditions of that island with those of the Philippine Islands where work had been prosecuted for over two years. Mr. Worcester recovered sufficiently from his illness to reach California in June by the way of Japan and the Sandwich Islands at which places he made arrangements for museum exchanges. Mr Bourns on finishing work in Borneo came to America by the way of Europe. At the British Museum he arranged for exchanges for Philippine Islands material. Owing to the financial condition in Minneapolis it has been found impossible to raise the money and prosecute the work of describing new species arranging the material and making exchanges, as had been planned, with the employment of Messrs. Worcester and Bourns in Minneapolis; but it is hoped by another season this work can be prosecuted to completion.

December 26, 1893.

Postponed meeting of the Academy of Sciences.

Sixteen persons present.

The following papers were read:

Preliminary remarks on the rodent *Dipolomys ordii* by President Osborn.

To illustrate the points in the Dipolomys President Osborn exhibited a skull and a few other bones of nearly related forms; several plates were also exhibited illustrating the skeleton as a whole.

Notes on the Anorthosites of northeastern Minnesota by A. H. Elftman.

The paper reviewed the observations of Dr. A. C. Lawson upon these rocks. The anorthosites are considered to be detached blocks inclosed in the diaboses of the Lower Keweenawan. The mineral composition also varies more than geologists have generally understood.

In the discussion of the paper H. V. Winchell called attention to the fact that in the Annual Report of the Geol. and Natural History Survey of Minnesota for 1887 notice was taken of several enormous blocks of Animike strata which appeared to be pieces floating in the great Gabbro overflow surrounding them. Their position points to their being torn off at the time of eruptive activity and moved from their original site to their present situation.

Evolutionary development in some species of Brachiopoda, by F. W. Sardeson.

Mr. Sardeson's paper aroused some discussion participated in by President Osborn, U. S. Urant, C. S. Felllows and others.

The relationships and generic nomenclature of Astragalus by E. P. Sheldon.

January 2, 1894.

ANNUAL MEETING.

Fourteen persons present, with President Osborn in the Chair.

The report of the Secretary touching the scientific work of the Academy and its financial affairs was read and the latter part referred to the auditing committee.

The report of the Treasurer was read; It summarized as follows:

1893.				
Jan. 25	By Cash,	D. P. Jones, loan		$100 00
May 3	"	L. F. Menage, subscription		130 00
May 29	"	H. F. Nachtrieb, loan		20 00
June 3	"	T. B. Walker, special subscription		10 00
July 28	"	F. S. Bourns, loan		15 00
Dec. 6	"	C. A. Pillsbury, subscription		100 00
Dec. 16	"	T. B. Walker, subscription		100 00
Dec. 26	"	E. C. Gale, loan		50 00
Dec. 31	"	Annual dues collected by Prof. Hall.		212 00
Jan. 14	To Cash,	for Insurance	$ 8 00	
Jan. 6 to Nov. 13 incl.	"	to Hobson, for taxid'y..	420 50	
June 6 to Dec. 26 incl.	"	for freight on Phillipine Collection	289 16	
Jan. 31 to Sept. 4 incl.	"	for drayage and misc....	5 00	
April 5	"	for engraving	7 50	
Dec. 22	"	for printing, Kimball Co.	17 50	
Jan. 3 to Dec. 28 incl.	"	for post'g, clerk hire, etc.	25 26	
Dec. 31	"	to D. P. Jones, acct. loan	25 00	
		Balance due Treasury		71 28
			$808 28	$808 28

The report of the corresponding secretary was then read. It was as follows:

NOTE.—The following is a list of publications received by the Academy for the year 1893. The list is not so large and complete as it should be, awing to the death of Mr. Pratt, and the unavoidable delay in securing a new Corresponding Secretary. Thus nearly three months receipts were accredited to the year 1894, and will appear in a future report.

CHARLES P. BERKEY,
Corresponding Secretary.

THE UNITED STATES.

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The Academy then proceeded to the election of officers. The election resulted as follows:

President, - - - Henry L. Osborn.
Vice-President, - W. Xavier Sudduth.
Recording Secretary, Christopher W. Hall.
Treasurer, - - - Edward C. Gale.
Corresponding Sec'y, Charles P. Berkey.
Trustee to fill unexpired term of D. Percy Jones, resigned, - Horace V. Winchell.
Trustees for three years, - T. B. Walker. T. S. Roberts.

On Sunday evening, December 3rd, last, William H. Pratt, Corresponding Secretary of the Minnesota Academy of Natural Sciences, departed this life. Mr. Pratt was born in Bridgewater, Mass., September 6th, 1822. When a mere boy his father brought the family to Illinois, and settled in a small town, engaging in the milling business. It was in this village that young Pratt secured the rudiments of an education, and devoting his time during vacation of the village school to helping his father in the milling business. He grew to young manhood, receiving meanwhile a very fair education. Quite early he began his career as a teacher by teaching a common school. In this work he was very successful, since his tastes and talents directed him. After a few years experience in teaching, Mr. Pratt came to Davenport, Iowa, in February, 1857, where he entered into partnership with Mr. Joseph C. Lopez in the proprietorship of the Davenport Commercial College. Mr. Pratt was so successful in the management of this institution for business training that in 1859 he bought out his partner, and in the same year bought another smaller business college in the same town. Prosecuting the work until 1865, he made his school one of a chain of business colleges and subsequently sold out his entire interest to Bryant, Stratton & Merrill, the proprietors of that extensive system of commercial colleges known under the name of Bryant & Stratton. Following this sale Mr. Pratt was for many years a teacher of penmanship in the Davenport schools, but it was especially in the Davenport Academy of Sciences that he did his best work. He was one of the charter members who organized the Academy in 1867. Becoming at once its first secretary and one of its trustees, he gave to this institution the best labor and efforts of his life. During his whole connection with the Academy his work was indeed a labor of love. Mr. Pratt had also been an omniverous reader, and paying special attention to natural history, he came to the work of organizing and developing the Davenport Academy with a high degree of preparation.

A unique feature of his work in connection with the Academy was the association which he developed between the Academy and the public schools. He arranged a series of lectures to the various grades of school children in geology, zoölogy, botany and comparative anatomy. He was very competent to teach on these subjects. He effected an arrangement whereby classes came to the Academy from the various schools, listened to lectures, and examined the specimens, which were arranged for their special benefit into a series of groups or study collections. In this work Mr. Pratt continued with unabated zeal until his removal from the State, October 1890, when he came to Minneapolis with his family for permanent residence. He immediately identified himself with the Minnesota Academy of Natural Sciences, was elected in January, 1892, Corresponding Secretary of the Academy, which position he held at the time of his death. Mr. Pratt was in attendance at the meetings of the Academy whenever his health would permit, and at all times was ready to advance the interest of the meetings by contributing to discussions and papers from his own wide range of obsesvation and experience. His wide acquaintance with scientific men throughout the country and abroad formed while he was secretary and curator of the Davenport Academy proved of great value to the Minnesota Academy in his work of extending and systematizing the exchanges of the institution with kindred academies and societies.

February 6, 1894.

Ten persons present, with C. P. Berkey presiding.

The following program was presented:

Note on some water divides in northeastern Minnesota, by Ulysses Sherman Grant.

[ABSTRACT.]

The International boundary between Lake Superior and Rainy lake is often supposed to be a continuous water course, except in one place; but such, however, is not the case, as four water divides occur in this distance. The first is between Rove and Rose (Mud) lakes in Cook county. The second is the divide between North and South lakes, also in Cook county; the waters of South lake find their way into the Gulf of St. Lawrence and those of North lake into Hudson Bay. There is also a divide between Swamp (Oak) and Ottertrack lakes at the east end of Hunter's Island, the boundary stream flowing northwest from Saganaga lake through Canadian Territory; this stream finally reaches the boundary again at Lac la Croix, about fifty miles west of Saganaga lake. The distance between Swamp and Ottertrack lakes is less than one-fourth of a mile, and this alone prevents Hunter's "Island" from being an island. The fourth divide is between Lac la Croix and Loon lake, in St. Louis county.

Brulé lake, a good sized body of water in Cook county, has two distinct outlets. The water flowing from the eastern end of this lake reaches Lake Superior through the Brulé river, and that from the western

end goes through Temperance river (or perhaps through Poplar river), which empties into Lake Superior, some forty miles west of the mouth of Brulé river.

Following Dr. Grant, Mr. Upham spoke briefly of the relative proportions of rainfall and evaporation.

[ABSTRACT.]

In that wooded Northern part of Minnesota and on its extensive prairie areas southward. A chart of the rainfall of this state, compiled by the speaker and previously referred to in the Bulletin of the Academy (Vol. III, page 151), shows an average annual supply of 32 inches of rainfall (including snow) in the region of Hunter's Island; while on the prairie part of the state it ranges from 26 inches in the vicinity of Mankato to 22 inches along our western boundary at Big Stone lake and north to Moorhead and Grand Forks. Careful records of rainfall in portions of New England, with gauging of the discharge from reservoirs, as Lake Winnipesaukee, drawn from for the water power of milling cities along the Merrimack River, shows that the evaporation from tbose areas of more plentiful rainfall ranges from 50 to 60 per cent. of its total amount. The proportion is probably nearly the same iu the wooded country of northern Minnesota, including all the drainage areas tributary to Lake Superior and to Rainy lake and the Lake of the Woods. On the somewhat dryer prairie region the relative amount of evaporation is greater. It has been estimated to be three-fourths of the rainfall on an average for the Ohio and upper Mississippi river basins; and it may be five-sixths of the whole rainfall for the basin of the Minnesota river. The large tract of high plains, lying farther west and extending to the Rocky Mountains, has a much less rain supply, of which likewise it doubtless returns as much as five-sixths to the atmospheric circulation by evaporation.

Mr. Upham also spoke of the glacial and modified drift adjoining nearly all the lakes of northern Minnesota on some portions of their borders, so that if the drift were removed probably most of these lakes could flow away, not being enclosed by rock basins. The opinion that glacial erosion of rock-bounded depressions produced many of the lakes of drift-bearing areas, long ago advocated by Ramsay, has been recently brought again prominently to the attention of geologists by Sir Alfred Russel Wallace, writing in the Fortnightly Review (Nov. and Dec. 1893). This explanation, however, is far less frequently applicabls to the lakes of the northern United States than the obstruction of drainage by irregular deposition of drift. For the great Laurentian lakes, from Superior to Ontario, Mr. Upham thinks, with Prof. J. W. Spencer, that their basins were produced by differential epeirogenic movements, resulting in warping of the earth's crust, during the Glacial period.

Secretary Hall then remarked:

[ABSTRACT.]

Sec'y Hall followed Mr. Upham with some remarks of the advisability of careful records and measurements of the determination of certain climatic conditions, particularly in temperature and rainfall between two contiguous districts of the state, viz., the area drained by the Mississippi river from Fort Snelling northward, amounting to 16,596 sq. mi. and the area drained by the Minnesota river amounting to 15,706 sq. mi. These two districts have the following points in common; first, they differ only about 900 square miles in area; second, they are uniformly level or slightly rolling in surface contour; third, they have about the same elevation above the sea, viz., 1200 or 1300 feet; They differ but little in latitude and loagitude since boundary between them is an irregular northeast and southwest line. They have the following points of difference; first, the Mississippi does not shed a great deal more water per annum than does the Minnesota; second, Mississippi is largely forest covered while the Minnesota is largely one of prairie. Tongues of forest extend into the Minnesota area as patches of prairie are here and there found in the Mississippi area; third, the amount of river drainage from these two areas could easily be determined by measuring the outflow of the two streams at Fort Snelling where they unite. The temperature, the moisture of the air, the annual rainfall and other conditions can easily be determined through a series of observation stations. Some efforts were made several years ago by the speaker to secure the necessary data but they were unavoidably interrupted.

Mr. A. E. Elftman then read a paper entitled, "Notes on the geology of the Greenwood lake area."

This area is one that Mr. Elftman studied under the direction of the State Geologist of Minnesota during the field season of 1893. The paper was briefly discussed by Mr. Upham, Dr. Grant, and others.

March 13, 1894.

President Osborn in the chair.

Twenty members present.

The following papers were presented:

Differentiation of igneous magmas, U. S. Grant.

An abandoned post-glacial valley of the Saint Louis river, J. E. Spurr.

Mr. Spurr's paper was illustrated by some maps and drawings showing the position of this valley and its relation to the accumulation of glacial debris along its borders.

"Departure of the ice-sheet from the basin of Lake Superior," Warren Upham.

This was illustrated by maps and diagrams especially of the glaciation and accumulation of glacial debris in the vicinity of Duluth.

H. V. Winchell then presented the following papers:

a. "Hisingerite in northern Minnesota."

b. "Remarks on a Psuedo-Meteorite."

President Osborn then announced the gift of a collection of birds and a black walnut cabinet in which to exhibit them by R. J. Mendenhall, life member of the Academy. The Academy directed that a vote of thanks be transmitted to Mr. Mendenhall for his generous gift.

Secretary Hall then announced from the trustees the chairmen of the several sections of the Academy for the current year as follows:

Anthropology, Dr. A. E. Johnson.
Biology, Prof. L. W. Chaney.
Botany. Dr. J. H. Sandberg.
Geology, H. V. Winchell.
Invertebrate Zoology, Otto Lugger.
Mineralogy, N. H. Winchell.
Mechanical Philosophy, Herbert W. Smith.
Sanitary Science, Dr. Chas. N. Hewitt.
Vertebrate Zoölogy, H. L. Osborn.

April 3, 1894.

C. S. Fellows elected chairman. Nine persons present.

The following program was presented:

"Explanation of the so-called Pseudo-Aurora," J. P. Goode.

"Notes on several recent deep wells in Western Minnesota." C. W. Hall.

"Augite Granite of Snowbank Lake," A. H. Elftman.

"The occurrence of datolite on the north shore of Lake Superior," C. P. Berkey.

Specimens of this mineral were collected by Mr. A. H. Elftman at Flood Bay. All are of the white nodular compact variety, similar in all respects to that occurring at some of the copper mines of northern Michigan. A chemical analysis gives:

Silica, $Si\,O_2$,	36.90
Alumina and iron, $Al_2\,O_3+Fe_2\,O_3$.	1.51
Lime, $Ca\,O$,	35.67
Boric acid, $[B_2\,O_3]$	20.32
Water. $H_2\,O$,	5.60
Total,	100.00

B_2O_3 was estimated by difference.

Conditions are favorable for the occurrence of datolite in the rocks at several localities along the north shore of the lake, but no specimens have yet been found in place. All have been found among the pebbles of the lake shore where foreign debris is mingled with that of local derivation. It is therefore possible that the mineral belongs to the drift. All that can be said at present is that datolite occurs among the beach pebbles of the north shore of Lake Superior.

Mr. H. B. Hovland of Minneapolis, and Frank J. Harris of La Cresent, were elected members.

The announcement was made that the entire collections of the Philippine Islands Expedition, with the exception of two boxes, had reached the city and had been taken charge of for care and such taxidermic work as the Academy should direct.

April 20, 1894.

The meeting was called in response to a request for a special meeting at 8 o'clock p. m.

A large attendance of the members of the Academy and their friends came and listened to a talk by Dean C. Worcester of the late expedition to the Philippine Islands. Mr. Worcester being in the city on business connected with continuing the work on the collections, consented to relate some incidents of the life of himself and Mr. Bournes among the people of the Philippine Islands.

Aprli 27, 1894.

A special meeting of the members of the Academy of Sciences was called for this evening. The call was made at the suggestion of the Board of Trustees and Mr. Worcester.

President Osborn in the chair. Seven persons present.

No Minutes read.

President Osborn proposed the following questions; the answers given expressed the sentiments of the members of the Academy present.

First. Is it desirable to sell part of the collections of the Philippine Islands Expedition in order to raise funds for prosecuting the work of labeling specimens and preparing manuscript for publication? The conclusion was that we cannot properly, and perhaps cannot legally, sell any part of the collections at the present stage of the proceedings towards their final public exhibition.

Second. Is it desirable to secure a lecture by Mr. Worcester? It was thought that a lecture at this season of the year could not be made to pay expenses.

Third. Is it desirable to secure a lecture by H. J. Smith on the Cliff Dwellers of the southwest? This also was felt to be inadvisable in view of the probable early exodus of our citizens to the lakes and other summer resorts.

A Committee was then appointed to secure subscriptions from members and friends of the Academy for the purpose of securing Messrs. Worcester and Bourns to work up the Philippine Islands collections, giving the specimens labels and leaving them in shape further preservation; and further to write the necessary manuscripts, describing new species and relating the general scientific results of the Expedition for publication by the Academy.

The Committee appointed was as follows: President Osborn, E. T. Allen, C. J. Bartleson, Chas. S. Fellows, E. C. Gale, C. W. Hall, Dr. W. H. Leonard, H. F. Nachtrieb, Dr. T. S. Roberts, T. B. Walker and H. V. Winchell.

It was further ordered that Professors Osborn and Nachtrieb and Dr. Roberts constitute a committee to arrange an outline list of the contents of the Philippine Islands collections for publication and to prepare a statement of the present needs of the Academy for the editorial pages of the city papers and to secure the coöperation of such papers in presenting to the public the present situation.

J. E. Spurr, of Massachusetts, was elected a member.

May 8, 1894.

President Osborn in the chair.

Twenty-one members present.

The following program was presented:

"Notes on hermaphroditism in the frog," Professor H. F. Nachtrieb.

The paper was discussed by President Osborn, C. S. Fellows, Professor MacMillan and E. C. Gale.

"Experimental embryology of plants, Professor MacMillan.

Mr. Elftman proposed the name of F. E. Harmon for membership. Mr. Harmon was elected.

June 11, 1894.

C. S. Fellows chosen chairman pro tem.

Sixteen persons present.

The following papers were presented:

A review of some recent theories of heredity, Professor L. W. Chaney, Jr.

Classification of the Brachiopoda, F. W. Sardeson.

Recent essays toward a classification of the Keweenawan Series in northeastern Minnesota, A. H. Elftman.

A communication was received by the Academy from the Council of the Scientific Alliance of New York signed by N. G. Britton, Secretary, in which attention was called to a series of preambles and resolutions adopted by the Alliance April 28, 1894, touching a reduction of postage rates on natural history specimens.

After listening to the communication, A. H. Elftman introduced the following memorandum which was offered to be sent as a letter of the Academy signed by the Secretary to the Senators and Representatives in Congress from the State of Minnesota.

SIR: I am directed respectfully to call your attention to the following preamble and resolutions recently adopted by *The Minnesota Academy of Natural Sciences* and earnestly to solicit your cooperation in the endeavor to obtain a reduction of postage rates on natural history specimens.

WHEREAS, The transmission by mail of specimens of natural history between students and workers in science has long been a very important means of facilitating their labors, and thus of diffusing knowledge and advancing the interests of science; and

WHEREAS, Such transportation is greatly hampered and restricted by the high rates of postage recently demanded for such material in both domestic and foreign mails; and

WHEREAS, The lack of provision for low postage rates upon such specimens amounts to a restrictive and often prohibitive tax upon the dissemination of knowledge; therefore,

Resolved, That *The Minnesota Academy of Natural Sciences* do hereby memorialize the Senators and Representatives of Minnesota in behalf of a reduction of postage upon scientific specimens, and to use their influence in every practicable way to further this object, so important to the interests of scientific study and research throughout the world.

October 2, 1894.

Vice President Sudduth in the chair.

Eleven persons present.

On motion the following program prepared for this meeting was postponed until some future date:

1. Physical features of the region around Lake of the Woods, Professor MacMillan.

2. The Succession of Paleozoic formations in southeastern Minnesota.

November 13, 1894.

Vice President Sudduth presided.

Thirty-one persons present.

The subject for the evening was a paper by Dr. Chas. N. Hewitt, chairman of the section of Sanitary Science, "A city water supply from the viewpoint of a health officer."

After the paper read by Dr. Hewitt, an explanation of several statistical charts prepared for the occasion was given; the subject was further discussed by E. S. Kelley, Health officer of the city, N. H. Winchell, Geo. C. Andrews, Dean Sudduth and others.

A record of the weather of Minneapolis has been prepared for the Academy's *Bulletin* and it will appear in the following pages. Mr. William Cheney for many years a voluntary observer and correspondent of the U. S. Signal Service compiled the record [See Paper H]

There is also an abstract of the correspondence of Messrs. Bourns and Woacester edited to form a sort of itinerary of the Menage Scientific Expedition to the Philippine Islands. This forms Paper I.

[*Paper A.*]

THE RODENTIA IN EVOLUTION—A PRELIMINARY STUDY.

WITH PLATE I.

H. L. Osborn.

It is the great objection constantly brought against evolution by those who have not accepted the doctrine, that no cases of evolutions now in process can be produced. Such objectors claim with reason that evolution, if it be true, must be universal, not only in range of application, but in time, and hence should be observable in animals and plants of to-day. It may be properly noted that biology is a young science, and that very accurate observations would be required to show that evolutions at the present time are not taking place as well as to show the converse. In view of the great variability of animals and plants, it seems almost strange that anyone should suspect that fixity in animal form is a law of life, and yet in spite of the variability in individuals, the lines of specific form run remarkably true, many species being almost or quite unchanged, as can be shown by sundry data, for many thousand years, and the recognition of this fact has helped the native conservatism of the human mind to hold to the position of immutability of animal species with wonderful tenacity. The reason for this is found in the fact that the observations on which the proof of evolution rests are more unusual, hence while students almost universally accept the theory as a working hypothesis, it only slowly gets abroad among the notions of mankind.

If any great group of animals be examined at all thoroughly their relations are unintelligible, except on the evolution hypothesis. It was the suggestion of Professor Louis Agassiz, the great opponent of Darwin, that the likeness of animals and their dissimilarities were indications of an ideal or mental connection between them due to their production by the same maker, just as the similiarities in style of works of art owe their existence to unity, not in the objects, but in the producer. It is necessary on this theory to believe that each kind of animal was produced in the first instance with special reference to the station it now inhabits, and all its structure must show evident reference to that specific end, and no other. It is late in the day to be proving evolution to the professional zoölogist, but as these pages are intended partly for the laity, these commonplaces may, I trust, be pardoned. The consideration of any group of animals shows that while Agassiz's theory of the cause of classification is ingenious, it is also highly improbable, because many facts go to show that animals judged by the standard of structure are but poorly designed to occupy the situation they occupy if they were originally designed to be such animals as they are to-day. The doctrine of descent with modification, would, however, as noted at the outset, require evolution to be now in process, and creatures whose structure is not as well adapted to theie surroundings as others must be regarded as forms lately come with new surroundings and not yet fully evolved.

The rodents are a large order of mammals. There are over 900 species enumerated. They are the most widely distributed of any order of the class. They present a great variety of situation and habit, and therefore they are a very favorable group on which to study the problems of evolution. At the risk of being tedious, I will briefly sketch the order, for some notion of the order is indispensable for my present purpose. There are four general kinds or sub-orders of *Rodentia*, viz.: The squirrel kind or *Sciuromorpha*, the porcupine kind or *Histricomorpha*, the mouse kind or *Myomorpha*, and the rabbit kind or *Lagomorpha*. These sub-orders are not in the least distinguishable on physiological grounds. The lines of habit and situation cross and recross the lines of structure and model in the most persistent way, but they are clearly definable in anatomical terms, as are also all of their subdivisions. Some of the anatomical terms of their definition will be given with the account of each sub-order.

The Sciuromorpha have a skull broad in frontal and parietal regions (cf. fig. 5, the ground squirrel, Tamias), a molar bone which reaches up behind the maxillary to the usually free lachrymal, usually five molar teeth, usually only three sacral vertebrae with the pelvic not very firmly articulated, the pubic symphsis is generally long and strong, the fibula is free from the tibia (cf. fig. 8 of prairie dog). The Sciuromorpha include animals of almost every habit and station, mostly inhabitants of the north temperate zone. They are the ground squirrels and spermophiles, prairie dog, marmot and rare and little known sewellel, all terrestrial and partly fossorial, and the beaver, fossorial and aquatic, the tree squirrels and arboreal and the flying squirrel and anomalure of Africa, arboreal and partly aerial. These are the simplest *Rodentia* in most respects, and the peculiarities of the others, except the Lagomorpha, can readily be understood if we suppose they are descended from these. They are all much alike osteologically, the beaver being the only one at all widely divergent, as can be seen in the case of the ground squirrel, the flying squirrel, and the beaver by a comparison of figures 2, 4 and 5.

The *Hystricomorpha* or porcupine kind are almost strictly confined to South America, the chief exception being the true porcupine of Europe, which furnished a figure for Shakespeare in Hamlet. The most of the family are not spiny, nor do they correspond with the correct notion of a porcupine, but they present structural features which distinguish the sub-order. The skull is broad in the frontal and parietal region, but the molar bone is short and does not run up to join the lachrymal, the zygomatic arch is short and the infraorbital foramen is very large (as in the beaver only among Sciuromorphs). The molars are never five in number and are in many less than four, in some three or even only two. There are usually four sacral vertebræ and sometimes (Paca) five. The number of toes is rarely five and sometimes only three and the metatarsals are never fused. The tibia or fibula are always distinct. These characters are easily derivable from the Sciuromorph type—the reduction of number of teeth, the incorporation of more bones in the sacrum and the reduction in the number of toes are all quite easily possible from Tamias as a starting point. The various creatures of the suborder are but little known except to travelers or special students. Some of them are the *Dega* of Chili of the size and habits of a rat; the plate beaver of Brazil, semi aquatic, with cylindrical scaly tail but soft wooly hair; the porcupines arboreal often prehensile tailed creatures; the chinchilla a terrestrial and fossorial creature of Chili and Peru; the *vischaca* of Argentine Republic burrowing so extensively as to make the ground unsafe for man or beast; the paca and capybara, the latter as large as a Newfoundland dog and weighing 100 pounds, a terrestrial animal but perfectly at home in the water; the Pategonian "guinea pig" or cavy a terrestrial and fossorial animal.

The *Myomorpha* or mouse-kind is the largest suborder of Rodentia and the most universally distributed being absolutely cosmopolitan. Their osteological characters are, a narrow frontal and parietal region (cf. fig. 3), slender zygomatic arch, malar bone slender and very short (fallen out in specimen figured) molars never 5 usually 4 often 3 or even 2, generally 4 and sometimes 5 sacral vertebrae, in some no pulie symphisis (cf. fig. 9 *Geomys* or pocket gopher.) The fibula is always anchylosed to the tibia and the toes are 4 or 3, in some the molars are found to found to form a canon bone. A few among the many mice are mentioned to convey an idea of the great range of habit within the limits of this exceedingly clearly defined sub order. 1, The water rat, *Hydromys* is nearly perfectly aquatic, with close glossy fur, flat head, slender body, a long tail, partially webbed feet, a native of Van Diemensland. 2, *Gerbilles* of which 50 species are said to be known is a leaping rodent with elongate leg and tail. 3, The Hamster mouse is a burrowing rodent with large cheek pouches as in the very different pocket gopher, tail very short but eyes large (unusual in fossorial animals) and toes short clawed. 4, The house mouse also *Acomys*, a mouse with spines in the skin recalling the porcupine belongs here. 5, The field mouse is a burrowing or running rodent, closely allied to it are the arctic *Cuniculus* and lemming and the muskrat an aquatic mammal with slightly webbed feet and horizontal flattened scaly tail. 6, The pouched gophers are considered a separate family of myomorphs but they are very like, in many respects, the field mice from which they seem to have been descended. They are chiefly fossorial, have minute eyes, short tail, a very remarkable sacrum and pelvis which has no pubic symphesis. 7, Still more extremely fossorial are the rodent moles, *Siphneae*, which are perfectly subterranean, have no functional eyes, no external ear and limbs short, stout and mole like. 8, The Jerboa or jumping mouse, or kangaroo-rat is a slender mouse like rodent with long slender hind limbs and reduced fore limbs, anterior part of body the cervical vertebræ being anchylosed, hind foot of only 3 toes and the metatarses are fused. The mice present the appearance of a very productive race of beings forced by pressure of numbers and competition in various forms to push out from terrestrial habits to fossorial, aquatic and other ones and as if they had some of them been thus changed in habit much longer than others, some being more competely correlated in their structure by their peculiar habits than are others.

The fourth suborder or *Lagomorpha* is very small and contains only two genera, *Lagomys* and *Lepus*. These unite in certain osteological characters unique among rodents, especially:—2 incisons on each side of the upper jaw (one rudimentary.) This is a more simple condition than that of remaining rodents and more nearly ancestral, reduction in the number of the teeth being among the results of specialization in many cases (eg Ruminants Cetaceans, etc., and also in the more specialized rodents.) The fibula, however, is not distinct but is perfectly fused with the tibia, more completely than in any Myomorph so that in this respect the Lagomorphs are more specialized than the Sciuromorphs. The Pika and hares, burrowing terrestrial and leaping in habit make up the suborder.

It will appear from this summary that the rodents cannot be classed by similarity of habit because if we were to attempt to place together all the aquatic kind we should have as a result a motley assembly of Sciuro, Historico and Myomorphs alike only in a few superficial features but fundamentally wholly diverse. So too, if we should attempt to put together all the fossorial rodents we should be obliged to associate marmots, chinchilla and mice, separating these essentially unlike creatures from arboreal terrestrial and aquatic animals, totally different in habit which are in many cases almost absolutely identical in bodily structure. Such a procedure is intolerable to the scientist of today. It was natural enough to the infantile scientist at the dawn of science to call all aquatic animals fish, and the names starfish, etc., are survivals of this ancient tendency. But science long since abandoded such crudities and habit and station are inevitably regarded as the latest acquisitions of animals to be followed later if it have any further history by structural adaptations to fit.

Before passing to the fuller development of this last point, I wish to dwell for a moment upon a detailed comparison of the muskrat and the beaver, two aquatic rodents. The dorsal surfaces of the skulls of these are represented in figures 1 and 2. These, on examination, are not found to present anything in common beyond the mammalian and rodent construction found in all the class and order. In one the narrow frontal and parietal, in the other these bones are broad; in one the very short molar, in the other a long and stout one reaching from the squamosal to the lachrymal bones. In the bones of the hind leg we find the anchylosed fibula of the muskrat, the free fibula of the beaver, but we do find in each a strong ridge on the hinder side of the tibia (as also in many other rodents). On the other hand if these be compared with animals of very unlike habits we shall find many points of resemblance. The beaver and the ground squirrel can be compared, figs. 2 and 5, and the muskrat and the brown rat, figs. 1 and 3, and important similarities at once come to light. Upon Professor Agassiz's view this would mean that when aquatic animals were being produced several plans used also in producing terrestrial and fossorial animals were adapted to the purpose in spite of the fact that one must have been more suitable than others and that perhaps some wholly non-rodent plan would have been more suitable still. Webbed feet are better for swimming than those that are not webbed; the beaver has good webbed feet and the muskrat has feet that are hardly webbed at all. It is quite obvious that the implications of the multitudes of such facts as these would be if they referred to the work of an artisan, that many poor models and few good ones were available when he was at work making his productions.

If, however, the animals of today be regarded in the light of evolution, all these matters at once become clear. Fossorial animals, for instance, vary greatly in the degree to which they are specialized for burrowing. Some are burrowers in habit, but hardly, if at all, in structure. Others have external but not the more deeply seated specialization of structure, while still others are completely fossorial in structure as well as habit. The fossorial habit in its external form, as in the moles, is marked by the following features, short hair, no external ear, eyes abortive and subdermal, anterior part of body stronger than posterior fore limbs short, stout hand, broad stout nails long, tail short or wanting, the sacrum stoutly anchylosed to the pelvic bones. Many of these characters are obviously favorable to a fossorial animal. They are possessed *in toto* by some rodents, as for instance, the male Bathyergus, and in part by others, as, for instance, the pocket gopher, but they are hardly possessed by the striped gophers, *Spermophilus 13—lineatus*, hardly differs in any respect from the ground and tree squirrel, though Franklyns gopher, *Spermophilus franklyni*, does present enlarged nail on the fingers and somewhat stouter limb bones than the striped gopher. And these facts would seem to mean that evolution has taken place, and in some gone further in production of variety of structure than in others, that some are more completely specialized, while others are now in the act of specializing, and others hardly begun.

Almost all the rodents in the species, genera and families, can be arranged in series, which lead from less specialized centre on more and more specialized radii to highly specialized final terms. The ground squirrel, the tree squirrel, the flying squirrel, and the anomalure, form such a series, starting from a point the ground squirrel, from which also we can proceed toward the spermophile, the marmot, the prairie dog, and finally the sewelled. The ground squirrel or some similar form is also a possible starting point toward similar centres in the hystricomorpha and myomorpha, but here the immediate terms are not yet known; perhaps they are wholly lost and will never be known; but it is not wholly certain that they may not some day be found, or their remains be found, if they existed and are now extinct.

It is not possible in the limits of this paper to refer to many other cases similar to the fossorial. The case of the development of the leaping habit has already been presented before this Academy. A very large amount of study of the rodents from this standpoint is necessary before the question can be thoroughly examined. Only one more point in conclusion. My attention was directed to this whole subject several years ago during the agitation which was then so very lively between the New Lamarkian and the Post Darwinian schools of evolution. Professor Cope, the leading exponent of the former, seeking a cause of the appearance of favorable variation which could be seized upon by natural selection and become adaptive modifications of structure, announced it as his belief from the study chiefly of vertebrate osteology, that the uses of the organs were productive of adaptive shapes and construction, so that as a result of change of habit a creature, though by inheritance from its parents it would have the family likeness, would also have a certain unlikeness, leading toward a perfect fitness for a new habit. This change, he argued, would be seized by inheritance and reappear in the next generation, when it would be improved upon, and so on, extending to the organization more and more deeply till a new organization would result. It would be necessary to such a mechanism of evolution that variations due to use should be shown to be transmissible by inheritance. The Post-Darwinians, represented by Professor Lankester, among the English, claim that inheritance does not extend to these acquired variations, but that variations which appear at birth in the animal are inheritable. When the extreme isolated cases are searched over, an abundance of examples can be produced which seem to substantiate Cope's position, but when the data are all carefully surveyed, the discovery of animals with special habits, but not correlated structure, are not easily explained. They seem to be creatures waiting for evolution to come to their aid, and by giving them specialized structures to help them in the struggle for life. If use develops function, animals as habitually fossorial as the striped gopher ought, it would seem, to be so in structure far more completely than they are. So the muskrat ought to have a more perfectly webbed foot, and so on. The Neolamarkians always answer such objections by the assumption that time has not yet elapsed for the changes to be brought about. But to me the detailed study of the rodents does not appear to favor Neolamarkism. Though it so plainly indicates that evolution has taken place, it also plainly indicates that structure is extremely conservative, and does not readily lend itself to change. We do not yet know how long the rodents have been as they are to-day, but the main line of descent had diverged by Tertiary time. So far as data are at hand from which to calculate the rate of evolution, the rate seems slower than it ought to be if the results of the uses of organs are seized directly by evolution.

February 2, 1892.

[*Paper B.*]

NOTES ON THE MINNESOTA SPECIES OF LACINIARIA.

E. P. Sheldon.

The genus *Laciniaria* is used to designate certain perennial North American herbs belonging to the natural order Compositæ. So far as has been determined this genus has fifteen living species and attains its greatest predominance in the South Atlantic states.

Speaking somewhat more minutely, they are characterized as follows: Perennial herbs with simple, wand-shaped, very leafy stems, from a tuberous or corm-like root-stock; they bear reversely racemose or spicate heads of handsome rose-purple flowers in late summer or autumn; the leaves are all alternate, entire, rigid and mostly glabrous.

The species usually inhabit dry, open, uncultivated grounds, although certain of them seem to prefer moist, low grounds or wet edges of pine barrens. Most noticeable in this regard are *L. spicata* (L) O. K., and the peculiar bog-inhabiting form's of *L. scariosa* (L.) Hill.

In general it may be said that *Laciniaria* is found from Ontario and the Saskatchewan on the north to Florida and northern Mexico on the south, and fiom the Atlantic ocean on the east to the Rocky mountains on the west.

Laciniaria scariosa (L.) Hill is by far the more common species, as it is found throughout the range; and considering its extreme variability and its close relationship to a large number of the other species, it may be taken as a centre around which the rest may be grouped.

In genetic relationship *Laciniaria* is near to *Brickellia* aud *Kuhnia*, on the one hand, and *Garberia* and *Carphephorus*, on the other.

It is to be noted that these all belong to the section

Adenostylinæ of the tribe Eupatoriaceæ. A tribe which has but one genus on the European continent, and that they are all typical North American prairie composites which attain their greatest abundance in the southern portion of their range.

Points like these tend more than anything else to throw light on the origin of the American composites and help to explain their present distribution over the North American continent.

We often turn aside from the more far-reaching points of relationship and distribution when studying a group of plants and question their utility.

In the present case a most pleasing answer can be given. First of all their beauty attracts our attention, and to such a degree that many species are artificially grown both in America and in the botanic gardens of the continent. Then again the corm or rootstock, particularly that of *Laciniaria scariosa* (L.) Hill, is largely used in medicine and as a substitute for vanilla.

SYNOPSIS OF MINNESOTA SPECIES.

§1. Pappns very plumose; heads 16-20 flowered, cylindraceous with turbinate base; bracts of the involucre much imbricated with herbaceous tips if any; lobes of the corolla pilose inside; leaves all linear and rigid, the lower elongated and grammiform.

1. *L. squarrosa* (L.) Hill.—Pubescent or partly glabrous; stem stout, 6 to 20 inches high; heads few or sometimes numerous in a leafy spike or raceme; bracts of the involucre all herbaceous, lanceolate, rigid and with somewhat pungent tips, squarrose-spreading and prolonged. Dry gravelly or sandy soil, Ontario to Minnesota, Nebraska, Texas and Florida.

In the southern portion of the state, rare.

2. *L. cylindracea* (Michx.) O. K.—Most glabrous, a foot high; heads few or several, 16-20-flowered, an inch or less long; bracts of the involucre all appressed, barely herbaceous, rounded and abruptly mucronate at the tip, the outermost very short. Dry prairies and woodlands, Ontario and Michigan to Minnesota and Missouri.

Frequent in the central portion of the state, but rare north and south.

Specimens from Brainerd (Macmln & Sheld.), Goodhue county (Sandberg), Minneapolis (Herrick), Glenwood (Taylor).

L. cylindracea (Michx.) O. K.—Var. *solitaria* Macmln.* Differs fron the type of the species in having a bushy stem 6 to 12 inches high, heads somewhat larger, never spiked, but solitary, terminal, erect or nodding.

This variety has much more the aspect of a pink than a Blazing Star.

Specimens from Brainerd (Macmln & Sheld.), Glenwood (Taylor).

§ 2. Pappus minutely plumose; heads 3 to 6-flowered; bracts of the involucre acuminate or mucronate, coriaceo-herbaceous, not appendaged; corolla-lobes naked; leaves all narrowly linear and the upper generally acerose.

3. *L. punctata* (Hook.) O. K.—Stems erect, 6 to 30 inches high, from a thick and branching or sometimes globular rootstock; leaves and bracts punctate, rigid; head 4 to 6-flowered, oblong or cylindraceous, from one-half to three-fourths inch long. Mostly numerous and crowded in a dense, often leafy, spike; bracts oblong, abruptly cuspidate—acuminate, often languinous ciliate. Dry prairies and plains. Saskatchewan and Minnesota, west to Montana and Colorado, south to Texas and New Mexico. Common in the prairie region of the state, more rare eastward.

Specimens from Red Wing, Cannon Falls (Sandberg), Blue Earth county (Leiberg), Cedar Lake (Holtz), Montevideo (Moyer), Lake Benton, Minneapolis (Sheldon), Emmet county, Iowa (Cratty), Lindbourg, Kansas (Bodin).

FORMS.

A. *albiflora* n. f.—Six inches to a foot high, spike short, heads 4 to 6, 2 to 6-flowered, bracts abruptly acuminate.

High crests of the Cotean des Prairies, Lincoln county.

B. *corymbosa* n. f.—Heads 1 to 3, borne on the ends of leafy ascending branches, 3 to 5 inches in length, tips of the involucre gradually acuminate, spreading.

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* Bot. Gaz. Jan. 1891.

High crests of the Coteau des Prairies, Lincoln county.

§3. Pappus from barbellulate to minutely short plumose under a lense, not to the naked eye.

* Heads subglobose or hemispherical, 15 to 40-flowered; involucral bracts many-ranked, somewhat spreading; corolla lobes short.

L. scariosa (L.) Hill.—Pubescent or glabrate; stem stout, 1 to 5 feeet high; lower leaves spatulate or oblong-lanceolate and tapering to a petiole, uppermost small, linear; heads racemose or spicate, the few to numerous involucral bracts broadest and rounded at the summit, either herbaceous or scarious edged and tipped with purple, greatly variable. Dry and sandy ground, Ontario and New England to the Saskatchewan, west to the Rocky mountains and south to Florida and Mexico.

Common in the southern and central portions of the state.

Specimens from Glenwood, Alexandria (Taylor), Blue Earth county (Leiberg), Minneapolis (Herrick), Brainerd (Macmln & Sheld.), Idlewild, Lincoln county (Wickersheim), Montevideo (Moyer), Minneapolis (Oestlund), (Kassube), Goodhue county (Sandberg), Minneapolis, Lake Benton, Sleepy Eye, Springfield. (Sheld.)

L. scariosa (L.) Hill. Var. *corymbulosa* Sheld.*—Tall and stout, smooth throughout, except the minutely roughened inflorescence; bearing the single *heads at the end of leafy ascending branches* which are 2 to 6 inches long; heads longer than in the type; scales of the involucre broadly obovate, dark purple, slightly scarious or not at all.

This plant was first found by Mr. John B. Leiberg in a bog near Mankato.†

Recent search has found it to be the prevailing form in bogs and low grounds throughout the southern and western portions of the state.

Specimens have been examined from Blue Earth county (Leiberg), Verdi, Lake Benton, Sleepy Eye, Waseca, Princeton, Fergus Falls, Minneapolis (Sheldon), Nicollet county

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* Bull. Geol. Nat. Hist. Surv. Minn., 9, 77, 1894.

† Upham, Cat. Flora, Minnesota, p. 69, 1883.

(Ballard), Meeker and Kandiyoh counties (Frost), Pope county (Taylor).

FORMS.

(A). *solitaria*, n. f.—Stems slender, 10 to 18 inches nigh; lower leaves linear-spatulate, gradually becoming smaller as they approach the small subglobose solitary head. Dry ground, rare. Cedar Lake (Holtz).

(B). *globosa*, n.f.—Strict and stout, 6 to 18 inches high from a branching rootstock, heads globose, sessile, bracts spatulate with scarious *white margined* tips. Flowers from *rose purple* to *cream-colored.*

Crest of the Coteau des Prairies at Verdi, Lincoln county, Minn.

** Heads oblong, 5-flowered; involucre squarrose by the spreading of the colored tips.

L. pycnostachya (Michx.) O. K. Hirsute or glabrous below; stem stout, 3 to 5 feet high, leaves crowded throughout, the lower lanceolate and the upper very narrowly linear; spike dense, cylindrical (5 to 10 inches long), heads (4 to 6 lines long), all sessile; bracts of the involucre 14 to 16, oblong or the inner narrower; the more or less scarious tipt purple, usually acute. Prairies, Indiana to Minnesota, south to Arkansas and Texas.

Frequent through the southern portion of the state.

Specimens from Minnesota Lake, Glenwood (Taylor), Springfield, Waseca (Sheldon), Montevideo (Moyer), Minneapolis (Oestlund).

*** Heads from short-oblong to cylindraceous; bracts of the involucre all appressed, obtuse.

L. spicata (L.) O. K.—Glabrous, or somewhat hairy; stem tall and stout, 2 to 5 feet high, very leafy; heads 8 to 13-flowered, one-half inch long, almost erect. Closely sessile and numerous in a dense spike 4 to 12 inches in length. Moist grounds from Massachusetts to Minnesota, and south to Florida and Louisiana.

South half of the state, rare.

Specimens from Blue Earth county (Leiberg), Red Wing, Cannon Falls (Sandberg), Minneapolis (Kassube), Lake Benton, Verdi, Lincoln county, Sleepy Eye.

March 8, 1892.

[*Paper C.*]

NOTES ON THE ALPINE CHARACTERISTICS OF THE MINNESOTA CREST FLORA OF THE COTEAU DES PRAIRIES.

E. P. Sheldon.

In Minnesota the rolling series of prairie hills known as the Coteau des Prairies, reaches its greatest heights in Lyon, Lincoln and Pipestone counties.

It is to be noted that nowhere in the state, except in the iron ranges on the north, do we attain so high an altitude as when we travel over the exposed treeless bluffs which constitute the crest of the Coteau.

Lake Benton which is the highest above the level of the sea of any of the Minnesota lakes, occupies a long narrow depression in the Coteau, presumably a part of the bed of an ancient watercourse. Arriving at the town of Lake Benton during the month of August, 1891, I was particularly struck by the characteristics of the flora.

In general we find many of the typical praire plants of the southern part of the state. But there are also species from the Saskatchewan district and the Rocky mountains, which find on these high and dry bluffs something remarkably approaching their natnral habitat.

It is to the prevalence of these, and to the peculiarly dwarfed habits of growth of the general flora that I wish to direct particular attention.

The phrase "Alpine characteristics," as applied to a part of this flora, should not be misunderstood. It is not that we have here a large number of peculiarly mountain plants, but rather that in their dwarfed habits of growth, nearly every species observed resembles the stunted and stubby growth so familiar to everyone who has traveled over bare mountain heights. I have noted that these hills are well nigh treeless, but in the gulches and waterways down their sides, stunted growths of *Quercus tinctoria* Bartr. are frequently found. *Quercus macrocarpa* Mich. is more rare, and I have frequently gone miles without seeing a single specimen.

Amelanchier canadensis Torr. and Gray is occasionally met with, as also *Salix longifolia* Muhl. and *Populus tremuloides* Michx.

The above which we know ordinarily attain to a considerable height, here present a bushy, shrubby appearance, and are commonly to be found flowering and fruiting at from one-fourth to one-third their normal height.

Many of the prairie pulses were noted: *Psoralea eseulenta* Pursh., a characteristic plant of the Cotea, was, at the time of my visit, just breaking loose from its summer moorings and preparing to scatter its seeds according to the custom of tumbleweeds. Its near relation, *Psoralea argophylla* Pursh., was frequently found at from five to eight inches in height. The Astragali come in for their due share of consideration.

Astragalus crassicarpus Nutt. was of course plentiful, but with peculiarly dwarfed and densely hirsute leaves.

Astragalus laxmanni Jacq. is quite common at from 3 to 4 inches high.

Astragalus hypoglottis L. and *Astragalus lotitlorus* Hook. are more rare plants of these prairie slopes.

Nearly related to the above is *Spissia lamberti* (Pursh.) O. K., which is often abundant and covered with a plentiful growth of *Erysiphe*.

Very peculiar are the forms of *Petalostemon violaceus* Michx. and *Petalostemon candidus* Michx. Low, dwarfed, and often bushy, their crowded, subglobose heads have more the appearance of a pink or a bachelor's button, escaped from our gardens.

Many other pulses were found, and as respecting their habits of growth, I must particularly mention two more. *Glycyrrhiza lepidota* Nutt. is found growing abundantly on the crest in low depressions and scatters its cockle-like burs through the agency of every passerby. *Parosela daleai* (L.) Britt. crowds out almost every other plant in many places on the sandy shores of lake Benton, where it is found fruiting at from two to twelve inches high.

Traveling up the "Hole in the Mountain" one early morning I met my first specimens of *Pentstemon acuminatus* Dougl. This plant prefers lower and somewhat moister ground than the other prairie species of Pentstemon. Besides this, *Pentstemon albidus* Nutt. and *Pentstemon hirsutus* (L.) Willd. were noticeable for their stunted preference of high morainish ground.

Many composites are, of course, to be included in this category. The peculiar forms of the different species of *Laciniaria* have been mentioned in a preceding paper.* *Solidago nemoralis* Ait. and *S. mollis* Bartl. were found flowering at from three to ten inches. The latter with its upright, rigid *hoary-pubescent* leaves, and its strict, dense thyrse is especially noteworthy. *Kuhnia cupatorioides* L. growing in bunches, stout and somewhat approaching the var. *corymbulosa* Torr. and Gray is very abundant; as also the purple cone flower *Brauneria pallida* (Nutt.) Britt. with its club-shaped stems. The latter was found completely matured and only six or eight inches high.

Gaura coccinea Nutt. was rarely found with branching, somewhat cæspitose habit. Two mustards attracted my attracted my attention. *Erysimum asperum* DC., which often flowers at from five to six inches on the high shores of Lake Benton; and *Sisymbrium incisum* Englm., found in the shade of dwarfed oaks.

The appearance of the latter is quite remarkable in Minnesota, although there is no reason why we should not expect to find other Rocky-mountain mustards on these paririe heights.

Plantago purshii R. & S. has frequently been observed flowering at from three-fourths to one inch high, both on the crest and at Pipestone quarries twelve miles away.

Many grasses came to my notice. *Boutelona racemosa* Lag. and *Boutelona hirsuta* Lag. were found to range from three to seven inches in height at the time of flowering.

Aristida purpurea Nutt., with its long triple awned seeds, looking more like a bunch of miniature pitch-forks than anything I can conceive, was abundant, as also *Stipa spartea* Trin., with its droll habit of having its seeds bore their way down into the soil.

Sporobolus depauperatus Vasey and *Andropogon sco-*

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*See these Bulletins, vol. III, No. 3.

parius Michx. are two other grasses which show very depauperate forms.

Among the many other plants which may be mentioned as showing Alpine characteristics on this crest of the prairie hills are the following:

Festuca ovina L.; *Festuca nutans* Willd; *Amorpha canescens* Nutt.; *Amorpha microphylla* Pursh.; *Prunus pumila* L.; *Teucrium canadense* L.; *Lithospermum angustifolium* Michx.; *Senecio lugens* Richard; *Crepis runcinata* Torr. & Gray; *Zygadenus elegans* Pursh.; *Hedeoma hispida* Pursh.; *Lepachys columnaris* Torr. & Gray; *Cyperus aristatus* Rottb.; *Chrysopsis villosa* Nutt.; *Linum rigidum* Pursh.; *Castilleia sessiliflora* Pursh.; *Solidago lanceolata* L.; *Solidago rigida* L.; *Aster ptarmicoides* Torr. & Gray; *Aster sericeus* Vent.; *Aster oblongifolius* Nutt.; *Allium stellatum* Nutt.; *Acerates viridiflora* Ell.; *Helianthus lætiflorus* Pers.; *Helianthus hirsutus* Raf.; *Artemisia frigida* Willd; *Geum triflorum* Pursh.; *Delphinium azureum* Michx.; *Physostegia virginiana* Benth.; *Rudbeckia hirta* L.; *Oxybaphus hirsutus* Sweet; *Scutellaria parvula* Michx.; *Polygala verticillata* L.; *Prenanthes racemosa* Michx.; *Gerardia aspera* Dougl.; *Vernonia fasciculata* Michx.; *Potentilla arguta* Pursh.; *Galium boreale* L.

These characteristics might well be pointed out on many of the Dakota hills, and they may possibly be shown to be peculiar to high-growing vegetation; yet neither in Minnesota nor in Dakota have I ever seen so many plants varying so widely as on the crest of the Coteau des Prairies in Minnesota.

April, 1892.

[*Paper D.*]

THE SAINT PETER SANDSTONE.*

F. W. Sardeson.

INTRODUCTION.

The name of this formation was written Saint Peter's Sandstone by its author, Dr. Owen, and some geologists still retain that form of the name. The amended form, Saint Peter, has however long been used, and is preferred. The name was adopted by Owen because of the good exposure that is situated at the mouth of the Minnesota river, which last in Owen's time was called the Saint Peter's. The city that was of the same name as the river formerly, is now called Saint Peter.

The type exposure of the formation was chosen because of its situation at the military post, Fort Snelling. It is typical, and a description of it sufficed to enable geologists to recognize the same formation at any other of the many exposures, which occur over a large area. Even the earliest descriptions of this sandstone are free from confusion, both because its very peculiar characters excited close attention, and because those characters are so persistent that recognition of the formation was nowhere difficult. In fact, owing to the persistency of its characters, descriptions of it, although drawn from different regions, are monotonously similar. The little variation that does exist seems to be intended to relieve monotony rather than add to scientific knowledge. The formation is noticeably lacking in mineralogical, petrographical, stratigraphical and palæontological diversity.

* Owing to unavoidable delay in the publishing of this paper, it has been necessary to revise it. It was first delivered to the Society November 13th, 1892. The revised copy was given to the Secretary of the Society November 13th, 1895.

THICKNESS.

The Saint Peter sandstone was supposed by James Hall (9)* to be remarkably uniform in thickness, ranging from 80 feet in its northern (Minnesota) exposures to over 100 feet in the southern (Illinois) ones. In a sense, it *is* remarkably uniform, for the thickness in one area of its great extent averages nearly the same as in any other. But Worthen (12) found this formation to be variable in depth in Illinois, and Chamberlin (21 and 26) has clearly and concisely shown that it is in fact not uniform, but very variable in thickness, even within short distances. This variability is due to the undulated surface of the dolomite upon which it rests, the undulation being so great as to cause the depth to vary from less than one to over 200 feet. The mean thickness has been estimated by Chamberlin (26) to be between 80 and 100 feet. It is more than 100 feet thick in the north.

These estimates are for the Saint Peter itself, exclusive of the Shakopee dolomite and New Richmond sandstone, which two formations McGee (31) Keyes (32) and Norton (33) have, for Iowa, included in the Saint Peter. Such a course is not warranted; when followed, care should be taken to add to the Saint Peter the thickness of the never-failing Shakopee beneath, lest a false meaning be given to already established data, as it has never been shown that Saint Peter and Shakopee taken together are ever reduced to marked thinness. No regularity for the undulations in the underlying dolomite has been observed, hence no explanation for the variability in the thickness of the Saint Peter sandstone is yet known.

GEOGRAPHICAL DISTRIBUTION.

The Saint Peter sandstone is seen in numerous exposures in southeastern Minnesota, in northeastern Iowa, in western southern and eastern Wisconsin, and in northern Illinois. In this wide area it is repeatedly interrupted or reduced to isolated areas by river valleys.

The original extent of the formation we do not know. The general northern edge of its area, presents an eroded, torn and glaciated margin which is very far from being the

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* The numbers refer to the bibliography at the end of the paper.

limit of the formation that must have existed at the time of its deposition. It probably extended a considerable distance northward. On the other hand the general southern extent is so deeply buried below the earth's surface that the limits to the southeast, south and southwest are undiscovered. Our knowledge is in fact confined to a relatively small fraction of the Saint Peter. The surface exposures as well as the area in which these exposures are found are narrow, from reasons that will be given below.

GEOLOGICAL DISTRIBUTION.

So far as we know, the Saint Peter was primarily coextensive with the overlying Trenton (Galena) and the underlying Shakopee. The now existing difference in extent is due to erosion, which of course has worked upon the uppermost strata to the greatest degree and it has caused the undermost—Shakopee—to have a few miles widest extent northward, as seen upon maps of the region.

The inequality in extent of these three Lower Silurian (Ordovician) formations is due very often to erosion that is still going on, very much also to glacial and preglacial erosion. In the latter case the once denuded area may be entirely covered with drift. How long ago the preglacial erosion took place is uncertain. An important and interesting addition to our knowledge is afforded, further, by the existence of a small area of Cretaceous clays (28, pl. 3) in Goodhue county, Minnesota, which lie upon the Saint Peter and Shakopee, the Trenton and other formations having been removed before the Cretaceous was deposited.

The situation of this small Cretaceous area at a high elevation, on top of the ridge near deep river valleys suggest that the valleys have been eroded mainly *since* Cretaceous time, and also its position upon an already eroded surface many miles within the present outer limits of the Saint Peter sandstone proves that the latter formation had been greatly eroded even *before* Cretaceous time. We learn from Worthen (12) that in a few exposures in La Salle county, Illinois, the Coal Measures rest immediately upon the Saint Peter sandstone; from this it is to be inferred that the overlying Trenton had been removed during the Devonian or, more probably, the early Carboniferous period.

From the fact that no Saint Peter sandstone has yet been reported from the Upper Peninsula of Michigan, it has been thought probable that a limit to the formation exists in that direction, and one which existed necessarily before the Trenton was deposited, since the Trenton is still there. It is possible that failure to report is due to failure to observe.

The known limits of the Saint Peter sandstone are those that have been produced by erosion, along the northernly and more elevated extent of the formation; the unknown limits are in the direction of the dip of the sedimentary rocks, i. e., in a general southeast and southwest direction. The Saint Peter may be continuous with formations of other adjacent areas but it has not yet been traced, nor as it would seem, satisfactorily correlated.

LITHOLOGIC CHARACTERS.

The Saint Peter sandstone averages about 99 per cent. silica in the form of grains of clear limpid quartz. There is very little cementing material of any kind so that it forms a "very friable stone . . . . . so loosely united that it appears like sand" (Keating, 4). The grains are typically clear white but the sand is often stained yellow or red locally. It is rarely cemented into a firm rock by an infiltration of iron oxide. Rarely also calcium carbonate infiltration has produced large concretions and areas of firm white rock. Normally it is easily eroded.

The sand grains are so much worn that they are nearly round and have a dead polish. Chamberlin (26) describes them as irregularly angular grains like the quartz from eroded acid eruptives and rarely of true crystalline form. The writer has found quartz crystals; but since the zones in which they occur, cross sometimes the sedimentary lamination instead of coinciding with it they are to be considered as originally rounded grains which have been rebuilt to perfect crystals. The rounded grains are the typical ones. In size, they vary from finest dust to coarse sand, 1 to 2 mm. in diameter, intermixed or imperfectly assorted. The dazzling white color gives the appearance of greater uniformity in size of grain than really exists.

An intermixture of argillaceous bands has been described (21) from northeastern Wisconsin; such an intermixture is generally found at the upper and lower limits of the formation. But, the Saint Peter Sandstone proper is a pure, friable, white rock with very little impurities. It is thoroughly pervious to water, so much so that a small stream poured upon the surface of a slab readily goes through it.

STRUCTURE.

Ordinarily the clear whiteness of the sandstone conceals its structure; on the other hand the infiltrated colors bring it out the more strongly. Stratification is always discernible often with fine lamination, crossbedding, and assorted layers of coarse and fine material. Transverse fissures also occur.

PALAEONTOLOGIC CHARACTERS.

Discovery of Fossils.

Owing to the friability of the rock and the total absence of shells, fossils are difficult to find. James Hall writes in 1862, (loc. cit.) that "no vestige of an organism has been observed" and "it is not probable that such remains will be found." Some years afterwards, however, N. H. Winchell (17.) reported shells of a *Lingulepis* from the top shaly strata of Saint Peter at Fountain, Fillmore county, Minnesota. T. C. Chamberlin (21 and 26) found worm burrows and fucoids near Beloit and Waterloo, Wisconsin, and these are reported by him to be not entirely in the uppermost strata of the formation.

Joseph F. James (34 p. 126) reports that he visited Fountain, Minnesota in 1889 and collected specimens of the *Lingulepis* and an *Orthis*. I have myself later collected the same and some other species at that locality in the described upper shaly strata. Species have been collected from similar strata near Dodgeville, Wisconsin. These fossils are all from the transition strata at the top of the formation, i. e. at the base of the Trenton.

Several species do occur in the body of the formation. As a student working under the direction of Professor C. W. Hall, I found in the year 1890, a large fauna in the Saint

Peter Sandstone, near Saint Paul, Minnesota. A notice of the same has been published (29). Fossils can be found still at the same localities. At Dayton's Bluff, the "Carver's Cave" of early writers, fossils were found between 60 to 80 feet below the overhanging Trenton, or Buff Limestone. A second exposure at Highland Park two miles south of the first is in strata lower than any at Dayton's Bluff, and here also fossils were found. At a third exposure, which is near South Saint Paul, there were found by Professor C. W. Hall and by myself a large number of species, in strata that are probably intermediate between those of Highland Park and Dayton's Bluff.

Condition of Preservation.

The fossils are found as casts of shells that have themselves been entirely dissolved without leaving even a stain of color or a trace of calcium carbonate in the sand. The cavities left by the shells are closed up by a consolidation of the sand in some manner so that generally little more than smooth cleavage planes remain to define the fossils. In the strata that are referred to the upper half of the formation, the fossils were nearly always ree from distortion. In the lower half on the contrary, few are not distorted. Here too there were found fossils which are the moulds only, of the casts of shells. The moulds were full of loose sand, which when removed simply by blowing and shaking, left smooth cavities in exact form of the interiors of shells themselves. The loose sand in the moulds was probably once embedded in the casts of shells. The process of fossilization must have been nearly as follows: A shell produced a cast, and was later dissolved away. The inner cast of the shell remained firm while the sand around it was disturbed and pressed around the cast taking the mould of it. The cast itself was then reduced by removal of the calcium carbonate to loose sand, the mould, however, remaining firm because already consisting only of sand.

Similar phenomena are to be observed in dolomitic limestone. The fossilization itself is not strange, but it reveals to us perhaps the reason that Saint Peter sandstone is so generally unfossiliferous, viz.: Because the fossils have been destroyed since the sandstone was deposited. One might dig up many fossils without seeing them unless care be taken to prevent the casts from being crumbled. The most favorable conditions are in the somewhat infiltrated strata where firmness is secured.

In many cases the shells of bivalves are found in such a manner as to prove that the ligament still bound them together at the time they were deposited in the sand. Of course such shells could not have been transported far nor much beaten about otherwise they would be found separated. Many of the shells were undoubtedly very thin and fragile.

LAMELLIBRANCHIATA.

Genus CYPRICARDITES.

Cypricardites (*Vanuxemia*) *fragosus* n. sp.

Plate II, figures 1, 2 and 3.

Cast acutely ovate in outline. Beaks extendfng beyond the anterior end of the hinge, gently curved, gradually expanding, and swelling out dorsally above the cardinal line. Casts concave under the beaks. Cardinal line curved and extended into an alate projection at the anterior end in front of the beaks but rounding evenly into the semicircular posterior margin. Antero-ventral margin slightly curved. The anterior alation contains the cardinal teeth four or five in number and has a very deep muscle scar just below it. Posterior muscle scar and posterior teeth not known. Along the anterior margin the shell is concave, between the beaks and the posterior ventral portion it is convex, end strongly so along the cardinal region. Transverse length of largest specimen 30 mm., breadth greatest at the posterior extremity of the hinge (18 mm.), convexity of single valve 12 mm. Shells probably very thick.

Found at Highland Park and South Saint Paul.

Cypricardites descriptus n. sp.

Plate II, figure 7.

Small, strongly convex, subquadrate, length 11 mm, breadth 9 mm. Beaks anterior, acute curved in. The point of greatest convexity is near the umbones, and the slope to the ventral margin is gradual. Cardinal line gently curved. Pallial lime simple and marked. The posterior muscle sears large, situated just below the extremities of the hinge. Surface smooth.

Highland Park.

Cypricardites finitimus n. sp.

Plate II, figure 6.

Shell of medium size, oblique, moderately convex, broadest posteriorly. Beaks broad, a little projecting, and slightly coiled. The point of greatest convexity is central. Anterior muscle sear prominent. Surface of the cast is concentrically marked by growth lines which appear to show the ventral margin a little more convex than on the figure. The only specimen found is a little compressed, and moreover does not show clearly but that it may be a modiolopsis.

Highland Park.

Cypricardites dignus n. sp.

Plate II, figures 4 and 5.

Shell rhomboidal, with the ventral margin longest; length of the largest specimen 18 mm, bredth 12 mm. Beaks anterior, tumid, close together. The hinge line is equal to about two-thirds the length of the shell, is curved and apparently continuous with the anterior margin. In general direction the anterior margin is vertical, but forms a strong even curve, which same is continued, but less strongly, through the ventral margin to the postero-ventral angle. The dorsal margin is more distinctly marked off but is gently curved. The point of greatest convexity is between the umbones and the centre of the shell along the rounded umbonal ridge which extends from behind the beaks obliquely back to the postero-ventral angle. Anterior to this umbonal ridge the shell is evenly and strongly convex, but between it and the dorsal and posterior margins the surface is concave. In general the specimens resemble *Nuculites inflatus* Emmous' Geo. Rep. N. Y., p. 395, fig. 2, but have a more prominent anterior margin and less produced hinge posteriorally. *Edmondia subtruncata* Hall Pal. N. Y., Vol. I, p. 156, and plate 34, fig. 9, (not plate 35, fig. 3, c.) is very much like the specimens from the Saint Peter but is larger and proportionally longer.

South Saint Paul.

Genus Modiolopsis.

Modiolopsis fountainensis n. sp.

Plate IV, figure 7.

The few specimens secured resemble *Modiolopsis plana* Hall, of the Trenton limestone which lies upon the Saint Peter sandstone. The Saint Peter specimens are larger casts, however, and have the beaks situated further back and erect instead of directed forward. The convexity of the shell was not strong but there was a broad deepening between the beaks and the lower posterior curve of the margin, accompanied by a straightening of the ventral margin. The anterior muscle scar is large and close to the anterior margin. The specimens were found with *Lingula morsii* N. H. W. at the top of the Saint Peter formation (see pl. IV, fig. 9, c.) below Fountain, Minn.

Modiolopsis postica n. sp.

Plate IV, figure 8.

Shell about 50 mm. long, width greatest across the posterior half (30 mm.) The hinge line is nearly straight. The beak, of the left valve here described, is obtuse, broad and close down to the hinge. The umbo is high but flattened anteriorally and is continued in a rounded umbonal ridge towards the dorso-ventral margin and in a broad depressed area towards the ventral margin. The posterior margin is broadly rounded and is continuous with the ventral margin, which in turn continues with the anterior forming a sigmoid curve. The surface of the cast is marked by fine concentric lines. All the specimens collected are imperfect and none show the anterior perfectly. The specimen figured is from the transition strata of the Saint Peter about four miles below Dodgeville, Wisconsin, along the Illinois Central railway tracks.

Modiolopsis litoralis n. sp.

Plate II, figures 13, 14, 15 and 16.

The figure represents an interior cast of average size and form of this species. The casts are all strongly convex between the umbones and the lower posterior margin, forming a broad umbonal ridge, and a broad sinus, as well as a straightening of the posterior margin. The beaks are indistinct but extend longitudiually and project above the hinge. One strong anterior muscle scar is situated apparently just at the anterior end of the hinge. Compare *Orthodesma curvatum* H. and W. Pal. O. II, p. 95.

From South Saint Paul and Highland Park.

Modiolopsis contigua n. sp.

Plate II, figure 8.

Shell small, length about 25 mm., bredth at the posterior extremity of the hinge, 15 mm., at the umbones about 9 mm. The hinge is somewhat curved and is in some specimens longer posteriorally than in the one figured, and in these it forms an obtusely rounded angle with the posterior margin. The ventral margin is concave or straight, the anterior margin short and strongly convex. The beaks are somewhat obtuse and are directed forward. Their posterior half swells into a high rounded umborial ridge that extends towards the posterior-ventral margin while the anterior half is flattened continuous with the concave area anterior to the umborial ridge. The greatest convexity is at one-third the distance from the umbones towards the lower posterior margin. The shell has been very thin and marked with growth lines. It differs from *M. plana* Hall, in being proportionately narrower and having a stronger umbonal ridge and more concave ventral margin. From *M. similis* Ulrich it differs by the same characters. The type specimen is a relatively broad one.

Found at South Saint Paul.

Modiolopsis gregalis n. sp.

Plate II, figures 10, 11 and 12.

Length about 25 mm.; bredth 12 mm. and greatest at the middle; beaks less than one fifth the distance from the anterior end, small, incurved and scarcely projecting. Hinge line nearly straight; dorsal margin rounded gently from the hinge but more strongly so near the ventral margin; ventral margin gently arcuate and gradually rounding up continuous with the anterior, which in turn curves abruptly at the antero-dorsal end. Convexity moderate and uniform except for a low broad umbonal ridge which extends from below the beaks towards the lower part of the posterior margin. Point of greatest convexity just above the centre. One reniform anterior muscle scar near the anterior end, close to the pallial line. Pallial line simple, and marked off by a marginal thickening of the shell.

Mopiolopsis subelliptica Ulrich, as described* is the nearest to this species of any known. The difference in size, the position of the muscle scars and the beaks, and the difference in outline and convexity are apparent but the resemblance is great. The specimen is about medium size.

South Saint Paul and Daytons Bluff.

Modiolopsis affinis n. sp.

Plate II figure 9.

Cast of medium size, length 15 mm, bredth 8 mm, beaks about one fifth the distance from the anterior end, not prominent, but strongly curved. The hinge line is curved and runs gradually into the truncate posterior. The ventral margin is arcuate, and the anterior semi-circular. The convexity is greatest anteriorly and along the strong umbonal ridge which extends down and back to the extended end of the shell at the ventral posterior margin. Above the umbonal ridge the shell is gently concave while below and parallel with it the cast is flattened. The pallial line is not distinct.

The above description is of a slngle specimen which very much resembles *M. gregalis* but is more convex in the anterior portion and has a strong umbonal ridge and some indications that the shell was marked by coarse elevated lines radiating from the umbonal ridge. The general outline of the cast led to the expectation that specimens intermediate in form would link this with *M. gregalis* n. sp. but although a large number of specimens of the latter have been found, the distinctive characters still remain.

South Saint Paul.

Modiolopsis senecta n. sp.

Plate II, figure 17.

Shell large, length 33 mm, bredth 15 mm, convexity very moderate, but slightly increased between the umbones and the posterior extremity. Hinge straight and long. The ventral margin arcuate and it extends uniformly to the longitudiual extremities of the shell so that the anterior and posterior margis are short obligue truncations. Pallial line and muscle scars not visable. Beaks not projecting, low, and placed far anterior. Only one specimen found.

South Saint Paul.

Genus Tellinomya.

Neither of the two species referred to this genus have the characteristic hinge teeth clearly preserved, but that is evidently because the sediment or sand was too coarse to preserve a cast of such minute structure.

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*Ext 19th Ann. Rep. Minn. Geol. Sur. March 3rd 1392

Tellinomya novicia n. sp.

Plate III, figure 3.

Length about 12 mm, bredth 8 mm, convexity of a single valve 3 mm. The beaks are prominent, curved, situated about one-third the length from the anterior end, and directed a little forward. Between the beak and the ventral margin the convexity is strong but uniform, while anteriorly and in the postero-dorsal direction the convexity is abrupt, giving the cast a triangular appearance. The hinge is about 8 mm long, curved and elevated posteriorally so as to form a concave surface below it. The pallial line is simple and well marked. The anterior muscle scar is large, round and placed midway below the beak, and tangent to the pallial time, which seems here to form a sort of clavicle. Posterior scar not distinct.

Found at South Saint Paul and Dayton's Bluff.

Tellinomya absimilis n. sp.

Plate III, figures 1 and 2.

Length about 20 mm, bredth 10 mm. Beaks anterior, small and curved close down to the hinge. Hinge, posterior to the beaks, is nearly straight and is long; anteriorally it is short and curved down, in continuation with the anterior margin, which is nearly straight above but curved abruptly back below forming an acutely rounded antero-ventral projection. The ventral margin is gently convex for the anterior half, gently concave to the posterior extremity, but in general direction is parallel to the cardinal line. The posterior margin is nearly straight, is well marked off from the ventral and dorsal, and forms an angle of about 110° with the latter. The point of greatest convexity is at the umbones anterior to the strong acutely rounded umbonal ridge which runs obliquely back forming the postero-ventral angle and giving a convex slope to the postero-dorsal and postero-ventral portions of the shell. Below the umbones the shell is strongly and evenly convex. The shell was thin and marked by fine plications which radiate from the umbonal ridge. The dentition is that of a *Tellinomya* but not distinctly preserved.

Highland Park.

GASTEROPODA.

Genus Holopea.

Holopea cf. obliqua Hall.

Plate III, figure 5.

Compare *Natica* (species undetermined) Hall 1847, Pal. N. Y., vol. 1, p. 42, pl. 10, fig. 4, and *Holopea obliqua* Hall 1847, Pal. N. Y., vol. 1, p. 107, pl. 37, fig. 2.

Small, of about three or four volutions, the last of which forms the main body of the shell. Volutions evenly ventricose above. Sutures well marked. No umbilicus. Surface with ridges of growth which run directly transverse. Apical angle about 115°. Three specimens have been found all of which are imperfect. There is no umbilicus, but in other respects they are exactly like *H. obliqua* Hall with the lower part broken off. In vertical sections of *H. obliqua* Hall from the Stictopora bed of the Trenton in Minnesota, the umbilicus was found to extend through the last or last two volutions only. There seems to be nothing that indicates a distinction between these specimens and *H. obliqua* as found in the Trenton of Minnesota.

South Saint Paul.

Holopea paludiniformis Hall.

Holopea paludiniformis Hall 1847, Pal. N. Y., vol. 1, p. 171, pl. 37, fig. 3.

One specimen indentical with the upper volutious of *H. paludiniformis* is imperfect but differs in no way that can be seen, from specimens that occur in the "Lower Blue Bed" of the Trenton limestone at Minneapolis.

Found at South Saint Paul.

Genus Murchisonia.

Murchisonia cf. *gracilis* Hall.

Plate III, figure 4.

Murchisonia gracilis Hall, 1847. Pal. N. Y., vol. I, p. 181, pl. 39, fig. 4.
Murchisonia gracilis Salter, 1859. Can. Org. Rem., Decade I, pl. 5, fig. 1.
Murchisonia gracilis ? Whitfield, 1882. Geo. Wis., vol. IV, pl. 5, fig. 19.

Several imperfect specimens have been found that approach *M. gracilis* Hall, but that have the whorls less oblique, and also were much larger when perfect than those in the Trenton and Hudson series of Wisconsin and Minnesota. The specimen figured here has been distorted so that the whorls appear too little oblique and the spire too broad. Other specimens show that there were four or five more volutions below and there must have been as many more to form the upper part of the spire. They resemble in every way the figure of *M. gracilis* (Hall) Salter, from the Chazy or Black River limestone at Paquette's Rapids, Canada. But this is larger, with more numerous whorls and a greater apical angle than those of the Trenton of Wisconsin and Minnesota, and it seems to differ in the same way from Hall's figures of Trenton specimens from New York.

Murchisonia cf. *tricarinata* Hall.

A specimen probably belonging to this species was found at Highland Park and was identified by me, but was afterwards destroyed accidentally so that more exact comparison with the typical Trenton species is no longer possible.

Genus Ophileta.

Ophileta fausta, n. sp.

Plate III, figures 8 and 9

Coil of about three volutions nearly in the same plane; spire concave, the sides forming an angle of about 45°. The umbilicus is difficult to distinguish from the concave upper surface except by noting the direction of the aperture. The outer surface of each volution is gently convex, and joins to the upper and lower surfaces by acutely rounded angles, the lower one of which is perhaps a little the stronger. The upper and lower surfaces of each coil are about equally convex, and are nearly straight. The inner surface is quite straight, is equal in length to one-fourth the outer surface, and equal to once the outer surface of the volution with which it is in contact· Sutures deep on the cast. Surface smooth but marked by five transverse lines which run a little forward from the suture to the upper outer angle, thence obliquely down and back to the lower outer angle and from there curve a little forward to the contact with the penultimate whorl. Shell probably very thin.

Highland Park.

Genus Platyceras.

Platyceras vetulum n. sp.

Plate IV, figure 1.

Several specimens have been found which appear to belong all to the same species, although they vary in the form of the aperature and convexity of the body whorl, owing partly to distortion. In general the casts show that the shells were small, dextrally coiled, and had the body whorl proportionally very large. The spire or apex is not well preserved in any of the specimens, but was low, scarcely rising above the body whorl, and con sisted of one, possibly two whorls. The aperature was ovate, narrowest on the side next the spire, and strongly indented by the penultimate whorl. The plane of the aperature is nearly parallel to the axis of the spire.

There is some resemblance in this species to very rapidly expanding shells of the genus *Holopea*. Unfortunately no specimens could be found sufficiently well preserved, and not enough of them, to allow of good generic diagnosis. The figure is of a large specimen.

Found at South Saint Paul.

Genus Pleurotomaria.

Pleutoromaria aiens n. sp.

Plate III, figures 16 and 17.

Shell large, consisting of about four volutions which are rapidly expanding and ventricose. The first volutions on interior casts are evenly rounded, but the last one on large specimens has a broadly rounded carina a little below the middle. Apical angle 120°. Suture deep. Aperture large, indented on the inner side by the penultimate volution. The margin curves back from the suture for nearly one-fourth of the last volution and then forward an equal distance, making a deep, rapidly narrowing fissure, the rounded apex of which forms the longitudinal ridge. The umbilicus is large and opens nearly to the apex. No surface markings except irregular growth lines.

Highland Park and South Saint Paul.

CEPHALOPADA.

Genus Orthoceras.

Orthoceras minnesotense n. sp.

Plate III, figures 11 and 12.

The only specimen is a fragment of the septate portion of the shell. In the length of about 30 mm. the dorsal and ventral sides converge from 30 mm. to 23, and in that length there are included eight septa. The transverse section is oval, probably broadest above. And the siphuncle, which is about five mm. in diameter, is placed five or six millimeters above the lower surface. The septa were strongly convex, and on the cast the sutures are seen to have been curved backward on the sides as shown in the figure. The surface was smooth and the shell very thin.

Found at South Saint Paul.

Orthoceras (?) sp. undet.

Plate III, figure 10.

Compare *O. montrealense* Billings, Canadaian Naturalist, vol. IV, p. 361.

A fragment of the shell showing numerous septa and fine longitudinal striæ and enough only to show what the circumference probably was is all that has been found of this species.

Highland Park.

Orthoceras sp. undet.

Plate III, figures 13 and 14.

This is a fragment probably of the siphuncle of an Orthoceras which shows no diminution in size at either end. The under side is the exact reverse of the side figured. It has probably suffered from compression since becoming fossilized.

From Highland Bark, Saint Paul, Minn.

BRACHIOPODA.

Genus Crania.

?*Crania reversa* n. sp.

Plate III, figures 6 and 7.

A single cast of a shell marked only by very indistinct concentric lines, with a nearly conical outline and centrally placed apex, has been found. Besides the general outline of a *Crania* it has what are probably a pair of large muscle scars, 1.5 mm. in diameter at half way between the apex and the posterior margin and about one mm. apart. Other characters can not be observed, but this appears to be the ventral valve of a *Crania*.

Found at Highland Park.

Genus Lingula.

Lingula morsii N. H. Winchell.

Plate IV, figures 2 and 3.

Lingulepis morsensis N. H. Winchell, Fourth Annual Report of the Geological and Natural History Survey of Minnesota (1876), p. 41, fig. 6, a, b, c.

Lingulepis morsii (Winchell) S. A. Miller (1889), American Geology and Paleontology, p. 352.

A few specimens of this species have been found near Fountain, Fillmore county, at the same exposure from which the type specimens are said to have been collected. They differ somewhat from the original description and figure but are no doubt the same. The shells are cuneate in outline, moderately convex, with an apical angle of about 50 to 60° (26°, Winchell). The surface is smooth, with but slight concentric growth marks, and of the usual green color, although in most specimens a deep iron coloration has taken place. Radiating (not concentric) elevated rounded striæ are present, strongest near the anterior margin.

The specimens figured are from one of the strata (*c.* fig. 9, pl. IV) of the transition at the base of the Trenton (Galena) group, near Fountain Minnesota.

Genus Orthis.

Orthis perveta ? Conrad.

Plate IV, figure 4.

An imperfect specimen only was found, but so far as can be seen it is like those that occur in the Buff limestone of the Galena series, that rests above the shale [See pl. IV, fig. 9, c.] in which this one was preserved.

BRYOZOA.

Genus Ptilodictya.

Ptilodictya ? sp. ?

Plate III, figure 15.

The drawing illustrates an iron-stained imprint found at Highland Park. No distinct characters remain on the fossil except the ramose outline, and evidence that it was flattened in one dimension like some of the Bryozoa so abundant in the Trenton series.

PORIFERA (Spongia).

Genus Raufella.

Raufella ? *fucoida* n. sp.

Plate IV, figures 5 and 6.

The figures are of casts found at Fountain, Minnesota, associated with, even containing, fragments of *Lingula morsii* N. H. W. They have some imperfect surface marks which, together with the general form, suggest that they represent Porifera, the walls of which have served to mould sand into internal casts and have since entirely disappeared. The casts are cylindrical and branched at regular intervals like *Raufella filosa* Ulrich and some other sponges of the Trenton series, and very much like an undescribed species very abundant and associated with *Licrophycus ottawaense* Billings in the Fucoid bed.

General Discussion.

The species are, therefore, distributed paleontologically as follows:

MOLLUSCA—	Lamellibranchiata—	*Cypricardites,*	4 species.
		Modiolopsis,	7 species.
		Tellinomya,	2 species.
	Gasteropoda—	*Holopea,*	2 species.
		Murchisonia,	2 species.
		Ophileta,	1 species.
		Platyceras,	1 species.
		Pleurotomaria,	1 species.
	Cephalopoda—	*Orthoceras,*	3 species.
MOLLUSCOIDEA—	Brachiopoda—	*Crania, ?*	1 species.
		Lingula,	1 species.
		Orthis,	1 species.
	Bryozooa—?	donbtful,	1 species.
PORIFERA—	?	cf. *Raufella,*	1 species.
	Total,	14 genera,	28 species.

All the species of the Saint Peter sandstone are very similar to others in the overlying Trenton limestone. In fact, if all had been found in some stratum of the lower part of the Trenton (Galena) series instead of in the Saint Peter formation, their occurrence would not have been thought surprising. The similarity with Trenton species is far greater than the lithologic difference of the two formations had led geologists to expect. But the Saint Peter fauna is only molluscan, i. e., there are wanting in it the Coelenterata, Bryozoa, Crinoidea and Trilobita which are so abundant in the Trenton. These conditions seem to prove that a physical much more than a time break separates the two formations, for the species are but little different while the faunas as a whole are widely different. A comparison with the formation that underlies the Saint Peter, shows an opposite relation. The Shakopee fauna, so far as the writer has found, consists of a few species of Gasteropoda and Cephalopoda. It is like that of the Saint Peter sandstone in being molluscan, but the individual species are different, being of the Upper Calciferous type. It can be argued from these considerations that the Saint Peter is separated from the Shakopee rather by a time gap than by physical changes. The paleontological evidence is not to be exclusively relied upon, since it is drawn from too few specimens and these not all of the very best kind. But the evidence as we have it agrees essentially with that found by stratigraphical and lithological comparison.

PHYSICAL RELATIONS.

There is in general, an upper and lower division of the Saint Peter sandstone, as has often been suggested by writers who have studied the lithologic characters of the formation, and I can see also a faunal difference, although not a wide one. No one has ever found an exact division, however, even in a single locality and a division of the whole formation is not at all practicable. It must be considered for the present, at least, as an undivided unit. The extreme upper portion of the Saint Peter has been described sometimes as a transitional zone, which it really is, but whether it is clearly distinguishable as such from the main formation is not certain. At Fountain, there are such strata which could be arbitrarily separated where the shales begin, (see fig. 9, pl. IV). But these strata are not constant for any considerable distance. There are also transitional shaly strata with intermingled sand grains at the top of the Saint Peter at Minneapolis, which contain only Trenton fossils and belong to the Trenton. Transition strata are usually found but they are not necessarily equivalent those in one locality with those of another.

The Trenton has been everywhere conformably laid upon the Saint Peter sandstone, with usually a short transitional zone between them. Where the Trenton has been eroded away, the Drift, the Cretaceous, or the Carboniferous rests unconformably upon the Saint Peter, as already described above under the head of Geological distribution.

Upon the relation between the Saint Peter and the Shakopee below it geologists are not agreed as they are upon the transition between Saint Peter and Trenton. McGee (31) Keyes (32) and Norton (33) agree in pronouncing the Shakopee inseparable from the Saint Peter and include the former in the latter. They say that the former really passes by degrees into the latter. This theory does not agree with observations made by other writers. Hall in 1852 (9) describes this transition as abrupt. Chamberlin (21) says that brecciated pieces of dolomite occur in places in the lowest stratum of Saint Peter. Irving (22) writes that "between the periods of deposition of the lower Magnesian and the Saint Peter there was a long gap whose record is in the eroded surfaces of the first named formation." Moses Strong (23) held a similar view. Chamberlin, who wrote later (26) corecting the theory that the great inequality at the top of the "Magnesian" was due to erosion, and showing that the undulating surface was really due to folding of the upper part of the "Magnesian" i. e. Shakopee, still does not contradict Hall's statement that the transition is abrupt. I have not observed a real unconformability between the two formations but such may exist, and the contact has been found an abrupt one as often as observed at all. In Iowa no exposed contact has yet been found by me. The Shakopee consists not only of dolomite but of more or less sandy strata and sometimes clay, and it may be that these sandy strata have been considered as a continuation downwards of the Saint Peter, a view that would require first other evidence to prove. It is contradicted really by the paleontological and stratigraphic evidence that we now have.

The Saint Peter folds conformably with the Shakopee, and the contact can be sometimes at least exactly marked because it is an abrupt transition. It is also conformable to the Trenton with a transition of alternating strata or of mixed materials. The Shakopee and Trenton are not however parallel to each other, for as well known the former is much folded while the latter is almost exactly horizontal, the Saint Peter between them being consequently of unequal depth. It was naturally supposed by geologists that the folding of the Shakopee was completed before the deposition of the Saint Peter began and that may still be supposed correct in part but not entirely.

Figure 10, plate 4 is a sketch of an exposed contact of the last member of the Magnesian series (i. e. Shakopee proper) and the base of the Saint Peter formation, as seen along the Illinois Central Ry., at the crossing of the Chicago Milwaukee and Saint Paul Ry., in LaFayette county, Wisconsin, a few miles north of the Illinois-Wisconsin state line. It represests one of the extreme cases of folding seen in the Peccatonica valley and is chiefly interesting in that the two feet of shale which is always found at the top of the Shakopee in that region is preserved beneath the sandstone undiminished except by compression. Had the folding taken place before a considerable depth, 20 feet or more, of sand was deposited, the shale would have fallen from the eminence by its own weight or at least been washed down by the water. The sandstone in this exposure is somewhat confused by compression yet it can be seen that here as at other exposures in the Peccatonica valley the stratification of the Saint Peter is conformable to the Shakopee. The upper surface of the Shakopee i. e. at the contact, is ripple marked.

There are small faults as described in a former paper (see 30., p. 354. fig. 4.) which extend upwards from the base of the Saint Peter formation through the sandstone, about half way up to the Trenton.

These phenomena were considered to be evidence that the Saint Peter was deposited partly before and partly after the folding of the Shakopee. Of this I shall speak again in discussing the origin of the sandstone.

STRATIGRAPHIC POSITION.

The position of the Saint Peter is of course clearly, between the Lower Buff limestone of the Galena (Trenton) series above, and the Shakopee dolomite of the Magnesian series below. It is conformable to both. Paleontologically it is closest united to the Galena (Trenton) series above it. Lithologically it belongs to the "Magnesian" series with the Shakopee, for it stands as the last of that series of sandstones and dolomites, and does not unite with the Galena (Trenton) series which consists of limestones and clays without sandstone. A time break seems to separate the Saint Peter from the Shakopee, while a physical revolution separates it from the Galena series. It thus appears to be a transition formation between the Magnesian series or Upper Cambrian and the Lower Silurian, and it has been so considered (30).

But that the Saint Peter represents the lowest member of the Ordovician (Lower Silurian) as understood by that term in England and in New York, is not unconditionally asserted. In fact, the Shakopee may be proved to be the lowest member of the Ordovician, when more exactly correlated.

CORRELATION.

The period to which the Saint Peter belongs is by far the most easily determined through its relation to the Galena (Trenton) series, which is richly fossiliferous. The Magnesian series also affords a means of determination because fairly fossiliferous. James Hall and J. D. Whitney (8) in 1858 correlated the Saint Peter, in this indirect way, with the Chazy of New York. Hall again in 1862 and in 1863 repeats it, and nearly all geologists have followed his correlation, hence the name Trenton, which belongs typically to a New York formation, has been equally applied to parts of the Trenton (Galena) series that overlie the Saint Peter. The Trenton series of New York and Trenton (Galena) series of the upper Mississippi valley are correlated. There is, nevertheless, diversity of opinion over the question, what part of the Galena (Trenton) series is equivalent to the Trenton formation proper of the New York Trenton series; what part equals the Black River formation; and what the Chazy.

By many geologists, the Galena (Trenton) series is believed to include only the equivalents of the Black River limestone and Trenton limestone proper, the equivalents of the former being called Trenton and that of the latter Galena limestone. The Saint Peter thus remains to be correlated with the Chazy.

This correlation cannot be said to be undoubtedly established, but represents the extent of our knowledge. It is here inserted because it takes the place necessarily of a direct comparison of the Chazy and Saint Peter faunas, both of which are relatively meagre.

The two formations, Shakopee and Oneota, beneath the Saint Peter faunally correlate well with the Upper and Lower Calciferous respectively, which underlie the Chazy proper, and they also correspond in their relation to each other and to the overlying formations.

Like that of New York, the formation called Chazy in Canada seems to hold a stratigraphic position comparable to that of the Saint Peter sandstone, and, as Joseph F. James (34, p. 131) has pointed out, it is in a way a transition between the Chazy proper and the Saint Peter, since it is neither chiefly limestone like the former nor pure sandstone like the latter, and since it lies geographically intermediate.

The Saccharoidal sandstone in Missouri* was believed to be the equivalent of the Saint Peter by Meek, as also by Shumard (loc. cit.), and more particularly by Worthen (12). In fact the Saccharoidal sandstone is lithologically and stratigraphically like the Saint Peter. Mr. Meek found fossils in it, but unfortunately they have never been described. No new evidence has since been added. Charles R. Keyes has recently doubted that the "Saccharoidal" sandstone is the representative of the Saint Peter in Missouri,† the latter being, as he thinks, either absent or represented by a limestone. He gives no reasons for this new departure.

ORIGIN.

Keating, who was surprised, like many other explorers, at the purity of the Saint Peter sandstone, mentions someone's theory "that this sandstone must have been formed by a chemical precipitation and not by mere mechanical deposition." (See 4, p. 330.) Owen, on the contrary, never mentions anything but sedimentary phenomena in his descriptions of the formation. Hall and Whitney (8) adopted the chemical theory to explain the purity, although apparently but once.

The Saint Peter sandstone is a mechanical sediment and consists of quartz grains such as come from the erosion and decomposition of acidic eruptive rocks (see Chamberlin, 26). Its structure is that of a mechanical sediment. It contains marine fossils. One must therefore explain the purity of the stone in some other way than that which explains the purity in salt and gypsum deposits. But no explanation offers itself readily.

* See Geological Survey of Missouri, 1st Ann. Rep. (1853) pp. 117 and 197; 2nd An. Rep. (1854) pp. 105, 145 and 160.

† Missouri Geological Survey, vol. 4, pp. 30. 35 and 38.

In the first place, with the exception of the very small percentage of kaolin the impurities distributed through the Saint Peter sandstone can be and evidently should be considered as recent infiltrations. Therefore the stone was once an almost absolutely pure quartz. In the second place, there are fossil casts in the white sandstone; these must have been produced by calcareous shells, although the shells themselves have been dissolved away so thoroughly as to leave no stain nor trace of their substance. Still other fossils are moulds of former internal casts as already described. The moulds are now full of loose sand, which together with soluble materials, probably, for the most part, calcium carbonate, formerly composed the internal casts from which the moulds are preserved. The amount of quartz sand as compared with the now missing soluble materials, seems to be less than half the content of the moulds. The question suggests itself: Could the strata of the Saint Peter have been originally one-half calcium carbonate? Was the formation originally a calcareous sandy mixture, which later became pure quartz by the chemical action of water?

The Saint Peter strata constitute a sandstone in the highest degree porous and water flows through it readily, so that the very best circumstances for infiltration and exfiltration are now afforded by it. It could have been for long periods a perfect underground waterway. It is, in fact, situated next under a series of clay, marl, and limestone formations that are more impervious to water, while beneath it are sandstones and somewhat porous dolomites through which water could pass somewhat readily. The exposed, eroded, and glaciated border of these formations is at the same time their more elevated portion, so that water sinking into any of them would be carried deeper as it coursed in the direction of the stratification. The water in the Saint Peter would be held back by the impervious strata above it, while that in the strata beneath could break upwards through the dolomites and sands into the Saint Peter, which latter thus would be the main underground waterway. This may explain why the sandstone is now so pure, for much calcium carbonate and other constituents could have been carried from the formation by coursing waters.

Such considerations may be used to explain other phenomena as well. It has been shown that the folding of the Shakopee took place at last partly after the sandstone was deposited upon it. (See fig. 10, pl. 4.) The folding is similar to that produced by lateral pressure, except that for some reason the top and not the base of the Magnesian series is involved in it. The Shakopee is very strongly arched here and there and the top of the Oneota likewise, but before the base of the latter is reached the undulation disappears, except in one or two localities, near the city of Saint Peter, Minnesota, for example, and there the underlying Jordan sandstone is pure like typical Saint Peter. The Saint Lawrence formation is not seen to be folded.

In view of the facts as given above, I am constrained to set forth a theory, without, however, considering it as conclusively proved, that the purity of the Saint Peter sandstone, the paucity of its fossils and its variable depth are all due to the effect of percolating waters and were not original characters, and, further, that the supposed unconformability at its base may have been produced solely in this manner. That is, that the Saint Peter has simply had all soluble material washed out of it, that it is thus reduced in thickness, and that the now dolomitic formations immediately beneath have been attacked in a similar manner and reduced—the whole process causing a shifting of the sand sufficient to produce inequalities in its thickness.

The great mass of Silurian and Devonian rocks resting upon the Saint Peter have not been reduced in that manner, nor to the same extent, but have preserved an unbending crust, while the Middle Cambrian sandstones below the Oneota formation remained likewise rigid. Inequalities produced during the reduction of the Saint Peter and Magnesian series also must have caused shifting and readjustment, and naturally these would culminate intermediately between the firm overlying and underlying formations, that is, in the formations that were being most reduced. This may explain why the folding begins midway in the Oneota, culminates at the base of the Saint Peter, and ends below the top of the same.

Heretofore geologists have considered the Saint Peter sandstone as originally deposited in an almost chemically pure condition. One argument against this view lies in the peculiar preservation of its fossils. Again a fair degree of purity is generally found, and all the exposed portions of the formation alike exhibit the conditions necessary for the theoretical origin that has been pointed out. Still it remains that this formation is unique among the Mississippi valley sandstones of Eopaleozoic time.

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November 13, 1892.

[*Paper E.*]

THE RUM RIVER VALLEY AS A BOTANICAL DISTRICT.

E. P. Sheldon.

The Rum river, with its tributaries, drains the surface area of Mille Lacs, Isanti and Anoka counties. Besides this, portions of Crow Wing and Aitkin contributory to Mille Lacs lake, and the eastern edge of Morrison, Benton and Sherburne counties are in its drainage basin. The valley is thus seen to occupy a narrow strip lying between the Mississippi drainage on the west and the St. Croix on the east.

Within this narrow belt the most varied conditions for plant growth are offered. It is to be noted that this section is between that contributory area on the north and east from which we would most naturally expect the entrance of plants usually found occurring wherever large coniferous belts are extant; and the prairie-plant-contributing area on the south and west, from whence we would expect the great host of prairie composites, pulses, grasses, etc.

Viewed in this light a study of the plant immigrants now seeking a foothold in the valley becomes as interesting as a review of the endemic plants. But we must remember that in a very recent time in the history of our continent the plants now considered endemic were emigrants from the north, the south, the east or the west. And we must not forget that the section under consideration has in times past been subject to the same glacial action as most of our Minnesota natural drainage basins. Furthermore, the Rum river valley now lies between the old Mississippi drainage on the east—the present St. Croix—and the later and present channel on the west.

Then again birds have flown, waters have carried and winds blown for ages past even as they are doing to-day, all assisting in the constant dissemination of seeds.

Before enumerating some of the plants recently found in this section, it would, perhaps, be well to point out some of the conspicuous sylvan characteristics noted, with a view to showing what a diversity of conditions and consequent multiplied chance for plant establishment.

The pine-barren region characteristic around Brainerd and Aitkin barely touches the northern edge of the drainage north and west of Mille Lacs lake.

The straight, slender jack pine, *Pinus divaricata* (Ait.) Sudw., which is found in quite heavy groves in the localities above mentioned, occurs only locally south to Princeton. East of Mille Lacs lake miles of almost impenetrable swampland renders botanical investigation difficult. The timber of these swamps is largely larch, *Larix americana* Michx. Intermixed with this is to be found a considerable quantity of black spruce, *Picea nigra* Link.

Of course the bordering edges are of typical hard-wood swamp, where maples, ashes and elms predominate. The north and west shores directly contiguous to Mille Lacs lake are high and abundantly covered with groves of maple, elm and oak. Quite often scattered clumps of the hackberry, *Celtis occidentalis* L., are found.

The major part of the Mille Lacs Indian reservation is covered with a luxuriant and valuable growth of pine, mostly *Pinus strobus* L. and *Pinus resinosa* Ait. South of this to a line a few miles north of Princeton the country is covered with a thick growth of mixed timber. This formerly contained considerable pine, but owing to the demands of civilization it has disappeared. Intermixed with this was a valuable and interesting growth of hard-wood timber, consisting mostly of oak and elm. In many places this has been cut off and the characteristic plants of burnt wood-lands have become introduced.

South of Princeton sand dunes and oak openings prevail. Here almost the only trees for miles around are *Quercus macrocarpa* Michx. and *Quercus velutina* Lam.

Heretofore there has been, to my knowledge, almost no collecting and identification of material in this valley, which seems to present comparatively so little of the effect which agricultural development always has on a given area. So we find very few cosmopolitan species, and these are found contiguous to the railroad and near the few and scattered farm houses and claim shanties.

Very interesting are the orchids found in the swamps and damp woods. Most frequent to appear is *Habenaria broctrata* R. Br. This plant, while never occurring abundantly in any one place, nevertheless is found throughout the whole valley wherever anything approaching the condition of hardwood swamps is found. *Habenaria tridentata* Hook. and *Habenaria obtusata* Rich. were found sparingly in a little swamp near Nicholas, Aitkin county. *Corallorhiza corallorhiza* (L) Karst., *Cypripedium acaule* Ait. and *Cypripedium arietinum* R. Br. occur more frequently. *Achroanthes unifolia* (Mx.) Raf. is another rare orchid found growing luxuriantly in a swampy opening near Vineland, Crow Wing county. In all specimens examined, last mentioned species, the pollinia occur singly in each cell.

Petorites palmata (Hook) Gray was found but it is local in its occurrence. It prefers low, damp situations on the edges of swamps and is frequently found in open groves of poplar saplings.

Gilia linearis (Nutt) Gray is abundant along the sandy beach of Mille Lacs lake, especially on the north and west shores.

This plant is very local in its range in Minnesota. Dr. Sandberg found it at Red Wing in 1885. Aside from this the Mille Lacs locality is the only one that is definitely known for this plant in the state. From these two eastern Minnesota localities it is reported westward to the Pacific.

Physolis grandiflora Hook., a distinctive plant of the

Saskatchewan and Lake Superior basins, reaches its southernmost limit along the western edge of Mille Lacs lake. It is found abundantly in the neighborhood of the aboriginal earthworks in the northwestern corner of the Indian reservation.

Oenothera albicaulis Nutt. reaches the easternmost limit of its range in central Mille Lacs county. It is found frequently on burnt woodlands and has doubtless been introduced through the agency of the railroad.

Oenothera rhombipetela Nutt. also seems to have its northernmost limit in Anoka and southern Mille Lacs counties. In Minnesota it is characteristically a sand-dune plant.

Pentstemon grandiflorus Nutt., *Pentstemon gracilis* Nutt. and *Penstemon pubescens* Solander are frequent in the oak openings of the southern portion of the valley.

A remarkable form, closely resembling *Pentstemon albidus* Nutt., but having the open thyrse and, to a certain extent, the bearded lip of *Penstemon pubescens* Solander., was found on the sandy shores of an old lake bed west of Princeton. The constant discovery of peculiar forms of the species of *Penstemon* renders the genus extremely difficult to study.

Phegopteris calcarea Fée is an interesting fern which has so far only Minnesota and Iowa for its American localities. In Iowa it was found near Decorah by Mr. E. W. D. Holway. In Minnesota it has hitherto only been reported by Miss Ellen Cathcart from the banks of the St. Louis river. I have found three new localities for it in the Rum river valley. It was first found on the shady banks of Farm island, in Farm Island lake, about nine miles south of Aitkin. Later in the season I found it growing in abundance on Robinson's island, in Mille Lacs lake, and on the shady banks of Bordin's creek, near Garrison, Crow Wing county. It prefers shady locations on the north side of high banks.

Its near congener, *Phegopteris dryopteris* Fée. was also found abundantly on Robinson's island and on Bassett's point, near Vineland, Mille Lacs county.

The enumeration of all the peculiar and interesting plants found would be of value, but it is rather my object to point out the prolific character of this narrow strip. This is due, of course, to the diversity of conditions for plant sustenance.

Then, too, a study of the plants introduced through the agency of the railroad would be of interest. But in a section so near to the original in nature a notice of the abundance of peculiar Saprophytic plants must be taken. Everywhere in the different timbered localities, in the swamps and over the burnt woodlands Agaricinæ and other fleshy fungi were especially noticeable.

The flora of the "Thousand lakes" must also be noted, and it is well to notice that even in the counties most thickly studded with lakes, each has its characteristic alga.

November 13, 1892.

[*Paper F.*]

THE FAUNA OF THE MAGNESIAN SERIES.

DESCRIPTIONS OF FOSSILS.

*F. W. Sardeson.**

The object in presenting the following notes on the faunal characters of the Magnesian series is to establish a systematic table as a basis for the rational division of the formations of the series. A mere compilation of species already described and referred to this series would seem to prove the existence of two faunas, one for the "Lower Magnesian" and another for the "Potsdam" or "Lower Sandstone" of the Upper Mississippi basin. But no such two faunas exist. Each is a confusion of different faunas. There were also very few species known and these of very rare occurrence. In searching for these old species—for all data had to be verified—several new species have been discovered.

All fossils collected have been referred with the greatest care to their proper division of the "Lower Magnesian" (Owen), viz.:

1. Shakopee dolomite.
2. New Richmond sandstone.
3. Oneota dolomite.

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* Partially revised November 18, 1895.

Or to those of the "Potsdam:"

4. Jordan (Madison) sandstone.
5. Saint Lawrence (Mendota) formation.
6. "Dresbach" or "Saint Croix" sandstone and the undivided series beneath it.

Only numbers 1 to 5, i. e., the Magnesian series (Hall and Sardeson), are fully included in this discussion.

Of these five formations it is found that the Shakopee has a fauna consisting of species of mollusca, all of which are peculiar to that formation. The New Richmond sandstone has so far yielded no fossils. The Oneota, Jordan and Saint Lawrence, on the contrary, are not only fossiliferous, but the species of each are in part the same as those of the other two. The fauna of the Oneota dolomite consists mainly of Gasteropoda, Cephalopoda, a few brachiopoda, and no others except one fragment of a trilobite (*Asaphus*). The Jordan fauna resembles that of the Oneota, but embraces also trilobites like the Saint Lawrence. The last named has yielded but one molluscan species as yet, and several Brachiopoda besides Trilobita. This account may be enlarged in future.

Nearly all the Trilobita are omitted here, both because they aid only in comparing the Jordan and Saint Lawrence with each other and with underlying strata, all of which have been heretofore united ("Potsdam"), but also because the species have been described from fragments and rare occurrences, most of which the author has not yet had the opportunity to verify. These will form a problem for the future. The Mollusca and Molluscoidea are presented below, and from a study of them it has been concluded that the Shakopee is faunally separate from the Saint Peter sandstone above and to a less degree also, from the Oneota below. The New Richmond sandstone maintains uncertain relations between them. With the Oneota are united the Jordan and Saint Lawrence, which last contains a fauna distinct from the next known fauna below it, i. e., that with *Obolella polita* Hall, *Lingula ampla* Owen, *Hyolithes primordialis* Hall.

The Mollusca, like the Trilobita, occur as casts. In the Oneota particularly, the casts have sometimes filled with chert and are locally more abundant for that reason. A dolomitized shell rarely occurs. The Brachiopoda more often have their shells preserved and can thus, like the silicified casts of molluscs, be found even where the reduction of the strata has obliterated the hollow casts. Such obliteration is often noted in the Shakopee and Oneota, and very frequently in the Jordan and Saint Lawrence.

The following table shows the distribution in vertical range of the species collected, and following it are notes upon and decscriptions of the same.

Table of Fossils Identified from the Magnesian Series.	*St. Lawrence.*	*Jordan.*	*Oneota.*	*New Richmond*	*Shakopee.*
Asaphus sp.			*		
Dikelocephalus minnesotensis Owen	*				
Lingula aurora Hall	*				
Lingula dolata n. sp.			*		
Lingula mosia Hall	*		*		
Lingula winona Hall	*				
Orthis (Billingsella) pepina Hall	*	*	*		
Bellerophon antiquatus Whitfield		*			
Euomphalus winonensis n. sp.			*		
Helicotoma (?) peccatonica n. sp.					*
Holopea obesa Whitfield			*		
Metoptoma barabuensis Whitfield		*			
Murchisonia argylensis n. sp.					*
Murchisonia putilla n. sp.		*	*		
Ophileta alturensis n. sp.		*	*		
Pleurotamaria sweeti (Whitfield)		*			
Raphistoma leisomellum n. sp.			*		
Raphistoma lewistonense n. sp.					*
Raphistoma minnesotense Owen	*	*	*		
Raphistoma oweni n. sp.			*		
Raphistoma ruidum n. sp.					*
Straparollus intralobatus n. sp.			*		
Subulites exactus n. sp.					*
Tryblidium (?)repertum n. sp.					*
Ascoceras gibberosum n. sp.			*		
Cyrtoceras dresbachense n. sp.			*		
Cyrtoceras winonicum n. sp.			*		
Endoceras consuetum n. sp.					*
Piloceras corniculum n. sp.			*		

DESCRIPTIONS OF SPECIES.

Dikelocephalus minnesotensis Owen.

Dikelocephalus minnesotensis Owen, Report of Geological Survey of Wisconsin, Iowa and Minnesota, p. 574, Tab. I, figures 1, 2, 10; and Tab. I, A, figures 3 and 6.

Dikelocephalus minnesotensis Hall, 16th Annual Report New York State Museum of Natural History, p. 138, pl. XI, figures 1, 3 and 4.

This species is found in the Saint Lawrence dolomite at Osceola, Wisconsin, and Hokah, Minnesota, and intermediate. At the last-named place specimens were taken out five feet below the firm stratum of dolomite or about 35 or 40 feet below the top of the Saint Lawrence formation.

Lingula aurora Hall.

Liugula aurora Hall, Annual Geological Report of Wisconsin, 1861, and 16th Annual Report, New York State Museum of Natural History, p. 126, pl. VI, figures 4 and 5, 1863.

Associated with *Dikelocephalus minnesotensis* Owen in the Saint Lawrence formation at Osceola, Wisconsin, Otisville, Minnesota, along the St. Croix river and in exposures along the Mississippi river in Minnesota and Wisconsin are three abundant species of lingula, of which this one is the largest. It is easily recognized by the surface ornamentation of the shell.

Lingula dolata n. sp.

Plate VI, figure 12.

Shell of medium size, ovate, length not much exceeding the breadth; slopes from the beak nearly straight; lateral and anterior margins uniformly rounded; beak probably acute. The convexity of the shell is moderate and seems to have been greatest towards the beaks. The surface is shining but marked by numerous fine, irregular concentric lines which run out on either side along the slopes from the beak.

From the Oneota dolomite near Stillwater, Minnesota.

Lingula mosia Hall.

Lingula mosia Hall, 16th Report New York State Museum of Natural History, p. 126, pl. VI, figures 1 to 3, 1863.

This species is referred by James Hall to the same formation as *Dikelocephalus minnesotensis* Owen. Very good shells agreeing in every respect with the figures 1, 2 and 3 and with the original description have been found at several exposures of the Saint Lawrence formation. Some of them retain the glossy surface of the shell and the coarse concentric striations. Other specimens, not distinguishable from these, occur in the middle or upper portions of the Oneota along the Saint Croix river. But these, as preserved, retain a stronger convexity of the shell.

Lingula winona Hall.

Lingula winona Hall, 16th Annual Report New York Museum of Natural History, p. 126, pl. VI, fig. 9, 1863.

This species was described by James Hall from specimens obtained at Lansing, Iowa, "occurring more than two hundred fest below the Lower Magnesian limestone and near the middle of the Potsdam sandstone." The specimens here identified with it occur in numbers with other Lingula in the Saint Lawrence formation near Osceola, Wisconsin, and other places along the Saint Croix river. They have the sub-quadrate outline, a thick shell and show a deep pedicel groove.

Orthis (*Billingsella*) *pepina* Hall.

Orthis pepina Hall, 16th Annual Report New York State Museum of Natural History, p. 134, pl. VI, figs. 23 to 27, 1863.

Orthis pepina Whitfield, Geology of Wisconsin, vol. IV, p. 170, pl. I, figs. 4 and 5, 1882.

Orthis (*Bilingsella*) *pepina* Hall (1892), Palæontology of New York, vol. VIII, pt. I, p. 230, pl. VII, a, figs. 1-9.

This species is found at Osceola, Wisconsin, and vicinity in the Jordan sandstone and it occurs also in the Oneota dolomite a few miles further south, near Stillwater, Minnesota. It occurs also in the Saint Lawrence formation.

Bellerophon antiquatus Whitfield.

Bellerophon antiquatus Whitfield, Annual Report for 1877, Geological Survey of Wisconsin, p. 52; and Geology of Wisconsin, vol. IV, p. 176, pl. I, figs. 13 and 14, 1882.

Described by Mr. Whitfield from the "soft friable sandstone of the Potsdam group at Osceola Mills, Wisconsin." It has not yet been found on the Minnesota side of the Saint Croix river, although specimens have been found in the Jordan sandstone at the locality cited.

Euomphalus winonensis n. sp.

Plate VI, figure 1.

Shell of more than two and one-half volutions; rapidly expanding and in contact for about two volutions. The apex and flattened surface are nearly in the same plane. The suture is deep and the umbilicus wide. Aperature circular except for a deep notch on the upper outer margin, the successive stages of which have produced an angular keel, a flattened upper surface to the coil and a slightly concave band just beneath the keel. On the volutions that are in contact the upper inner surfaces are concave or of reduced convexity. The surface is marked by strong, irregular lines of growth, which curve obliquely back on either side of the keel, forming an angle at the acute edge of the carina. The shell was apparently very thin, and the apical portion of it was either filled solid or crossed by strongly concave septa for nearly one and one-half volutions on the largest specimen found.

From the Oneota dolomite near Dresbach, Winona county, and near Red Wing, Goodhue county, Minnesota, and at Blanchardville, La Fayette county, Wisconsin.

Helicotoma (?) *peccatonica* n. sp.

Plate V, figures 1 and 2.

Known casts of the shell are of about three volutions. These are strong and evenly convex on the inner and lower surface, while the outer surface is flattened and is bounded above and below by angular carinæ, of which the upper may prove to be of the nature of a band. The upper surface of each volution is divided into an outer concave surface, a convex median ridge and an inner flattened slope that joins the suture, and each volution is impressed on the upper inner side by the preceding one.

The coil is turbinate with an apical angle of about 130°, with a wide umbilicus and deep sutures. The aperture is circular in general outline. The growth lines are not distinctly preserved.

From the Shakopee dolomite in the Peccatonica river valley, near Argyle, Wisconsin.

Holopea obesa Whitfield.

Plate V, figure 19.

Holopea obesa Whitfield, Geology of Wisconsin, vol. IV, p. 348, pl. XXVII, fig.11, 1882.

Shell large, of five strongly convex volutions, and with an apical angle of 90° or less. Each volution is indented by the preceding one, but otherwise the upper surface is strongly convex. The lower portion of each volution is rounded, while the outer surface is less and the umbilical surface still less convex. The sutures are deep. No surface marks or growth lines are visible on the quartz casts that have been found.

Found among fossils from the upper portion of Oneota formation at Dresbach and Altura, Minnesota, and Blanchardville, Wisconsin.

Metoptoma barabuensis Whitf.

Metoptoma barabuensis Whitf,, Geology of Wisconsin, vol. IV, p. 195, pl. III, figs. 16 and 17.

One specimen, a little smaller but otherwise not distinguishable from this species as figured and described, comes from the Jordan sandstone at Osceola, Wisconsin, where it is associated with *Pleurotomaria sweetii*, Whitf., etc.

Murchisonia argylensis n. sp.

Plate V, figures 11 and 12

Shell of many volutions (about fifteen), closely coiled; apical angle 160°. The columella is slender and imperforate, the sutures deep and the outer surface of each coil flattened. Casts of the interior are more uniformly convex and end acutely about one-fourth the distance from the apex.

The aperture is vertically sub-qnadrate, and there are indications that it was deeply notched on the outer margin. Along the coil there appear two minute longitudinal grooves, dividing the outer surface into three nearly equal areas, the middle one of which is probably the band.

Figure 11, plate V, is a sketch of a specimen showing the cavity left by a shell, the apical third being entirely empty, the middle portion enclosing a cast of the interior, and the lower volutions containing the replaced shell, which is broken open and shows the columella.

From near Argyle, Wisconsin, in the Shakopee dolomite. Found also at Shakopee and Cannon Falls, Minnesota, in the Shakopee dolomite.

Murchisonia putilla n. sp.

Plate V, figures 5 and 6.

The specimens of this species are small turreted coils of six to eight or more volutions with an apical angle of 45°. The outer surface is marked by a strong angular carina a little below the middle height of each volution, and a second and third subangular carinia divide the outer from the upper and lower surfaces respectively. The lower surface of the body whorl is moderately convex and is joined with the inner surface somewhat abruptly. There is a large perforated columella formed by the vertical, moderately convex inner side of the volutions. The upper side of each volution coincides in form with the base of the preceding one, so that the suture is close, and in fact it is formed by the contact of two carinæ.

Previous to fossilization or silicification several of the specimens have been indented deeply by the sharp crushing processes of some animal. These wounds, besides being peculiar tooth marks in appearance, seem to show distinctly from their form and from the compression of the shells that the latter yielded by bending or folding and not by fracture. One shell had been also partly uncoiled.

Found in the top of the Oneota dolomite near Dresbach, Winona county, and at Stillwater, Minnesota, and Blanchardville, Wisconsin. Also from the Jordan sandstone near Rapidan, Blue Earth county, Minnesota.

Ophileta alturensis n. sp.

Plate V, figures 3 and 4.

Shell a dextral coil of six or more slowly expanding volutions, the spire of which does not rise above the carina of the body whorl. The volutions are strongly convex below, but are flat or concave in the umbilicus, and straightened or slightly concave below the carina on the outer side. This high, acute carina on the upper outer angle gives a concave upper surface, which, however, curved down to the suture on the inner side. The umbilicus is very wide.

The growth lines are coarse and indistinct. They curve obliquely back from the sutures to the carina for a distance equal to the width of the upper surface of the volution, forward again down to the base and thence with a back and forward curve across the umbilical surface.

Found in the Oneota dolomite near Dresbach, at Altura and Mankato, Minnesota, near the top of the formatiom. Also at Caledonia, Houston county.

Plurotomaria sweeti Whitfield.

Holopea sweeti Whitfield, Geology of Wisconsin, vol. IV, p. 174, pl. X, fig. 3, 1882.

Casts of this shell occur at Osceola Mills, Wisconsin, in the Jordan sandstone. They agree with Mr. Whitfield's description and the figure of his specimen except that the growth lines on casts of the exterior show that the aperture had a very deep sinus which has left on some an elevated, broadly rounded band just below the middle of the outer surface of the last volution. This species is of the same type as the *Pleurotomaria aiens* Sar., from the Saint Peter sandstone.

Raphistoma leiosomellum n. sp.

Plate V, figures 7 and 8.

The shell of this species, as shown by the quartz casts found was small and consisted of about four rapidly increasing volutions, which embrace in such a manner as to form a lenticular coil. Each volution conceals about one-half of the surface of the preceding one. The suture is channelled, the periphery is marked by a rounded somewhat swollen band, and the umbilicus,.which is about one-fourth the entire width of the coil, is abrupt and ascends by degrees quite to the apex. The surface is smooth and nearly equally convex above and below.

From the upper portion of the Oneota dolomite near Dresbach, at Altura, Winona county, and near Caledonia, Houston county, Minnesota.

Raphistoma lewistonense n. sp.

Plate V, figures 9 and 10.

The only specimen of this species found is a hollow cast of the exterior of a shell, and from this rubber casts have been taken. These show a coil of about four volutions which are flat above and strongly ventricose below. The suture of each volution falls a little below the periphery of the preceding volution. The umbilicus is about one-third the entire width and ascended probably to the apex. The varices of growth appear to run obliquely back from the sutures to the periphery and thence directly down and into the umbilicus.

Found in the Oneota dolomite near Lewiston, Winona county, Minnesota. Identified also at Shakopee and Cannon Falls, Minnesota.

Raphistoma minnesotenses Owen.

Plate V, figures 15, 16 and 17.

Straparollus (*Euomphalus*) *minnesotensis* Owen (1852), Report Geological Survey of Wisconsin, Iowa and Minnesota, p. 581, tab. II, figs. 12 and 13.

Euomphalus vaticinus H., 1863, 18th Rep. N. York Mus. Nat. Hist. p., 136.

Shell large, of *eight* or *nine* slender whorls, which gradually expand and remain in contact throughout. The apical angle is very obtuse at first but gradually decreases to about 120° as the coil expands, giving a somewhat lenticular outline. This character also varies in specimens of the same size; umbilicus very wide. The volutions are strongly convex below and above, but gently concave along the strong angular carina upon the outer side and strongly concave along the same above. The carina rises above the sutures on the internal casts, but not so strongly on the exterior of the shells. The aperture is subquadrate and deeply notched.

This is an abundant species in the upper strata of the Oneota, but is found only as imperfect specimens, the smaller ones of which are easily mistaken for a distinct species. There are, however, no others with which this one could be confused known to occur in the same formation.

Found at Dresbach, Winona county, near Red Wing, Goodhue county, at Mankato and other places in Minnesota, and Blanchardville, Wisconsin. Also found in the Jordan sandstone near Rapidan, Blue Earth county, Minnesota. At Red Wing also in the Saint Lawrence.

Raphistoma oweni n. sp.

Plate V, figure 18.

Shell of ten or twelve very slender whorls in close contact, but not always uniformly coiled. The apical angle of the shell varies a little from 140°. The umbilicus is very wide. A transverse section of each volution presents a quadralateral figure which is approximately a parallelogram with the outer angle acute, equal to about 75°. Upon the outer angle or carina is a small band which on the spire rises a little above the sutures. The upper surface of a volution has a depression along the carina, is nearly flat over most of the surface, but strongly rounded on top into the suture. Below, the surface is flattened or gently concave on the outer and umbilical areas, but has a strongly convex or subangular area between these two. In the umbilicus each volution leaves exposed to view a part of the outer surface of the preceding one, while on the apical surface the sutures are close or only slightly channelled. The surface is indistinctly striated on internal casts by transverse lines which on the upper surface curve back at an angle of about 45°, from the suture to the carina. The irregularity in coiling does not seem to be due to distortion.

From the Oneota dolomite of the Magnesian series in the Saint Croix valley, above Stillwater, Minnesota.

The first specimens seen of this species were collected by Mr. A. D. Meeds, of the University of Minnesota. The name is given in honor of Dr. David Dale Owen.

Raphistoma ruidum n. sp.

Plate V, figures 13 and 14.

Shell of four or more volutions rising in a low spire. The volutions are convex above with a narrow concave area along the periphery. Below, the surface of each is moderately convex along the periphery and strongly convex next the umbilicus, but gently concave for the greater distance between these two areas. The umbilical surface is flattened also and is the shortest of the four sides of the subquadrate figure presented by a cross section. The outer side next the umbilicus is the longest, and the sides are about in the relation of 5, 6, 7 and 8. The umbilicus is wide and deep.

A cast of the interior shows that the shell was ornamented by sharp elevated striæ of growth. These are evident also on casts of the interior, and curve obliquely back for a distance greater than one-eighth of a volution and suddenly out in a reversed curve near the acute edge of the volution.

Specimens of this species were found near Argyle, Wisconsin, in the Shakopee formation, and at Shakopee, Minnesota, in the quarry at that place. Also near Cannon Falls, in the Shakopee formation.

Straparollus intralobatus n. sp.

Plate V, figure 20.

Coil small, of three to four volutions, in the same plane, or nearly so, and in close contact. The aperture is transversely oval except where indented on the inner margin by the penultimate volution. The surface of the cast is marked by growth lines that are rather variable and indefinite and run a little backwards near the dorsal side.

Found at Altura, Winona county, above the middle of the Oneota dolomite.

Subulites exactus n. sp.

Plate VI, figure 14.

Casts of the interior of shells of this species show a long, slender spiral of twelve or more whorls in all. The accompanying figure shows a cast of probably the fifth to eighth whorls. The whorls are gently convex on the outer surface, but are more strongly rounded near the sutures, which are wide and deep on the casts and appear to have been equally strong on the exterior of the shell. Surface marks can not be detected and the form of the aperture is not well shown but must have been elongate, rounded very narrowly above and more broadly below, and with the centers of the inner and outer lips somewhat increased in convexity.

Found at Shakopee, Minnesota, in the Shakopee dolomite, and in the same formation near Cannon Falls, Minnesota.

Tryblidium repertum n. sp.

Plate V, figures 21 and 22.

Shell small, low, with the apex towards the posterior and directed backward. Aperture oval, about 11 mm. in longitudinal and 9 mm. in transverse diameter. Apical elevatiou of the shell 6 or 7 mm. From the apex the surface curves gently down to the anterior margin, while on the posterior and along the lateral portions the surface is concave. There are some slight indications of concentrie undulations, but other characters are not visible on the casts of oölitic dolomite.

One specimen referred to this species has a much higher apex and a proportionally narrower aperture supposed to have been caused by contortion previous to its deposition in the stratum, but it is in every respect symmetrical.

From the Shakopee dolomite formation near Argyle, Wisconsin.

Ascoceras gibberosum n. sp.

Plate VI, figures 8, 9 and 10.

All that is known of this species are casts of the septate portion, one of which is sketched. The specimens do not show conclusively that they represent the hollow chambers extending along the chamber of habitation, but presumably that is their nature. The septa, eight or nine in number, are not regularly equidistant, and grow one above and over the other in the dorsal (or ventral) portion of the shell somewhat irregularly but always overlapping the last above and on the sides, but slightly underlapping below. This last charncter gives some indication that there may have been also a regular system of septa in the base of the shell. The entire shell must have been short and small, with the aperture contracted and oblong ovate dorsoventrally.

From the Oneota dolomite at Dresbach, Minnesota.

Cyrtoceras dresbachense n. sp.

Plate VI, figure 4.

Shell small, expanding somewhat rapidly, and curved. Transverse section ovate, with the apex on the dorsal side. The septa are numerous and arch rather strongly forward on the outer, and also on the inner, surface. The siphuncle is small and is situated near the inner side of the shell. The chamber of habitation and the surface of the shell are not known. Septa arched dorso-ventrally, otherwise nearly flat.

From the Oneota dolamite near Dresbach, Minnesota.

Cyrtoceras (?) *winonicum* n. sp.

Plate VI, figures 2 and 3.

Shell small, very slowly expanding, straight or slightly curved. The septa ate strongly concave in dorso-ventral direction, very gently so across from side to side, and the sutures curve forward above and below and backward across the sides. The depth of the chamber of habitation is not known. The septa are very close together, eight or ten falling in a length equal to the transverse diameter. The siphuncle is small, marginal and flattened next the outer wall. Transver section of the shell oval. The surface of the shell is not preserved on any of the specimens, but the casts are smooth.

Found near Dresbach, Winona county, Minnesota, among other fossils from the Oneota dolomite.

Endoceras consuetum n. sp.

Plate VI, figure 11.

The shell long, straight, slowly expanding. The chamber of habitation is deep, about two and one-half to three times as deep as high. Transverse section vertically suboval, with the outline of the siphuncle circular and about one half as great in diameter as the shell. Siphuncle close to the ventral side. The septa are close together and concave. The sutures arch forward slightly near the dorsum and apparently backward on the ventral side, and in general they are oblique to the longitudinal axis. The shell was very thin, and on the cast leaves indistinct undulating growth lines along the body portion, parallel to the sutures of the septate portion. There is a concave band on the surface of the first septum on the specimen, near the siphuncle, but which may be due partly to distortion.

From near the top of the Shakopee at the crossing of the Chicago, Milwaukee and Saint Paul and the Illinois Central railways, ten miles west of Monroe, Wisconsin, and one-half mile below Pickett station.

Piloceras corniculum n. sp.

Plate VI, figures 5, 6 and 7.

The siphuncles of four shells have been found as quartz casts. These show a rapidly, uniformly expanding shell of small size. The sutures on the siphuncle are distant about one-fourth the vertical diameter of the same, but on different specimens have a varying direction. The concavity of the septa appears to decrease as the shell increases and their apices are not uniformly directed on different specimens, and in one case the apex is toward one side, A transverse section of the siphuncle is vertically oval, on all alike. A third specimen, not figured, retains a portion of the outer surface and septa, and indicates the position of the siphuncle as close to the dorsal (concave) side and its diameter about one-half that of the shell. Surface of the shell probahly smooth.

Without an extensive series of specimens it is quite impracticable to determine whether one or two species are here described, but the great variation of some characters seen in the specimens at hand seems to indicate strong variability rather than specific difference.

From the Oneota dolomite, near Dresbach, Winona county, Minnesota.

Besides the above list of fossils Professor Calvin* has described several species, viz.:

Metoptoma alta Whitf.
Tryblidium sp.
Straparollus claytonensis Calvin.
Straparollus pristoformis Calvin.
Raphistoma pepinense Meek.
Raphistoma multivolvatum Calvin.
Raphistoma paucivolatum Calvin.
Holopea turgida Hall.
Murchisonia sp.
Orthoceras primigenium Vanuxem.
Cyrtoceras luthei Calvin.

from the Lower Magnesian of northeastern Iowa. But his descriptions leave us in doubt wheather they are Oneota or Shakopee or both. I could not clearly recognize in the short descriptions, which are not accompanied by figures, any of the species described by me. The Shakopee and Oneota were examined near McGregor, Iowa, and although I found no fossils, still fossils ought to be found there in both formations. These two formations present their normal stratigraphic and lithologic character in Iowa. Fossils from southeastern Minnesota and southwestern Wisconsin, which are on opposite sides of northeastern Iowa, present the same faunas in each of the formations, Shakopee and Oneota. In Iowa they should also occur. *Raphistoma multivolvatum* Calvin may be *R. minnesotense* (Owen). His other two species of *Raphistoma* one can only reject. His *Holopea turgida* H. may be *H. obesa* Whitf. The others seem to be some that I have not found.

The Shakopee fauna is most like that of the "Upper Calciferous." That of the Oneota, Jordan and Saint Lawrence is likewise comparable to the Lower Calciferous of New York. It, in fact, resembles the Calciferous far more than it does the peculiar fauna described by Whitfield† from the Baraboo district of Wisconsin which has been supposed to be "Lower Magnesian." These are:

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*Amer. Geol., vol. 10, pp. 144-148 (1892).
†Geol. Wisconsin, vol. IV, p. 194.

Leptæena barabuensis Whitf.
Metoptoma barabuensis Whitf.
Metoptoma recurva Whitf.
Metoptoma similis Whitf.
Metoptoma retrorsa Whitf.
Scævogyra swezeyi Whitf.
Scævogyra elevata Whitf.
Scævogyra obliqua Whitf.
I mention also:
Euomphalus strongi Whitf.
Ophileta (*Raphistoma*) *primordialis* Wihchl.
Palæacma irvingi Whitf.

Of the above *Raphistoma primordiale* Winchl. may be again *R. minnesotense* (Owen)—Oneota to St. Lawrenee. One other—*Metoptoma barabuensis* Whitf. I think is represented by one specimen from the Jordan sandstone at Osceola, Wisconsin. It is not improbable that the whole list contains really the missing Gasteropoda of the Saint Lawrence formation. If so then this formation is wider from the Oneota than I think it to be. Still this fauna may belong to an older formation, preceding the Saint Lawrence.

Regarding the biological side of the question of the relations of these fossils, it must be observed that to associate, for example the species *Raphistoma leisomellum*, *R. lewistonense*, *R. minnesotense*, *R. oweni* is to extend the limits of the genus. These with *Ophileta alturensis* form an interesting series of forms which, however, is best not further enlarged upon here. There may in the future be some interesting discoveries, for there occur here and there "fucoids" and other structures like fig. 13, pl. 6, from the Shakopee near Pickett Station, Wisconsin, that show the former existence of still other fossils than those thus far found.

December 6, 1892.

PLATE I

All similar views are made on the same scale, irrespective of actual size, and as nearly as possible in exactly similar positions so as to facilitate direct comparison. The lettering is the same for all the skulls, and is the initial letter or letters of the bones referred to: N, nasal; Px, pre maxillary; Mx, maxillary; M, molar; Fr, frontal; Sq, squamosal; Pa, parietal; Ip, inter-parietal; Oc, occipital.

Fig. 1. Muskrat; natural size. Fig. 2. Beaver; reduced one-half. Fig. 3. Common Brown Rat; enlarged one-half. Fig. 4. Grey Squirrel; natural size. Fig. 5. Chipmunk; natural size.

Fig. 6. Hinder aspect of tibia and fibula of Pocket-Gogher. Fig. 7. Hinder aspect of tibia and fibula of Beaver; reduced one-half. Fig. 8. Hinder aspect of tibia and fibula of Prairie Dog.

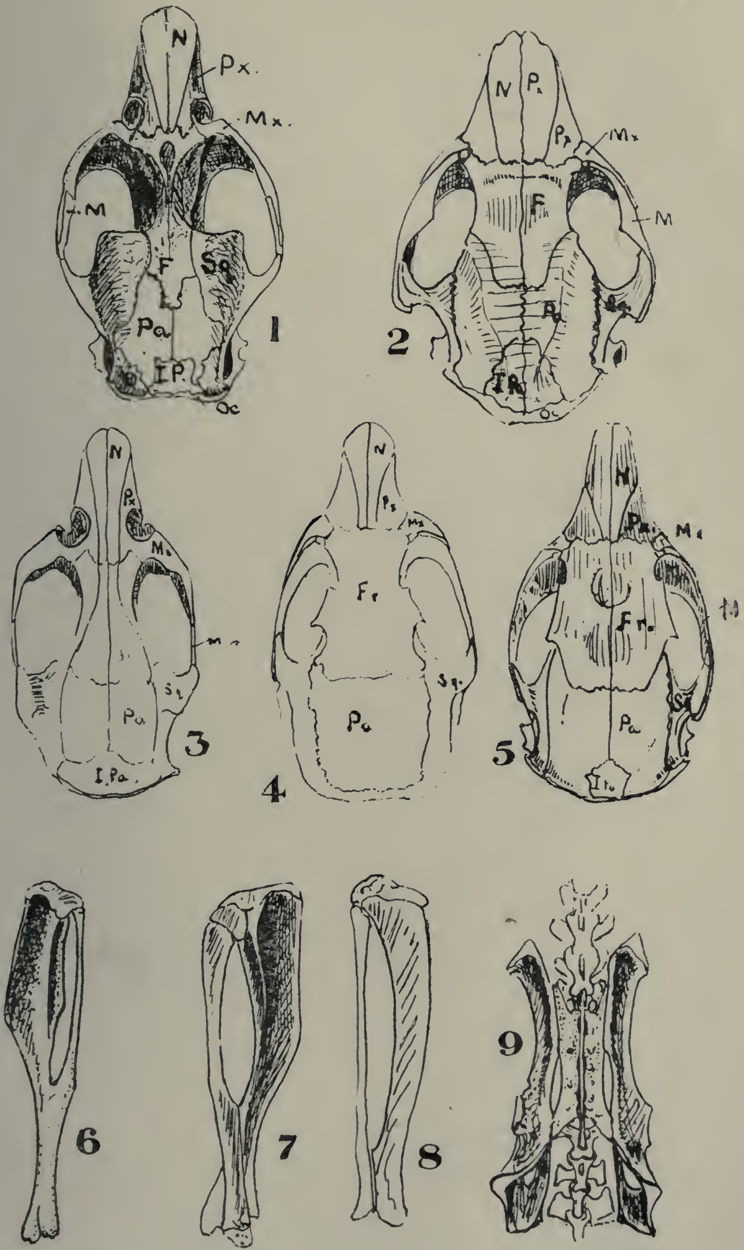
N
Px.
Mx.
M
F
Sq
Pa
I.P.
Oc
1
2
3
4
5
6
7
8
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PLATE II

1, 2 and 3. *Cypricardites* (*Vanuxemia*) *fragosus* n. sp. (1) The right valve of a large specimen. (2) Anterior muscle scar and cardinal teeth of a left valve. (3) The concave cast of the anterior portion of a specimen showing the deep muscle scars, the articulation of the cardinal teeth and a section cutting off the anterior ear and the umbones.

4 and 5. *Cypricardites dignus* n. sp. (4) Right valve of the largest specimen, and (5) left valve of another showing a little variation in form.

6. *Cypricardites* (?) *finitimus* n, sp.

7. *Cypricardites descriptus* n. sp.

8. *Modiolopsis contigua* n. sp. The upper anterior margin is imperfect.

9. *Modiolopsis affinis* n. sp.

10, 11 and 12. *Modiolopsis gregalis* n. sp. (10) Left valve of an average sized specimen and (11) (12) cross sections of another specimen at one-fourth and two-thirds the distance from the anterior end respectively.

13, 14, 15 and 16. *Modiolopsis litoralis* n. sp. (13) Cast of an average specimen; (14) (15) (16) sections at three-fourths, one-half and one-third the distance from the anterior end.

17. *Modiolopsis senecta* n. sp. Figure of the only specimen seen.


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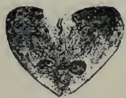
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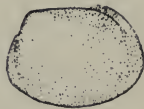
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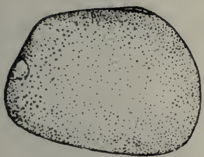
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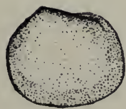
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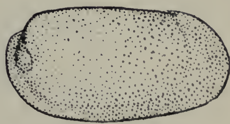
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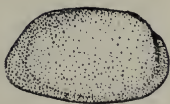
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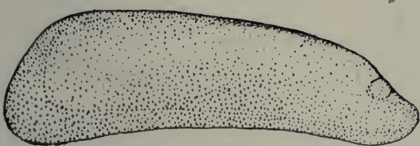
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PLATE III

1 and 2. *Tellinomya absimilis* n. sp.
3. *Tellinomya novicia* n. sp.
4. *Murchisonia gracilis* Hall.
5. *Holopea obliqua* Hall.
6 and 7. *Crania ? reversa* n. sp.
8 and 9. *Ophileta fausta* n. sp. (8) Outer surface of part of the last volution showing the direction of the transverse striæ, and a transverse section of the same specimen. (9) Coil of an imperfect cast.
10. *Orthoceras* (?) sp. undet. Cast of a fragment of the shell and reconstructed circumference.
11 and 12. *Orthoceras minnesotense* n. sp. (1) View from the left side and (12) from the smaller end of the fragment.
13 and 14. Siphuncle of an *Orthoceras* with a transverse section of the same.
15. Bryozoon (*Ptilodictya ?*).
16 and 17. *Pleurotomaria aiens* n. sp. (16) View showing the deep notch in the aperture and (17) apical view of the same specimen.

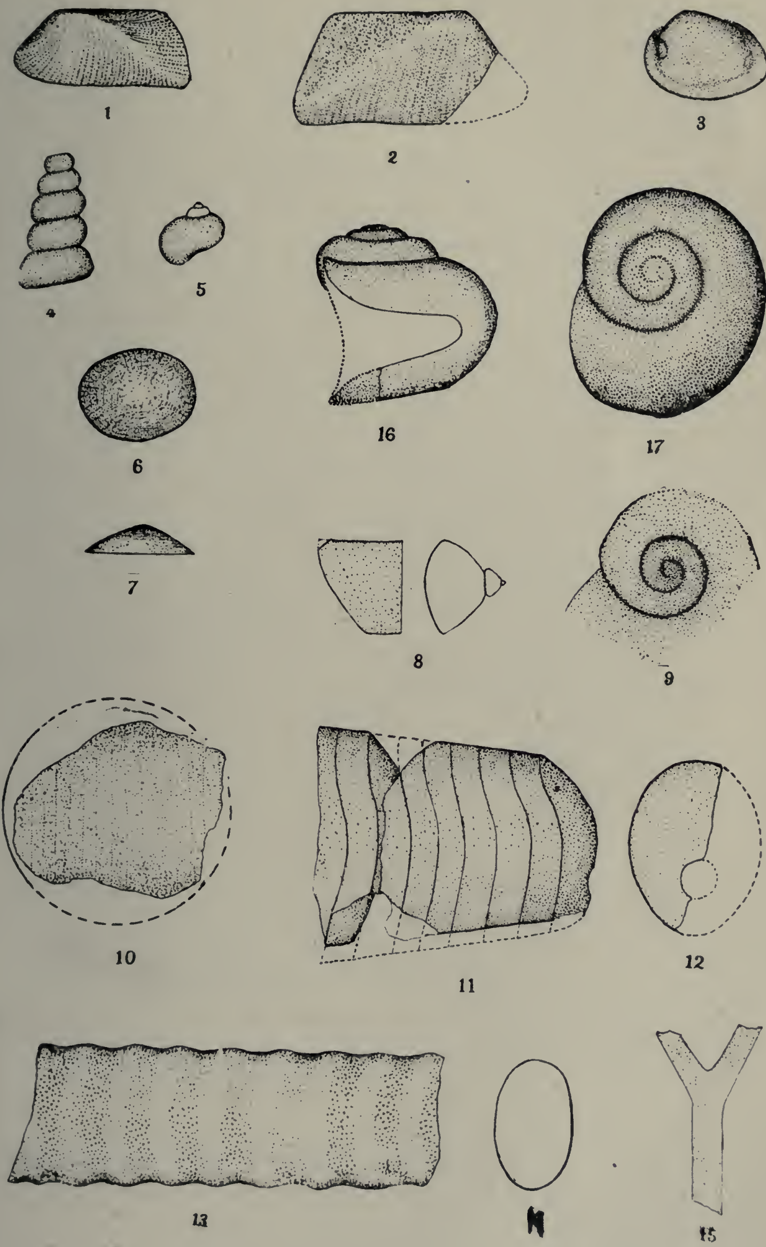
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PLATE IV

1. *Platyceras ? vetulum* n. sp. Apical view.

2 and 3. *Lingula morsii* N. H. Winchell. Outline of a cast (2) and of a shell (3). Both specimens are under the average size.

4. *Orthis* cf. *perveta* Conrad. From an imperfect cast of a ventral valve.

5 and 6. *Raufella fucoida* n. sp.

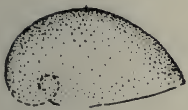
7. *Modiolopsis fountainensis* n. sp. Cast of right valve.

8. *Modiolopsis postica* n. sp.

9. Transition from Saint Peter to Trenton near Fountain.
   - a. Coarse sand and small ferruginous pebbles and argillaceous shale.
   - b. Coarse light yellow sand; 3 feet 6 inches, variable.
   - c. Argilaceous shale, mixed with sand and lime at the top and bottom; 4 feet.
   - d. Coarse sand.
   - e. Firmer ferruginous laminæ.

The formations above and below these strata are characteristic Trenton and Saint Peter.

10. Contact of Shakopee and Saint Peter formations near Pickett Station, Wisconsin.
   - a. Saint Peter.
   - b. Green shale laminæ.
   - c. Dolomite, much folded, exposed in elevation about 20 feet.
   - a b c. Illinois Central railway track.



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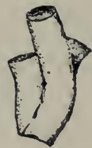

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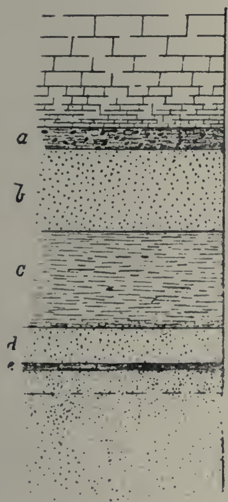

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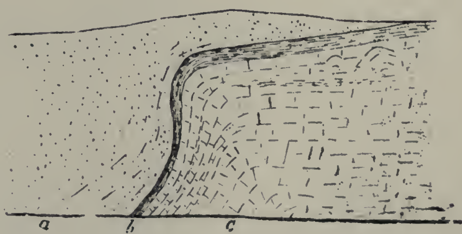

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PLATE V

1 and 2. *Helicotoma peccatonica* n. sp. Apical view and reconstructed transverse section of the coil.

3 and 4. *Ophileta alturensis* n. sp. Apical view of the coil and cross section of the same.

5 and 6. *Murchisonia putilla* n. sp. Outline of the coil and of the umbilical side of part of a coil with three or four volutions wanting.

7 and 8. *Raphistoma leiosomellum* n. sp. Apical view and an ideal cross section of the coil.

9 and 10. *Raphistoma lewistonense* n. sp. Apical view and cross section of a rubber cast of the exterior.

11 and 12. *Murchisonia argylensis* n. sp. Natural cast of a smaller specimen and an outline of the exterior of a shell obtained on a rubber cast.

13 and 14. *Raphistoma ruidum* n. sp. Apical surface of an interior cast and ideal cross section of the same.

15, 16 and 17. *Raphistoma minnesotense* Owen. (15) Apical view of a few of the first volutions; (16) a reconstructed cross section of an interior cast; and (17) a fragment of about the eighth volution. The upper fignre shows the upper surface with growth lines, the next is a transverse section, and the last shows the lower surface.

18. *Raphistoma oweni* n. sp. Apical view of the coil.

19. *Holopea obesa* Whitfield. A broken cast showing in part a transverse section.

20. *Straparollus intralobatus* n. sp. Apical view and outline of the aperture of the shell.

21 and 22. *Tryblidium repertum* n. sp. Apical and side views.

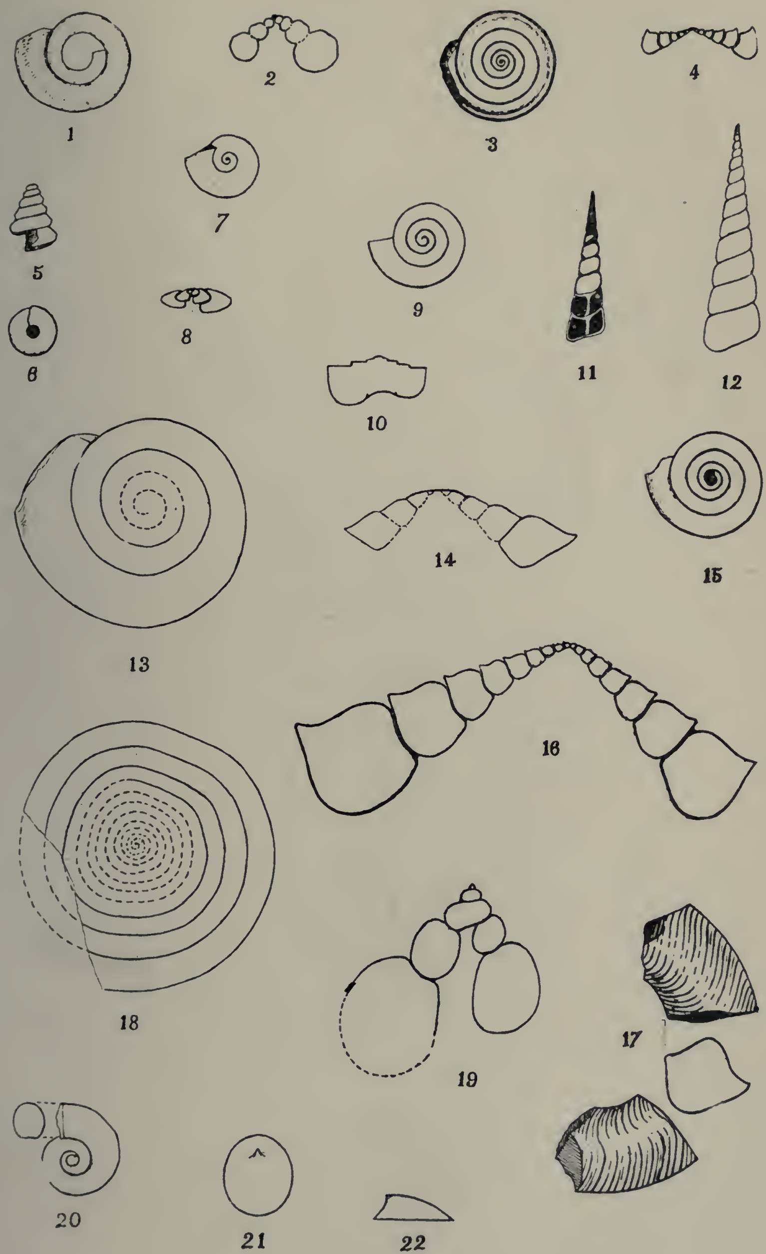
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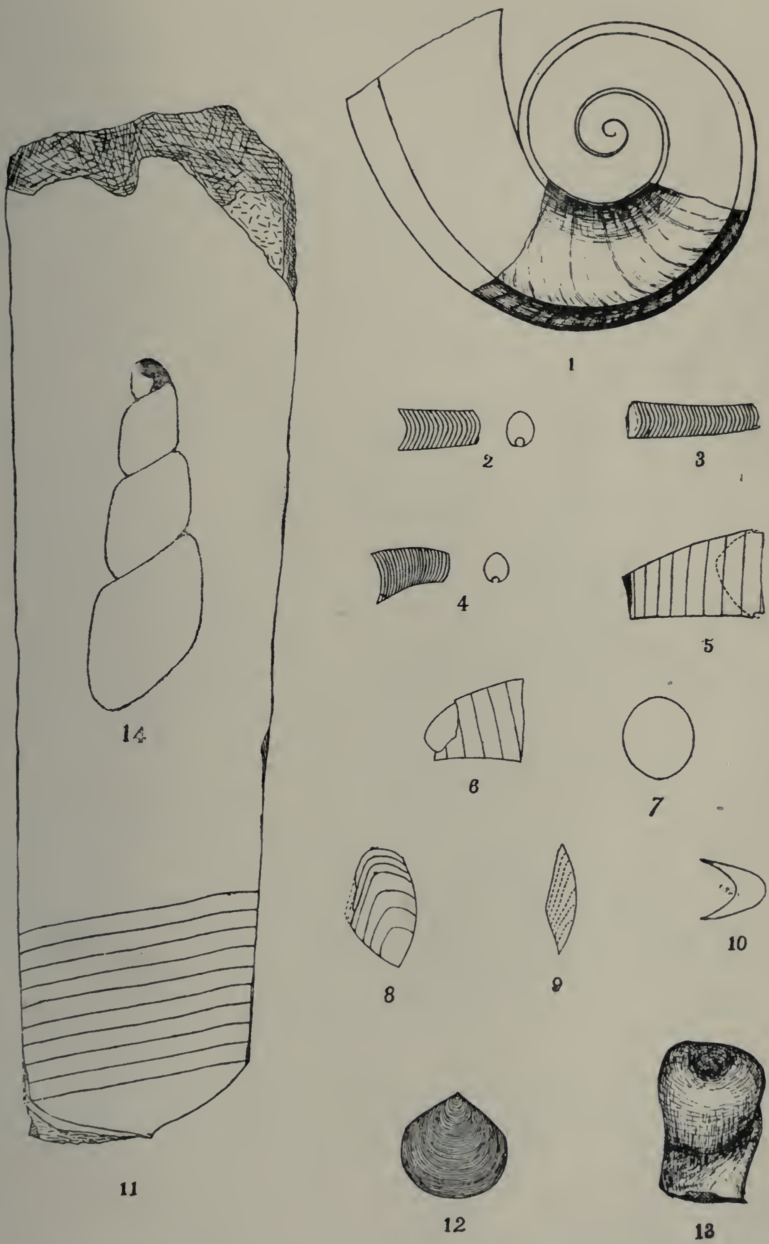
PLATE VI

1. *Euomphalus winonensis* n. sp. Upper surface of a fragment reconstructed from other specimens.
2 and 3. *Cyrtoceras winonicum* n. sp. Fragments of two shells preserved as interior casts. The last has a part of the chamber of habitation attached.
4. *Cyrtoceras dresbachense* n. sp.
5, 6 and 7. *Piloceras corniculum* n. sp. (5) Specimen, drawn with the concavity of the last septum indicattd in dotted lines. (6) Another specimen and (7) cross section of the same.
8, 9 and 10. *Ascoceras gibberosum* n. sp. Side view of the septate portion as an internal cast, and (9) longitudinal and (10) transverse sections of the same.
11. *Endoceras consuetum* n. sp.
12. *Lingula dolata* n. sp.
13. *Receptaculites*-like strncture from the Shakopee.
14. *Subulites exactus* n. sp.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[*Paper G*]

THE STRUCTURE, LITHOLOGY AND GENESIS OF THE MAGNESIAN SERIES OF THE NORTHWESTERN STATES

[ABSTRACT]

By C. W. HALL

An investigation of the dolomites of the upper Mississippi river valley was begun more than a year ago.* The studies to follow have been only in part carried out. This paper, presented at the meeting of the Academy held December 6th, 1892, contained historical matter, a discussion of the method of the study pursued, and a presentation of some microscopic results. In view of the writers' intention to take up again the lines of experimentation and examination begun, and the lack of space in this Bulletin, at the present time only a summary is given of the points discussed and the results then set forth.

But that some of the results of the field work and necessary comparisons may be available, it is thought best to present a key to the nomenclature of the Magnesian series. This is given on the basis of the naming applied in the paper of the authors just cited. The names were derived by an historical process and are apparently in undisputed use at the present time. In order that the formations may be recognized in the field under the names assigned to them and that the literature may be used without confusion, this key has been prepared. Dr. F. W. Sardeson has assisted in its tabulation.

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*The general results of the investigation have been published alsewhere owing to the unavoidable delay in the publication of this Bulletin. For these results the reader is referred to "The Magnesian Series of the Northwestern States," by C. W. Hall and F. W. Sardeson, Bulletin Geol. Soc. America, Vol. VI, 1895, pp. 167-198, with one plate.

Of the names which occur in the Minnesota Geological and Natural History Survey Reports, the meaning is as follows:

ST. LAWRENCE means St. Lawrence,
in the Second Annual Report (1873), p. 152.
in the Final Report, vol. 1 (1884), p. 424.
" " " 2 (1888), p. xxi.
" " " " p. 70.
" " " " p. 119.
" " " " p. 160.
" " " " p. 381.

ST. LAWRENCE means Oneota,
in the Fourth Annual Report (1875), p. 32.
in the Fifth " " (1876), p. 29.
in the Final Report, vol. 1 (1884), pp. 217–223.
" " " " p. 254.
" " " " p. 282.

JORDAN means Jordan
in the Second Annual Report (1873), p. 47.
in the Final Report, vol. 1 (1884), p. 426.
" " " 2 (1888), p. 21.
" ' " " pp. 70–71.
" " " " p. 121.
" " " " p. 161.
" " " " p. 138.

JORDAN means New Richmond Sandstone,
in the Fourth Annual Report (1875), p. 35.
in the Fifth Annual Report (1876), p. 28.
in the Final Report, vol. 1 (1884), pp. 217–221.
" " " " p. 252.
" " " " p. 284.
" " " " p. 335.

MAGNESIAN LIMESTONE means Oneota,
in the Final Report, vol. 2 (1888), p. 21

LOWER MAGNESIAN means Oneota,
in the Final Report, vol. 2 (1888), pp. 9, 12, 36.
" " " " pp. 70–72.
" " " " p. 409.

LOWER MAGNESIAN means Oneota, New Richmond and Shakopee together,
in the First Annual Report, (1872), pp. 78, 80.
in the Fourth " " (1875), p. 32.
" " " " p. 87.
in the Final Report, vol. 1 (1884) p. 253.
" " " 2 (1888) p. 124.
" " " " p. 162.

MAIN BODY OF LIMESTONE means Oneota and Shakopee,
in the Final Report, vol. 2. (1888), p. 382.

NEW RICHMOND or RICHMOND means New Richmond,
in the Final Report, vol. 2 (1888), p. 9, 11, 37.
" " " " p. 80–83
" " " " p. 388.

SHAKOPEE means Shakopee formation,
in the Fourth Annual Report (1875), p. 38.
in the Fifth Annual Report (1876), p. 26.
in the Final Report, vol. 1 (1884), pp. 217–219.
" " " " p. 252.
" " " " p. 285.
" " " 2 (1888) p. 21.
" " " " pp. 9, 10, 38.
" " " " pp. 70–73.

SHAKOPEE means Oneota, New Richmond and Shakopee together,
in the Second Annual Report (1873), p. 138.
in the Sixth Annual Report (1877), p. 120.
in the Final Report, vol. 1 (1884), p. 336.
" " " " p. 429.
" " " 2 (1888), p. 124.

In the Wisconsin Geological Survey reports, especially the Final Reports of the Survey of 1873-1879, the name Potsdam sandstone is uniformly used for all the formations from and including the Jordan sandstone downwards into the Cambrian. The name Madison beds or sandstone is consistently used for an upper part of the Potsdam, and also the name Mendota beds or limestone for the next lower part. As now known, these two formations are equivalent to the formations in Minnesota, respectively Jordan (syn. Madison) sandstone and St. Lawrence (syn. Mendota) formation. Unfortunately the rules of nomenclature here require the newer names to yield. The change can be easily applied because the displaced names were consistently used in relation to the geologic formations. Detailed citation is therefore not necessary.

The name Lower Magnesian limestone is applied in the Wisconsin reports without discrimination between the upper, Shakopee, and lower, Oneota, dolomite, both of which formations the name covers, excepting by one author, L. C. Wooster (vol. 4, 1882, p. 106), who distinguishes the Lower Magnesian proper (i.e., Oneota) from the Willow River beds (i.e., Shakopee) and designates the sandstone between them New Richmond.

In Iowa the small extent of surface exposures is productive of fewer descriptions. The name Potsdam sandstone included all formations below the Lower Magnesian limestone, and the name Lower Magnesian covered all rocks to the St. Peter sandstone until recently. McGee uses the name Oneota for the formation exclusive of the Shakopee and New Richmond.* Charles R. Keyes follows McGee in his studies of the current year.†

The further topics of the paper are summarized as follows:

1. In Minnesota there are two well defined dolomite formations, Oneota and Shakopee. Below these is a great thickness of sandstone and green shales into which a few stray bands of dolomite enter and give dolomitic character to certain layers of the St. Lawrence. Above the Shakopee, after more than one hundred feet of sandstone, comes the Galena series characterized by a weakening of the dolomitic habit through the occurrence of a limestone with less than fifteen per cent. of magnesium carbonate.

2. A marked faunal break separates the St. Lawrence formation from the sandstone beneath; another break occurs between the Oneota and Shakopee, the two dolomites named above, and a third betweeen the Shakopee and St. Peter sandstone. These three faunal breaks establish at least three faunas and three corresponding time divisions between the Algonkian and the St. Peter (Chazy).

3. Below the St. Lawrence, and extending downwards to Algonkian rocks, lies a sandstone, generally a very pure quartz sand but locally of a varying composition, which is recognized by paleontologists as upper Cambrian. Above the upper Cambrian lies the Lower Calciferous, carrying the St. Lawrence sandstone, shale and dolomite; the Jordan sandstone and the Oneota dolomite: then follows the upper Calciferous consisting lithologically of the New Richmond sandstone and Shakopee dolomite.

4. The clean, purely quartzose condition of the sandstone formations associated with the dolomites, together with the semi-

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*The Pleistocene History of Northeastern Iowa, by W J McGee, Elèventh Ann. Rep. Director U. S. Geol. Survey, 1890, part. I, p. 332.

†The Geological Formations of Iowa, by Charles Rollin Keyes. Iowa Geological Survey, Vol. I, First Ann. Rep. for 1892. Des Moines, 1893, p. 23.

crystalline character of the shales associated with them, leads to the conclusion that the dolomites and all associated rocks must have undergone extensive chemical changes.

5. The dolomites assume many interesting characters. The development of rhombohedral grains is a very general process; the structure of the rhombohedra presents many crystallographic features; locally too, the formation of a siliceous oolite is equally characteristic of the Shakopee.

December 6, 1892.

[*Paper H*]

METEOROLOGICAL STATISTICS

By William Cheney

These statistics are the result of personal Meteorological Observations, made at Minneapolis, Minnesota, by William Cheney, voluntary observer United States Weather Bureau since 1864. The tables here given cover the period from 1883 to 1894 inclusive and are followed by a Summary of mean weather conditions and dates of maximum and minimum temperatures.

TEMPERATURES

Year	Spring	Summer	Autumn	Winter	Mean	Maxim'm Temperature	Minim'm Temperature	Precipitation
1883	39.10	66.86	42.30	6.11	38.90	July 1-2, Aug. 21 .....94°	January 22...—31°	26.977
1884	41.26	67.32	45.67	9.26	40.33	Aug. 15, Oct. 2 90°	January 4....—33°	29.683
1885	40.87	67.23	44.70	5.13	40.47	July 8..........94°	January 2....—38°	26.665
1886	45.46	69.99	45.32	12.85	42.26	August 15 .....95°	Jan. 10, 22, Feb. 2 ..—29°	29.579
1887	44.65	70.15	42.50	5.35	41.42	July 14-15......96°	January 7....—34°	32.791
1888	35.94	68.32	44.69	8.58	40.02	June 15, July 11 92°	January 21...—42°	30.125
1889	46.38	68.77	43.41	17.40	44.32	July 7 ....99°	February 23..—26°	18.360
1890	40.90	68.08	44.87	18.23	42.66	July 30 ....95°	January 16...—21°	27.072
1891	43.31	66.27	46.11	18.24	43.81	August 8 ......98°	February 4 ..—21°	26.696
1892	40.02	67.96	45.91	19.19	42.21	June 11-12 .....93°	January 19...—29°	37.895
1893	38.53	71.23	46.29	9.21	41.11	July 24........101°	February 1, 4 —28°	32.227
1894	47.40	73.80	46.23	11.90	47.63	July 11, 26 ....105°	January 24...—28°	21.680
Average	41.99	68.84	44.92	11.78	41.68			28.312

MONTHS	Atmospheric Pressure: Corrected for temperature and elevation	Temperature of the air (in degrees Fahrenheit): Monthly mean	Extremes: Maximum	Extremes: Minimum	Monthly range	Number of times temperature reached—: 90° or above	Number of times temperature reached—: 32° or below	Precipitation, in inches: Monthly	Precipitation, in inches: Total snowfall	0 entirely clear Pr. ct. of cloudiness 10 entire cloudiness	Relative humidity 100 complete saturation	Prevailing winds
1883												
January	30.089	*-2.64	22	*-31	53	0	31	2.225	22¼	5.2	.53	N. W.
February	30.165	9.47	41	*-27	68	0	28	0.918	9 3-16	4.5	.62	S. W.
March	29.991	21.97	48	*-12	60	0	31	0.325	1¾	5.0	.66	N. W.
April	29.802	43.62	73	22	51	0	6	3.828	7¼	5.6	.63	S. E.
May	29.802	51.72	75	33	42	0	0	2.529	0	6.0	.60	S. E.
June	29.770	64.13	88	45	43	0	0	6.590	0	5.1	.70	S. E.
July	29.820	70.25	94	57	37	2	0	4.432	0	5.4	.71	S.
August	29.911	66.19	94	50	44	1	0	0.469	0	5.7	.70	S. E.
September	29.946	55.37	84	29	55	0	2	1.988	0	4.6	.71	S. E.
October	29.981	42.36	74	19	55	0	8	1.166	2½	6.5	.73	S. E.
November	29 909	29.16	59	* -2	61	0	28	0.685	¼	5.2	.66	N. W.
December	30.014	15.16	49	*-21	70	0	30	1.822	10⅜	4.7	.60	N. W.
Total for year			94	*-31	125	3	164	26.977	53 9-16			
Mean for year	29.933	38.90								5.3	.65	S. E.
1884												
January	30.104	3.83	38	*-33	71	0	31	0.731	7 5-16	4.6	.55	N. W.
February	29.997	8.78	39	*-18	57	0	29	2.225	22¼	6.7	.62	W.
March	29.993	23.64	58	*-16	74	0	22	0.952	4¾	5.9	.63	W.
April	29.865	43.17	72	21	51	0	8	1.727	3⅛	6.0	.63	N. E.
May	29.813	56.98	82	35	47	0	0	2.991	0	4.8	.60	E.
June	29.873	67.76	87	48	39	0	0	4.181	0	4.0	.75	S. E.
July	29.463	66.99	87	56	31	0	0	1.653	0	5.0	.71	W.
August	29.831	67.21	90	51	39	1	0	3.910	0	5.9	.73	S. E.
September	29.840	61.58	87	47	40	0	0	5.267	0	5.0	.77	S. E.
October	29.919	48.41	90	18	72	1	9	3.079	⅛	5.5	.74	N. W.
November	30.000	27.02	59	*-13	72	0	24	0.660	6⅝	4.6	.70	N. W.
December	30.052	8.58	46	*-32	78	0	31	2.307	24⅝	6.2	.60	N. W.
Total for year			90	*-33	123	2	154	29.683	68 13-16			
Mean for year	29.896	40.33								5.3	.67	N. W.

*-Below zero.

MONTHS	Atmospheric Pressure	Temperature of the air (in degrees Fahrenheit)				Number of times temperature reached—		Precipitation in inches		0 entirely clear Pr. ct. of cloudiness 10 entire cloudiness	Relative humidity 100 complete saturation	Prevailing winds
1885	Corrected for temperature and elevation	Monthly mean	Extremes Maximum	Extremes Minimum	Monthly range	90° or above	32° or below	Monthly	Total snowfall			
January	30.073	0.78	42	*-38	80	0	31	0.387	3⅞	4.0	.50	W.
February	29.984	6.02	44	*-30	74	0	28	0.331	3 5-16	4.0	.53	W.
March	29.988	23.66	49	*- 7	56	0	31	0.637	6⅜	5.6	.66	W.
April	29.869	43.37	70	19	51	0	8	2.870	2¼	6.0	.68	S. E.
May	29.459	55.58	86	28	58	0	2	2.075	¾	6.0	.65	W.
June	29.841	65.29	87	41	46	0	0	3.335	0	5.0	.74	S.
July	29.814	72.59	94	61	33	3	0	4.520	0	7.1	.72	S. E.
August	29.847	63.81	86	45	41	0	0	3.590	0	5.7	.76	N. W.
September	29.850	59.10	84	40	44	0	0	5.270	0	3.6	.73	S. E.
October	29.888	42.47	78	24	54	0	13	1.755	¾	4.5	.70	N. W.
November	29.886	32.54	52	15	37	0	22	1.005	1 15-16	7.0	.80	W.
December	29.961	20.47	48	*-15	63	0	27	0.890	5 9-16	6.2	.70	S.
Total for year			94	*-38	132	3	162	26.665	24 13-16			
Mean for year	29.872	40.47								5.4	.68	W.
*-Below zero.												
1886												
January	30.082	3.76	31	*-29	60	0	31	3.012	30⅛	6.8	.59	N. W.
February	29.982	14.31	46	*-29	75	0	29	0.550	5½	5.2	.65	N. W.
March	29.923	27.46	60	*- 9	69	0	29	1.510	13	6.5	.69	W.
April	29.871	49.17	81	14	67	0	5	3.617	0	6.5	.70	S. E.
May	29.812	59.76	83	42	41	0	0	0.990	0	4.5	.58	S.
June	29.820	66.50	91	48	43	2	0	5.350	0	4.4	.67	N. W.
July	29.817	73.12	93	58	35	4	0	2.465	0	4.5	.67	N. W.
August	29.796	70.35	95	45	50	8	0	2.330	0	5.0	.67	S. E.
September	29.824	57.70	87	32	55	0	1	5.440	0	6.6	.75	S. E.
October	29.952	52.02	81	24	57	0	6	0.460	0	4.6	.68	S.
November	29.891	26.23	68	*- 3	71	0	25	2.485	23½	5.0	.67	W.
December	30.096	6.76	42	*-24	66	0	29	1.370	9	5.0	.56	N. W.
Total for year			95	*-29	124	14	155	29.579	81⅛			
Mean for year	29.906	42.26								5.4	.66	N. W.
*—Below zero.												

1887 MONTHS	Atmospheric Pressure: Corrected for temperature and elevation	Temperature of the air (in degrees Fahrenheit): Monthly mean	Extremes: Maximum	Extremes: Minimum	Monthly range	Number of times temperature reached—: 90° or above	Number of times temperature reached—: 32° or below	Precipitation in inches: Monthly	Precipitation in inches: Total snowfall	0 entirely clear Pr. ct. of cloudiness 10 entire cloudiness	Relative humidity 100 complete saturation	Prevailing winds
January	29.935	0.23	28	*-34	62	0	31	1.368	13 11-16	5.1	.52	N. W.
February	30.079	9.05	42	*-28	70	0	28	2.225	22¼	5.0	.58	S. E.
March	30.024	25.82	47	*-12	59	0	29	0.707	4⅞	5.0	.69	N. W.
April	29.780	44.40	80	15	65	0	9	3.758	4⅜	5.5	.64	S. E.
May	29.793	63.73	88	40	48	0	0	2.590	0	3.1	.58	S. E.
June	29.800	69.67	93	51	42	2	0	3.170	0	4.6	.70	S.
July	29.891	74.75	96	61	35	8	0	3.490	0	4.4	.67	S.
August	29.856	66.02	92	45	47	1	0	4.170	0	6.8	.74	S. E.
September	29.937	57.15	83	37	46	0	0	4.170	0	4.7	.76	S. E.
October	29.908	40.88	67	12	55	0	13	2.450	2	5.2	.70	N. W.
November	29.958	29.47	63	*-20	85	0	21	0.890	7⅞	5.4	.67	N. W.
December	29.954	15.88	39	*-22	61	0	31	3.803	33⅛	8.0	.72	N.W.
Total for year			96	*-34	130	11	162	32.791	86 3-16			
Mean for year *-Below zero.	29.910	41.42								5.2	.66	N.W.&S.E.

1888

1888 MONTHS	Atmospheric Pressure: Corrected for temperature and elevation	Temperature of the air (in degrees Fahrenheit): Monthly mean	Extremes: Maximum	Extremes: Minimum	Monthly range	Number of times temperature reached—: 90° or above	Number of times temperature reached—: 32° or below	Precipitation in inches: Monthly	Precipitation in inches: Total snowfall	0 entirely clear Pr. ct. of cloudiness 10 entire cloudiness	Relative humidity 100 complete saturation	Prevailing winds
January	30.184	*-1.68	34	*-42	76	0	31	1.262	12⅝	5.2	.48	N. W.
February	29.972	11.54	40	*-35	75	0	29	1.108	8⅜	6.0	.62	N. W.
March	30.040	17.77	42	*-13	55	0	31	2.462	21⅛	6.0	.69	N. W.
April	30.014	40.22	74	25	49	0	15	5.125	3	5.2	.70	N. W.
May	29.794	49.82	77	30	47	0	2	6.210	1½	7.0	.71	N. W.
June	29.721	67.43	92	49	43	2	0	2.500	0	6.3	.71	S. E.
July	29.855	72.00	92	60	32	1	0	5.560	0	6.0	.75	S. E.
August	29.863	65.52	91	46	45	1	0	2.270	0	4.7	.79	S.
September	29.925	56.98	79	35	44	0	0	1.580	0	4.2	.74	N. W.
October	29.825	44.12	73	30	43	0	5	0.990	0	6.6	.74	N. W.
November	30.028	32.97	65	4	61	0	23	0.450	1½	5.4	.75	N. W.
December	29.950	23.61	56	4	52	0	29	0.608	2⅜	6.3	.71	N. W.
Total for year			92	*-42	134	4	165	30.125	50½			
Mean for year *—Below zero.	29.931	40.02								5.8	.70	N. W.

1889 MONTHS	Atmospheric Pressure: Corrected for temperature and elevation	Temperature of the air (in degrees Fahrenheit.): Monthly mean	Extremes: Maximum	Extremes: Minimum	Monthly range	Number of times temperature reached—: 90° or above	Number of times temperature reached—: 32° or below	Precipitation in inches: Monthly	Precipitation in inches: Total snowfall	0 entirely clear Pr. ct. of cloudiness 10 entire cloudiness	Relative humidity 100 being complete saturation	Prevailing winds
January	29.929	18.13	40	*-12	52	0	31	1.035	7¼	5.1	.70	N. W.
February	30.068	10.45	47	*-26	73	0	28	1.363	13⅛	5.0	.62	N. W.
March	29.939	34.87	63	17	46	0	25	1.070	4½	5.0	.66	N. W.
April	29.883	48.35	74	28	46	0	3	1.530	0	5.3	.56	N. W.
May	29.811	55.93	81	38	43	0	0	3.060	0	5.5	.58	N. W.
June	29.818	65.11	90	45	45	1	0	1.530	0	6.3	.67	S.
July	29.790	70.97	99	56	43	4	0	3.160	0	4.8	.70	S. E.
August	29.862	70.24	93	55	38	5	0	2.390	0	3.5	.67	S.
September	29.823	58.19	91	37	54	1	0	0.820	0	5.0	.69	S. E.
October	30.039	43.78	75	25	50	0	13	0.060	0	3.6	.68	S. E.
November	30.010	28.25	54	*-5	59	0	28	1.082	8⅝	4.8	.72	N.W.
December	29.904	27.53	44	*-8	52	0	29	1.260	9¾	6.6	.73	S. E.
Total for year			99	*-26	125	11	157	18.360	43¼			
Mean for year *-Below zero.	29.906	44.32								5.0	.66	N.W.
1890												
January	30.075	9.67	42	*-21	63	0	31	1.037	10⅜	6.0	.59	N. W.
February	29.980	17.48	47	*-12	59	0	27	1.275	11¼	5.5	.65	N. W.
March	30.013	22.15	50	*-15	65	0	29	1.685	11¾	5.4	.68	N. W.
April	29.939	47.49	77	21	56	0	3	1.750	0	4.0	.60	S.
May	29.752	53.05	84	31	53	0	2	4.160	2½	6.0	.63	N. W.
June	29.769	69.16	94	54	40	3	0	5.970	0	6.0	.79	S. E.
July	29.827	71.01	95	58	37	5	0	1.900	0	4.8	.74	N. W.
August	29.887	64.07	94	50	44	2	0	2.590	0	5.3	.75	S.
September	29.936	56.04	85	35	50	0	0	3.350	0	4.3	.78	S. E.
October	28.983	44.58	70	20	50	0	8	2.460	0	7.0	.77	N. W.
November	29.099	33.98	55	8	47	0	24	0.390	3½	4.5	.74	N. W.
December	29.086	23.26	51	*-1	52	0	29	0.505	2¾	5.0	.71	N. W.
Total for year			95	*-21	116	10	153	27.072	42⅛			
Mean for year *—Below zero.	29.696	42.66								5.3	.70	N. W.

1891 MONTHS	Atmospheric Pressure: Corrected for temperature and elevation	Temperature of the air (in degrees Fahrenheit.): Monthly mean	Extremes: Maximum	Extremes: Minimum	Monthly range	Number of times temperature reached—: 90° or above	Number of times temperature reached—: 32° or below	Precipitation in inches: Monthly	Precipitation in inches: Total snowfall	0 entirely clear Pr. ct. of cloudiness 10 entire cloudiness	Relative humidity 100 being complete saturation	Prevailing winds
January	29.072	20.67	43	0	43	0	30	0.863	8⅝	5.5	.68	N. W.
February	28.993	10.78	44	*-21	65	0	28	2.108	20⅞	4.6	.60	N. W.
March	29.067	23.25	47	*- 6	53	0	27	1.620	12	7.0	.70	E.
April	29.024	47.85	83	17	66	0	7	2.025	4	4.4	.69	N. W.
May	29.162	58.84	84	36	48	0	0	1.540	0	3.6	.56	S.
June	28.982	65.22	88	42	46	0	0	4.010	0	6.5	.77	S. E.
July	29.105	66.13	85	51	34	0	0	2.800	0	5.3	.75	N. W.
August	29.064	67.47	98	46	52	4	0	3.680	0	5.4	.70	N. W.
September	29.085	65.84	91	43	48	7	0	1.925	0	4.4	.68	S.
October	29.099	46.90	72	26	46	0	6	1.840	0	6.3	.73	N. W.
November	29.053	25.59	56	*-13	69	0	25	0.825	8¼	6.6	.72	N.W.
December	28.902	27.19	49	*-6	55	0	27	3.460	6½	6.0	.73	S. E.
Total for year			98	*-21	119	11	150	26.696	56¼			
Mean for year *-Below zero.	29.051	43.81								5.5	.69	N.W.
1892												
January	29.106	9.52	43	*-29	72	0	30	0.660	2½	3.7	.59	N. W.
February	29.134	20.86	41	*-20	61	0	27	1.535	13½	6.5	.70	N.
March	29.112	27.09	55	*- 4	59	0	25	1.152	8⅞	5.4	.71	N. W.
April	29.060	42.02	64	18	46	0	14	0.680	0	6.4	.64	S. E.
May	28.979	50.94	74	30	44	0	4	7.510	2	8.1	.73	N.
June	29.885	64.51	93	40	53	2	0	6.250	0	6.6	.78	S. E.
July	29.985	70.88	90	49	41	1	0	12.010	0	5.6	.78	S. E.
August	29.972	68.50	87	42	45	0	0	4.700	0	5.1	.78	S. E.
September	29.999	61.09	84	39	45	0	0	1.540	0	3.7	.79	N. W.
October	30.018	49.31	83	20	63	0	7	0.420	0	4.1	.70	S. E.
November	30.043	27.32	52	0	52	0	27	0.601	5 5-16	7.4	.74	S. E.
December	30.116	14.53	38	*-18	56	0	34	0.837	6⅞	6.1	.66	N. W.
Total for year			93	*-29	122	3	165	37.895	39 1-16			
Mean for year *—Below zero.	29.617	42.21								5.7	.71	S. E.

1893 MONTHS	Atmospheric Pressure: Corrected for temperature and elevation	Temperature of the air (in degrees Fahrenheit.): Monthly mean	Extremes: Maximum	Extremes: Minimum	Monthly range	Number of times temperature reached—: 90° or above	Number of times temperature reached—: 32° or below	Precipitation in inches: Monthly	Precipitation in inches: Total snowfall	0 entirely clear Pr. ct. of cloudiness 10 entire cloudiness	Relative humidity 100 being complete saturation	Prevailing winds
January	30.067	3.70	33	*-26	59	0	31	1.825	18¼	5.3	.60	N. W.
February	30.125	9.40	38	*-28	66	0	28	1.800	18	7.5	.65	N. W.
March	30.038	22.50	49	*-12	61	0	28	1.647	9⅞	7.0	.71	N. W.
April	29.870	39.10	70	19	51	0	23	6.220	19.6	8.3	.77	N. W.
May	29.881	54.00	82	32	50	0	2	2.515	0.5	7.0	.68	S. E.
June	29.835	71.70	93	45	48	7	0	1.760	0	6.0	.73	S.
July	29.867	73.70	101	53	48	9	0	1.930	0	5.0	.71	N. W.
August	29.923	68.30	100	42	58	5	0	6.800	0	5.8	.74	N. W.
September	29.906	60.50	90	28	62	1	3	2.760	0	5.0	.75	S. E.
October	29.915	48.30	79	14	65	0	7	1.420	0	5.0	.77	N. W.
November	29.998	30.08	69	*-13	82	0	24	1.080	10.8	6.0	.71	N. W.
December	30.102	12.00	41	*-20	61	0	31	2.470	15.9	7.0	.61	N. W.
Total for year			101	*-28	129	22	177	32.227	92.9			
Mean for year *-Below zero.	29.961	41.11								6.2	.70	N. W.
1894												
January	30.096	10.20	41	*-28	69	0	30	1.37	13.7	5.2		N. W.
February	30.122	13.5	41	*-16	57	0	28	.08	.80			S.
March	29.934	34.5	75	*- 3	78	0	22	3.05	11.1			N. W.
April	29.920	49.2	79	24	55	0	5	4.53	2.7			S. E.
May	24.903	58.5	88	36	52	0	0	3.17	0			N.
June	29.852	72.6	96	38	58	7	0	1.00	0			S.
July	29.909	76.5	105	50	55	19	0	.27	0			N. W.
August	29.954	72.3	97	45	52	10	0	.55	0			N.
September	29.909	63.2	96	34	62	2	0	1.26	0			N. W.
October	29.842	48.4	74	29	45	0	2	4.52	.7			N. W.
November	30.078	27.1	52	*- 6	58	0	28	.52	2.20			N. W. & S
December	30.065	25.6	47	*-15	62	0	28	1.36	2.30			S.
Total for year			105	*-28	133	38	143	21.68	32.8			
Mean for year *—Below zero.	29.548	47.63										N. W.

[*Paper I*]

LETTERS FROM THE MENAGE SCIENTIFIC EXPEDITION TO THE PHILIPPINE ISLANDS

By Dean C. Worcester and Frank S. Bourns

[The following letters were written by the two young men who went out as leaders of the Menage Scientific Expedition to the Philippine Islands. This Expedition was fitted out and maintained from the summer of 1890 until the close of 1892, by Louis F. Menage, Esq., a citizen of Minneapolis and a member of the Minnesota Academy of Natural Sciences. While these letters were written as reports to the Academy of the progress of the work of the Expedition, they form so interesting an itinerary of exploring scientists and so instructive an account of a collector's adventures in a strange region, that they are published for wider reading. Mr. L. A. Griffin has selected for publication here only the paragraphs pertaining to the scientific aspects of the work of the Expedition.

After leaving the Philippines, Mr. Bourns spent some time in Borneo for the double purpose of taking notes on the relations of the Borneo fauna and that of the islands which had been so successfully explored and of securing some orangs for the Academy. His account of "An Orang Hunt in Borneo," written for another use by the Academy, is so interesting and so fitting an associate to the letters that it is given a place at their close.—C. W. Hall.]

I.

Salay Davo, Guimaras (opposite Iloilo),
Philippine Islands, December 12, 1890.

Gentlemen of the Minnesota Academy of Natural Sciences,
Minneapolis, Minnesota:

Since our arrival in the Philippine Islands, Sept. 6th, we have been anxiously awaiting the letter promised us from the Bishop of Minnesota to the Archbishop of Manila and instructions as to which of the methods of preparing birdskins we should follow. But as mail up to October 28th has arrived and no communication from you has reached us, and as it is past the end of the first quarter, we have decided not to delay longer in writing you, and accordingly have the honor to submit the following report.

We were subjected to a great deal of annoying delay in Manila, on account of the non-arrival of our letter from Spain. Since our visit here in 1887 the laws regarding firearms have been greatly changed, making it much more difficult to import them and nearly impossible for a foreigner to obtain permission to use them. Just as we had obtained permission to pass our goods at the Custom House and to procure proper licenses, a Royal Order from Spain was received by the Governor General. This fortunate arrival aided us greatly. Not only were our requests promptly granted, but in addition we were given a special letter from the Governor General to the Governors of all the provinces which we intended to visit. This is not only a letter of introduction but is also an order to the effect that all our reasonable requests be granted and our safety be looked after by the Governor of the province to whom the letter might be presented.

Besides this letter we obtained one from the Rt. Rev. Netter, acting Archbishop of Manila, addressed to the resident priests of the Philippines. This letter will be, and has already been, of great service to us, as in many of the smaller and more out of the way places the priest is the only white man to be found and is therefore a man of much influence.

Being thus well supplied with letters and papers from both civil and ecclesiastical authorities, we were prepared to start out on our work. We decided for our first trip to visit Panay, Guimaras, Negros and Siquijor, but as the boat did not leave for three weeks, we were compelled to look out for some suitable place near Manila where we could put in the intervening time. It was difficult to find such a place as all the region around Manila is under cultivation and for our work we must be near the forest. Finally we met an American named Thomas Collins, who told us that he thought his place would just suit us. He was engaged in the wood business at a small place called Quisao, about forty miles from Manila on the eastern side of the great Lake of Bay. His wood boats were going and coming every week, making it easy of access, so we accepted an invitation to visit him.

Taking small river boats (bancas) at Manila, we went up the Pasig river to the lake, where we found one of Mr. Collins' cascas or wood boats awaiting us. It was evening when we reached the boat and three o'clock A. M. before we set sail, but the wind being favorable, by noon of the next day we were at Quisao, and soon comfortably established in Mr. Collins' house and ready for work. The forest was farther off than we had expected to find it, and could only be reached by two hours' hard tramping, but we decided to make the best of it.

Unfortunately it was still the rainy season and we were in consequence much hindered by the weather.

We stayed there from September 27th to October 15th, working as much as the weather and our strength would permit, and then started back to Manila. We started Wednesday in order to have plenty of time to catch the regular monthly boat leaving Saturday for Capiz, the town in North Panay we wished to visit next. We expected to reach Manila in twenty-four hours, thus leaving us ample time to make all necessary preparations for our projected five months' trip in the Central Islands.

But we soon found that Philippine weather and Philippine boats, especially of the casco variety, are not to be depended on. A heavy storm drove us upon a rocky shore. The experiences of the next three days were not pleasant, but we escaped being wrecked, and reached Manila on Sunday morning, missing, as we supposed, the boat for Capiz. On our arrival however we were pleased to find that the same storm which had delayed us had also delayed the steamer, but that she would sail at three o'clock that afternoon. We had five short hours in which to make our preparations, but succeeded in getting the boat just as she was starting out.

The results of our work in Luzon show very significantly that much remains to be done in these Islands. Luzon is better known from a geological point of view than any other island in the group. One hundred and seventy-seven species of birds were already recorded, yet during our short stay in a locality close to Manila, which has been frequently visited by ornithologists, we obtained eight species of birds not previously recorded from that island.

The total number of species obtained by us was sixty-one; the number of specimens, one hundred and seventy-one. We also obtained a fine lot of alcoholic material. We shot the largest iguana of which we have any knowledge. It has been stated that these creatures never exceeed five feet in length, but the specimen mentioned measures five feet and four inches. On dissection two full grown chickens were found in its stomach. A venomous snake nine feet and four inches in length, which we shot, we have preserved in alcohol.

We were disappointed in not finding land shells abundant, but hope to be able to obtain a good set on our trip to north Luzon.

Our steamer reached the mouth of the Capiz river at eleven o'clock Monday night. We were landed on the shore with all our baggage about twelve. By two however we had everything safely under cover in a nipa house, and soon after had our hammocks strung. Next morning we sent our baggage by boat up to Capiz, while we went overland, a distance of about three miles. We went directly to the tribunal or town house and finding a large room suitable to our purposes, moved in. After making our calls on the various officials, we began to look around for forest. The surrounding country was low and swampy, and planted almost exclusively with the nipa palm. The long leaves of this palm furnish an excellent thatching material, very generally used, while the blossom stalk furnishes a favorite beverage called palm wine or tuba de nipa. This wine is very similar to the tuba de coco, or wine obtained from the cocoanut palm. The tuba de nipa however, besides being used as a beverage, is very largely used in the manufacture of a stronger distilled wine or even of alcohol, and many stills for its preparation may be found around Capiz.

We had been previously assured that we should find good forest around Capiz, but in this we were disappointed. Wednesday, acting upon the advice of the priest of the town, one of us went on horseback to Panay, a small village eight or ten miles away, expecting to find good forest there. In this we were again disappointed, the region around Panay being very similar to that around Capiz. No time was lost however as the small boys of Capiz proved to be very enterprising, and in return for a few coppers supplied us with wild cats, birds, iguanas, monitors, snakes, lizards, etc. For over a week we worked from early morning till late at night, and only got our work finished when we refused to buy any more specimens. Living Viverra tangalunga and Paradoxurus philippinensis were brought in and as we had an abundant supply of fresh meat we kept them alive for some time, and made interesting observations on their habits. We were glad to obtain iguanas in the way we did. They are so tenacious of life as to be able to run for a considerable length of time after having the heart cut out, and it is therefore exceedingly difficult to obtain them with a shotgun without injuring them greatly as specimens. We obtained perfect skeletons of two of the largest size, and skins of half a dozen others. As it takes half a day's work either to skin or to skeletonize one of these animals, we hope that those prepared may prove acceptable to the Academy.

At the end of a week, another trip on horseback was made in search of forest, but like the previous one was unsuccessful. It was evident that forest was not to be found within ten miles of Capiz. On Friday, October 31st, acting on the recommendation of the Governor of the province, we started for Balete, a small place some thirty-five or forty miles away. The Governor assured us that virgin forest surrounded the town.

The first day's journey was by sea, the night being spent in a small town called Batan. In the morning we transferred our baggage to a small river boat or faroto and continued our journey. We followed the Jalo river up to Balete, where we were well received by village authorities, and gladly accepted the invitation of the native priest to stop with him.

A short investigation satisfied us that there was no more forest around Balete than around Capiz. We had however, on our way up the river, passed several large colonies of fruit bats, and upon these we now prepared to descend. Within a week we put up forty-four skins and four skeletons, besides some thirty birds and considerable alcoholic material. Unfortunately five of the skins and the four skeletons were destroyed in a rather peculiar manner. It is quite a common custom in the Philippines to keep pigs in the parlor, but we did not suppose that our host the priest followed the custom. We were mistaken however, for on our return from a two days' hunt down the river we found that five of the skins and the four skeletons which we had left nailed to the wall a little too near the floor had been destroyed by the priest's pet pig.

On Monday, November 10th, with a light outfit, we embarked in two small river boats, and started up the river, determined to reach the forest if possible. The river soon became so small that it was very difficult to get along, even with our small boats. The boatmen were often compelled to draw the boats by hand over long rifts or small waterfalls. After eight hours of this kind of traveling we reached the house where we were to stop. It was the last house of any size on the river and is the property of a native of some means, who is engaged in growing hemp on the mountain sides. We were still distant about a three hours' walk from the forest, but were as near as we could get with our baggage.

Our first day's hunt convinced us that we had struck good ground, so we settled down for ten days' work. The forest was too far away to make it practicable to go there, shoot our birds, return, and skin them the same day, so we adopted the following plan of work:

One of us accompanied by a guide would start early in the morning for the woods. At noon a messenger from the house would take him his dinner and a supply of loaded shells, and carry back the birds shot that morning. At night he would again be sent with food for supper and breakfast, and would take back the birds shot in the afternoon. A small hut on the edge of the jungle furnished a shelter for the night. The next day the same operations were repeated, the hunter returning at night. But few paths could be found, most of them leading along the river or its branches. In consequence the hunter's clothes were wet all day, and this, combined with the hard tramping over rocks or through the jungle, made two days of this work all that could be endured without rest. So for the next two days the work would be changed, thus making it possible to obtain birds from the distant forest.

But the work was beginning to tell on us. The region was noted for being very unhealthy and the food supply was running low. Two or three days exhausted the supply of chickens, and then we were compelled to depend upon our guns for meat. Bread or beef had not been tasted for three weeks, boiled rice being our staff of life. Four days before we left we purchased our host's parlor pig, and then lived quite well on pork and rice. At the end of ten days we returned to Balete and from there went directly to Capiz, arriving at midnight, November 23rd. On the following Thursday we took the boat for Iloilo, arriving Saturday, November 29th.

During our entire stay in Panay, we were much hindered by rain, but for the next six months we expect to be free from that trouble.

While our collection of birds from Panay is not numerically large, we never put in the same length of time more profitably, so far as scientific results are concerned. We obtained about 250 specimens, representing about 80 species; about 60 of these we were able to identify with considerable certainty.

We were greatly surprised to find Aethopygia magnifica, abundant. This, the most beautiful sunbird of the Philippines, has heretofore been supposed to be confined to the island of Negros. The female we found very difficult to obtain, but we succeeded in getting three specimens. We are under the impression that it is still undescribed, and would be glad to receive definite information on the subject. We also have a fine series of specimens of Cinnyris Guimarasensis, including both male and female. This bird was shot new by us on our previous trip, and was supposed by Dr. Steere to be peculiar to Guimaras. The female however was not obtained, so that we now have it for the first time. In addition to the above we have four species which we believe to be new to science. They are: (1) A small kingfisher of the genus Ceyx. (2) A flycatcher of the genus Zeocephus. (3) A flycatcher, probably of the genus Setaria. (4) A frogmouth of the genus Batrachostomus. The latter is of special interest, being a Bornean genus. One species is already known from Palawan and another from Mindanao, but the finding of one in the central Philippines is a great surprise.

In general, our work on the birds of Panay seems to show a closer relationship between the birds of Panay, Guimaras and Negros than was previously supposed to exist.

Our most valuable find however was among the mammals. We obtained a single specimen of a *true cat* from Panay. The specimen obtained is a young female, but will be sufficient to establish the species. The animal is well known to the natives under the name maray or maral. From the natives we obtained a good description of the adult male. The only record known to us of a cat occurring in the Philippines is in Wallace's "Island Life," where Felis, sp. unknown, is noted as existing in Palawan. We believe that neither Viverra tangalunga nor Paradoxurus philippinensis were previously recorded from Panay.

Maccacus philippinensis was abundant. We send the skin of one large specimen, the skeleton of another, and several skulls. In addition to the fruit bats we send specimens of other species, one of which we hope may prove to be new.

We also send what few shells we could obtain. They were very rare where we were and even a high offer to the natives failed to bring in a satisfactory supply.

Our alcoholic collection comprises specimens of fresh water fish, reptiles, amphibians, crustaceans, preparations of the alimentary canal, etc., etc. We cannot at present give even an approximate estimate of the number of specimens, but the collections from Luzon and Panay fill an eight-gallon cask. We shall ship most of the above at the earliest opportunity, retaining only such specimens of the birds as we need for the purpose of comparison and study.

It may seem strange that we should spend so much time in searching for forest. Many of the islands like Palawan, Mindanao and Mindoro are completely covered with jungle, while others such as Luzon, Panay and Cebu have been under cultivation from before the time of the Spanish settlement, and in them it is difficult or even impossible to find virgin forest. But from this very difficulty, the results, when once the forest is reached, are such as to prove highly satisfactory from a scientific point of view.

On our arrival in Iloilo we apparently were both in good health. But on the very night of our arrival Mr. Worcester was taken down with a fever peculiar to the country, known as "febre pernicioso." This fever was undoubtedly contracted in the mountain region beyond Balete. Fortunately medical assistance was at hand, and serious results were avoided. Although our plans were interrupted to some extent and some time was lost, we are once more in condition to resume work. From here we expect to go to Negros and Siquija, returning to Manila in time to visit Mindoro in the dry season. There we expect to spend three months.

We shall have the honor of reporting to you again at the end of our Negros and Siquija trips.

The last mail brought us the certificate of membership. Allow us to take this opportunity to thank you most heartily for the same.

We remain, gentlemen,

Very truly yours,

Dean C. Worcester,

F. S. Bourns.

II.

Manila, March 19, 1891.

We have the honor to submit the following report of the second quarter's work of the Menage Scientific Expedition.

On December 26th we sailed from Iloilo for the town of Bais, a small place on the eastern coast of Negros, where we arrived on the 28th. We at first thought of settling down in Bais for a couple of weeks and making a collection of sea shells, but found it impossible to get a suitable house. Just at this time aid came to us from an unexpected source. We received a call from a Spanish gentleman who introduced himself as Senor Ignacio Simo. As we afterwards learned, he is the son-in-law of Senor Joaquin Montenegro, the wealthiest sugar planter in this part of Negros.

Senor Simo said that he had heard of the trouble we were having in finding a house and he wished to offer us the use of a small house situated on their plantation. We were very glad to accept this offer and moved out that afternoon. Instead of a small house, we found a large and well furnished one, usually occupied by Senor Montenegro's son, which had been vacated for our especial use. More than this we found that we were in reality the guests of Senor Montenegro and his family. They aided us in every way possible, furnishing us with men, horses, or carts, whenever we required them. Their kindness was greatly appreciated as it not only made it pleasant for us, but facilitated our work greatly.

We worked there for two weeks and then moved into the mountains. Our friends furnished us with twenty-two or twenty-three men, so we were able to take all necessary baggage and food. We went back about a three hours' journey and took up quarters in a native house conveniently situated on the bank of a small mountain stream. We were well located as the forest came up almost to our doors.

The people of the region are all savages, called by the Spaniards Monteses (Mountaineers). They are of course Malays, but have not been converted to Christianity and retain many of their old manners and customs. For instance, one of the old customs which still clings to them is observed when one of their number dies. In the belief that the departed spirit will be lonesome without company, the nearest male relative arms himself, starts out, and kills the first person he meets, black or white. Fortunately the health of the community was good during our stay. Our friends strongly advised us to take along a few soldiers, for the moral effect upon the people, but as we considered that the moral effect would be to make them think we were afraid of them, we deemed it not best to do so. We had, as guides, our host and his son, and experienced no trouble whatever with the savages, though on numerous occasions while hunting in the forest we met parties of them fully armed with their knives and spears. After two weeks of work in this place we returned to the plantation, again being furnished with carriers by our friend Senor Montenegro. The next two or three days were spent in arranging and packing our collections. On January 30th we left Bais for Dumaguete, which place we left two days later for Siquija.

During our stay in the mountains we were able to work to the best possible advantage, the forest being near at hand and our guides familiar with all parts of it.

We obtained 285 birds, of 69 species, 12 of these being new to Negros, and two of the 12 new to us. The first day out we were fortunate enough to obtain a sunbird of the genus Aethopygia (Aethopygia bonita, Bourns and Worc.) which has certainly never been described. It is one of the smallest and most brilliantly colored of the Philippine sunbirds. As it feeds in high trees it was very difficult to shoot. Careful and persistent work during our entire stay brought three male and two female specimens. This find was a surprise, as the sunbirds are much sought after by collectors on account of their brilliant plumage, and the chance of discovering new birds belonging to the family is very small.

Our other new bird is a kingfisher of the genus Ceyx, of which we have as yet but a single specimen, a female. Its peculiarities are small size and high color. We also found in Negros the small Ceyx discovered in Panay, though it was by no means as abundant as in that island. We were fortunate also in obtaining four specimens of the cat described in our previous letter. Of the four, two, a male and a female, are adult, one is two-thirds grown and one a kitten.

In one respect we have been particularly unfortunate during our six months' stay. That is in regard to the weather. When we reached Negros we supposed we had left the wet season behind, but during our entire stay in the mountains it rained daily, ending in a sort of cloud burst which raised the stream to such a height that we feared we should not be able to get out in time to catch the steamer for Dumaguete. By actual count the path from our house in the mountains to the plantation crosses the stream thirty-four times, and on the day we went out, though the water had fallen greatly, it was waist deep at most of the crossings. This last grand effort of the elements seems to have exhausted the water supply and we have since had good weather.

From Dumaguete to Siquija we traveled in a small native boat. The journey was pleasant, lasting eight hours, very good time considering the facts that we were heavily loaded and that currents were for the most part against us.

We were soon established in our old quarters in the tribunal, buying birds, shells, etc. We had many friends and acquaintances there, and knowing what we wanted, and that we gave coppers in exchange for birds and shells, they soon were hard at work collecting, and we were as hard at work preserving specimens of all kinds. The people are very poor, a man's daily wages being only five coppers. Many, finding they could make more than that collecting birds and other specimens, spent their whole time at it.

The second day after our arrival Mr. Bourns was taken ill with fever. A liberal use of quinine however stopped it at the end of the third day. Although it showed a tendency to return on one or two occasions, it did not come again in full force until we reached Dumaguete, where it was easily stopped by the use of a very efficient fever remedy which we have, but which we had unfortunately left behind when we went to Siquija.

After a seventeen days' stay in the town of Siquija we moved back into the mountains to a small place called San Antonio, five or six miles from Siquija and about 975 feet above the sea level. We were comfortably established in an old deserted "convento," once occupied by a priest, but since his departure left to go to ruin. The house was large and well arranged for our work, and, although rather too well ventilated, it served our purposes admirably. After two weeks' work in and around San Antonio, we returned to Siquija, and on Friday, March 6th, sailed for Dumaguete.

The results of our work at Siquija are very satisfactory. The number of birds previously known from the island was 54. To this number we have added 27, of which at least four are new to science. They are: (1) Another kingfisher of the genus Ceyx. It is the most brilliant-colored representative of the genus yet discovered. We have three specimens, two males and a female. (2) A kingfisher of the genus Halcyon, very similar to Halcyon Winchelli, but brighter in color, and showing one or two other differences. We have but a single specimen, a male. (3) A very remarkable crested cuckoo, belonging to a genus unfamiliar to us. It is unlike any cuckoo we have ever seen from these islands. We regret we were unable to obtain but a single specimen. (4) A cuckoo which has become protectively modified. It so much resembles a small hawk found in the island that we mistook it for the latter when seen on the wing.

We left San Antonio, arrived at Siquija the same day and on Friday, March 6th, embarked for Dumaguete where we arrived just in time to see a steamer bound for Iloilo (our destination) sail out of the harbor. We fortunately caught a boat on the following Monday. Although we had only 220 miles to go, it took five days to make the journey. The boat stopped at several small towns in Negros and Cebu and in each case several hours.

One of the stops however proved of great value to us. The island of Cebu has been under cultivation for so long that very little forest is now left, and that is being rapidly destroyed. The eastern and southern parts of the island are entirely destitute of anything approaching virgin forest, and but very little is found in the northern and western portions. So difficult is it to find forest, that collectors have done very little there, as is shown by the fact that only fifty-five birds are recorded.

At one of the places where the boat stopped to load sugar, a bit of forest could be seen a mile or two back from the coast. As the boat was to stop several hours, one of the party took a gun and went on shore. The results of a four hours' tramp in the woods show clearly that Cebu is still a good field for a naturalist.

Of ten birds shot, six were new to Cebu and one of these may be a new species.

We shall revisit the place probably about a year from now. Mr. Pickford, an English planter living there, says it is about the only part of Cebu where good forest can be found, and that in a few years none will remain. This gentleman also offered to aid us in any way possible, at any time when we desired to visit the island.

We are now making preparations for our Mindoro trip. It is the most dangerous trip we have yet to make, with the possible exception of the proposed trip to Sulu and the interior of Mindanao, but on the other hand, it is one of the most promising. The island is inhabited by savages, and is very unhealthy. As we have on previous trips succeeded in managing the savages, we think that we can do so this time. We are going into the island in the dry season when the fever is least prevalent, and hope to avoid sickness, but shall not neglect to take along a good supply of medicines. All provisions will have to be taken from Manila, as in the interior it is impossible to get other food than rice or sago, with perhaps an occasional jar of wild honey. Such a bill of fare, as we found by bitter experience, is not calculated to withstand the influence of the climate.

Three months will be spent in the island, during which time we shall probably be beyond mail facilities. On our return to Manila we shall report to you in full regarding the work done in Mindoro.

We remain,

Very truly,

Dean C. Worcester,

F. S. Bourns.

III.

Sulu, October 5, 1891.

I wrote to Mr. Menage by the last mail, but delayed my letter to you, in order that I might be able to state fully the results of our work here.

This island is undoubtedly the most dangerous place in the Philippines, and this fact has been a great obstacle to us. We have been obliged to hunt together, to keep an armed guard of friendly Moros with us, and to confine ourselves pretty strictly to one region in our hunting. We found on our arrival here that the Moros were not nearly so well provided with firearms as we had been informed, and that they were as a rule very poor marksmen. We also found that their reputed regard for Englishmen was strictly confined to *unarmed* Englishmen, that they were crazy to get hold of firearms, and would kill a man of any nationality for a gun. So we have gone in fighting order. We had little to fear from an open attack, but they could easily hide in the woods and shoot us at short range.

Our instructions from the Governor were brief and significant: "If you meet an armed Moro, order him to put down his arms and retire. If he does not instantly comply, shoot him." Our usual good luck has stood by us however, and we have confined ourselves, in our shooting, to natural history specimens.

The Spanish authorities have been very kind, giving us all possible aid in our work, and in spite of difficulties, the results have been very satisfactory. Before leaving home I compiled a list of Sulu birds, but could find only twenty-seven recorded. Immediately on our arrival I began to make inquiries as to whether other naturalists had been here. I finally heard of a person who was here in 1886. Whether my list includes the results of his work I cannot tell. If it does, we have added fifty-eight species to the birds known from the island. There is no virgin forest however within a day's journey of town, and it is simply out of the question for us to go farther away than that. As it is we have had one or two close shaves. On October 1st ten Moros are reported to have laid an ambush for us on the path we had always taken before. By the merest chance we went another way that day, and they caught a Tartar in the shape of a lot of soldiers, who were out hunting for some cattle that had been stolen the night before. Last Saturday we caught sight of a single Moro sneaking up on us with a rifle. He sprang into the high grass the instant he saw we had discovered him, and made his escape.

* * * * * * *

We have a great puzzle in the small blue kingfishers of the genus Ceyx from this place. They vary from the form with indigo-blue back to the form with silvery-white back and not a vestige of blue about it. One seeing only the two extremes would not hesitate about separating them, but with the series of specimens that we have it is a hard matter to decide what should be done. It is one of the cases where it would be convenient to "throw the intermediate forms out of the window."

Reports as to Tawi Tawi are most encouraging. The natives are friendly, we are assured that we shall find virgin forest at our very doors, and that there are fifty birds there for every one here. The Spanish authorities agree that the island has never been visited, and the natives agree that the birds there are different from those here. Theoretically they ought to be, and we hope to break the record both on number of specimens and number of new species. Present indications are that Tawi Tawi will prove one of our best islands, if not the best one of the group.

The drawbacks are scarcity of food, and the prevalence of malarial troubles, but we have plenty of provisions and plenty of medicines. From Tawi Tawi we shall return to this place, and I will report again at that time.

Some valuable Moro arms have been presented to us by Spanish officials here in Sulu. We shall make a much more complete collection of arms, articles of dress and utensils of one sort or another before our final leave.

Very truly yours,
DEAN C. WORCESTER.

IV.

Sulu, November 12, 1891.

Your letter of September 11th was waiting for us on our return from Tawi Tawi a week ago, and was very gladly received. On the 9th of October we arrived at Tataan, in the island of Tawi Tawi. The entire north coast of Tawi Tawi is uninhabited, except at Tataan which is a small Spanish military post, kept up merely to maintain their claim to the island. There is a small fort, large enough to accommodate one company of soldiers, who are under the command of a Lieutenant. There is also a Governor, an army Captain, who combines the office of Governor, "Commandante" of the post, Administrator of the Post Office, Captain of the Port, and I cannot say how many others. The present incumbent is a very genial grayhaired Spaniard, who treated us kindly during our stay and showed us every courtesy. Outside the fort stand the house where the Governor lives, the house formerly used by him, which fell to our lot during our stay, and the house of the official interpreter. Scattered over the neighboring hills are a few small clearings where some poverty-stricken Moros cultivate wild rice. They are without exception escaped slaves, and come from Balinbing, a pirate settlement on the opposite side of the island. Dependent on Spanish protection, they are entirely harmless, so that there is no danger in hunting near Tataan. The Governor and Lieutenant above mentioned, with a European Sergeant, are the only white men on this great island. The southern coast has always been notorious as a refuge for pirates. There are several settlements there at present, of which Balinbing is perhaps the most noted, but all the places are under the surveillance of Spanish gunboats, and as the only path across the island, which runs from Tataan to Balinbing, has fallen into disuse, we felt perfectly safe.

The house we occupied was a large one, made in the usual way, and containing but a single room. Fifteen minutes' walk brought us into virgin forest. Our first few days of work were disappointing, as we had hoped to strike an entirely new set of birds in Tawi Tawi, and it seemed as if they were going to turn out to be identical with those of Sulu. But as birds that were extremely rare in Sulu, so that we could not get satisfactory sets of duplicates, were very common here, we felt that we could put in our time profitably. Some very pleasant surprises awaited us, however. The first was a pigeon, of the genus Ptilopus. There are several "bloody-breasted" pigeons in the Philippines, but this one differs strikingly from all the others in having a beautiful orange spot on the breast, in place of the usual red one, as well as in the coloring of the back. It is a magnificent bird, and we decided at once that our trip to Tawi Tawi was a success, even though we got nothing else.

We did not have to remain content with this bird, however. There are three species of "racquet-tailed" parrots known from the Philippines. They are rather closely allied, and distinguished by the shade of green, the amount of blue on head, etc. Well, I shot what I supposed to be the Sulu "racquet-tail." As my man picked it up I noticed what seemed to be a great blood spot on the back of its head. This surprised me greatly, as I had killed it with fine shot, and had been particular to fire when its head was concealed by a branch. Closer examination showed that what I had supposed to be a blood spot was a bunch of red feathers, squarely in the center of the blue spot on the head. It is a most singular modification, and it seemed at first as if it must be a freak, but this red blotch is universally present on the heads of male birds, and the new Prioniturus from Tawi Tawi is the most remarkable, as well as the most beautiful, species of this genus yet discovered in the Philippines. We were able to secure a good series of specimens in fine plumage.

A few days later I went to what is known as "the big river," some six or eight miles inland, to hunt for kingfishers. I expected to find Ceyx argentata, or some closely allied species. I did find a new red Ceyx, and also, to my great surprise, a new Alcedo. Both of these are fine birds. The red Ceyx resembles, in a general way, the red Ceyx from Basilan, though sufficiently different in coloring to leave no doubt whatever of its being a different bird, but the most remarkable thing is the change in habits. The Basilan bird is strictly a woods bird, subsisting entirely on insect food, and never found along streams. The Tawi Tawi bird is invariably found along streams, feeds on crabs and shrimps, and is so reluctant to leave the water that it is comparatively easy to shoot one after once seeing it. The Alcedo was a great surprise. Only one species, Alcedo Tengalensis, has hitherto been known from the Philippines. This ranges over the entire archipelago, and occurs in Tawi Tawi. I was so much surprised to find this new bird there that I marked the first few specimens "Ceyx" in spite of appearances; but I saw enough of the bird and its habits before leaving to satisfy me that it is a true Alcedo. We got good series of both these fine kingfishers. We also obtained a single specimen of a new black and white pitta. This was killed at the very close of our stay by Mateo, and he got so excited when he saw it that he shot it very badly, and I was obliged to make an alcoholic specimen of it. These are birds of which we can speak with considerable certainty.

We also have the following: A sunbird most resembling Cinnyris Juliæ, of Basilan, but differing from any specimens we ever secured in the greatly increased amount of red on the breast. It is probably distinct, but may be only a variety. An oriole, resembling Oriolus Sturii, of Basilan, from which it differs in having under-tail coverts invariably streaked with black Only one of the specimens we obtained in Basilan was so marked. It also has a gray throat, not seen in Basilan birds, and a rather brighter black, probably a variety. A Phabotreron, somewhat resembling Phabotreron amethystina, from which it is however readily distinguished. This may prove to be a new species. A kingfisher identical in coloring with Halcyon Winchelli of Basilan, but differing constantly in form and size of bill. We do not know what to make of this bird. A kingfisher which greatly resembles the beautiful Halcyon coromanda of the north and east, with which it may prove identical. I am not prepared to say, as we have not seen a specimen of H. coromanda for more than a year. In any case we have secured some fine specimens of a very valuable bird, not hitherto known from the southern islands. A kingfisher resembling Halcyon pileata, probably identical with it, but the latter has previously been known only from Balabac. We got only two specimens of H. pileata during our year's work before, and I do not remember the bird with sufficient distinctness to feel sure.

In general I may say that we confined ourselves to the rare and interesting birds, and let the common ones go. We obtained a starling, probably Sturnia violacea, of which we could get no specimens before. We got a splendid series of the beautiful Aethopygia that we first found here in Sulu. We obtained a fine series of specimens of the small blue Ceyx which has puzzled us so much, varying from a bird with brilliant deep-blue back to one with a silver-gray back and no blue on it at all. This is the most remarkable variation I have ever observed. Other fine birds we have in abundance. We obtained in all nine distinct species of kingfishers from the island, besides several varieties. Luzon is the only other island known to possess as many, and the list has been completed there only by years of work by half a dozen different naturalists.

We put up four hundred and eleven skins. Mr. Bourns was ill during the first eight days of our stay, otherwise the number would have been larger. We could not get the slightest evidence that the island had ever been visited before. We were able to record eighty-nine species of birds. We never did so well in this respect before, either on our former trip or on this one. Our nearest approach was in 1888 in Samar, where five of us recorded eighty-five species in one month. Samar, like Tawi Tawi, had not been previously visited.

Wild hogs are so abundant as to give us fresh meat nearly every day. Deer are entirely wanting. In this respect Tawi Tawi differs from Sulu, Basilan and the northern and central islands, and resembles Balabac and Palawan. The difference is difficult to account for.

I now come to the curious mammal of which I enclose description. Shortly before we left for Tawi Tawi the Jesuit priest here, Padre Marche, informed us that just before our arrival he had made a trip to Tawi Tawi, and had bought of the Moros there a curious animal. He said it had the face of a bear, the hands of a monkey, moved like a sloth, and was called "cocam" by the natives. He sent it as a gift to Padre Sanchez, the priest in charge of the Jesuit museum, in connection with the college at Manila. I believe nothing of this kind has been found in the Philippines before, and it makes an important addition to the rather meager list of Philippine mammals. It is evidently one of the Lemuridae, but as generic characteristics are not given in the book I have, I cannot go farther.

I am very sure the creature is nocturnal. We had a hard time to get a single specimen, but I have got track of a place where it is abundant. We expect to return to Tawi Tawi, and may obtain additional specimens. I partially skinned the specimen we have and then preserved it bodily in alcohol, so that the skin can be saved and an anatomical study made if desirable.*

Thursday, November 26, 1891.

We find it impossible to reach Cagayan de Sulu at this time, as the steamer stopped there coming down, and will not do so going back. We can however reach this island readily and more cheaply from North Borneo, later on, so it will make no difference in the end.

We shall arrive in Manila a month sooner than I expected unless the Calamianes should prove rich enough to warrant a two months' stop. I shall probably write next from Manila.

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*Description published in Zoologischen Anzeiger, No. 389, 1892, by Henry F. Nachtrieb.

We have been unfortunate in the matter of our pictures of the "cocam." They had to be instantaneous, with one exception, and we misjudged the sun, and took them too early in the morning. I enclose one picture, which shows the creature asleep.

We have passed the time very quietly since I wrote the first part of this letter. We have killed a fine female deer, and a good wild boar, as well as some birds, but have spent most of our time in attempting to photograph Moros and learn as much of their beliefs and customs as possible.

The former task has been a most difficult one. They believe that they are sure to die soon if their pictures are taken, so we have to steal most of them. Instantaneous pictures can be taken only between eleven and one, at this time of year, and it rains at that time three days out of four.

As regards information concerning their beliefs, customs, etc., we have been most fortunate. We got into the good graces of one of the Moro dignitaries in attendance on the Sultan, and he was very glad to trade us the information we desired, for tales concerning the wonders of America. We have learned things in this way that we could not possibly have learned in any other. In fact, he has told us one thing which a Moro is forbidden to tell on pain of losing his head. I think we shall be able to give you some interesting facts concerning the Moros, on our return, and to show you some pretty fair pictures, as well.

We expect to sail for Paragua in the morning. We are well rested, free from fever, and ready for hard work once more.

Very truly yours,

Dean C. Worcester.

V.

Puerto Princesa, Palawan, P. I.,
January 26, 1892.

As Mr. Worcester is at present very busy with other matters and the time before the closing of the mail is limited, he has asked me to write you, giving some account of our work in the island of Palawan.

We arrived upon this island December 1st, and had no trouble in finding a good house near the edge of the town, where we were soon established. Our first work was to care for four specimens of Tragulus obtained at Balabac while the boat stopped. We secured in all seven specimens, of which we now have three in the form of skins and four as skeletons. They were all obtained by exchange, we giving a few ordinary but brightly-colored birds for them. We were very fortunate in obtaining these specimens, as this little deer does not exist in Palawan and we were unable to stop at Balabac beyond the usual halt of the boat.

The month of December was spent here in town, collecting all the birds we could get. We were very successful, as we obtained 550 specimens, of which we used in exchange for various things, probably fifty.

This month we have also obtained some birds, so that in all we have something over 600 specimens, of 99 species. Of these 25 were not obtained by us on our first trip, but we now fail to get eleven that we previously captured. Most of these however are water birds of wide range and little value. The only valuable birds that we know of, not in our present collection, are two hornbills. We were fortunate in getting a very fine specimen of Polyplectron napoleonis, or, as it is called here. the "royal peacock.' On our previous trip we were unable to obtain a single specimen, while now we have at least a dozen males in fine plumage and an equal number of females. The male of this species is probably the most showy bird found in the Philippines. Among other rare birds obtained are, Aethopygia Shelleyi, Arachuthera dilutior, Prionochilus Johannae, Zeocephus cyaneiceps, Tiga Everetti. As to new birds, we cannot write definitely as our list is incomplete, lacking some thirty species. We have one bird from the mountains that interests us greatly. It is a small, nearly tailless, brush or ground bird and the single specimen we have was caught in a lasso set for the royal peacock.

At the end of the first month's work, having a good set of birds of the island, we set out for other parts, to follow up reports that were brought us of a mountain goat and a very large monkey. We also hoped to be able to get more of the mammals of the island than we could get by staying in town. So on New Year's day we started, in company with a Spanish friend and a number of Tagbanna (native) carriers, for a small settlement named Tagbaroos, situated about ten miles up the coast and quite near the mountains. The natives of Tagbaroos had reported to us that at a distance of a day's march from their town there existed a mountain goat. As their knowledge of the animal was very slight and we greatly doubted the existence of the animal, we sent our trusted hunter, Mateo, in advance to see if he could find any evidence. Mateo is the Malay who returned to America with Dr. Steere in 1874 and was afterwards his chief hunter here. He was gone three days and a half and reported that there was no evidence whatever of the existence of a goat in the region he visited; in fact, the country was not suitable for such an animal.

Upon the receipt of this news we decided to divide our forces, one remaining in Tagbaroos to take care of the peacocks, squirrels, wild cats, etc., that were being brought in daily by the natives, and the other going back to Puerto Princesa and from there across the bay to another native village, called Igwahit, to start the people there also on a hunt for birds and mammals. At the end of a week's time we were to unite in Puerto Princesa, to get our home mail and then start out together for Igwahit. This plan we carried out. The lot fell to Mr. Worcester to go to Igwahit, and with Mateo and one servant he left on January 5th. During my stay in Tagbaroos I was kept fairly busy with peacocks, animals, etc., and felt fairly well satisfied with the week's work.

On arriving at Puerto Princesa on January 10th, I found Mr. Worcester already there and was delighted with his account of operations across the bay. He reported that the natives had taken hold of the work in earnest and the village was engaged in setting snares or hunting animals. For two days both he and the two servants had been busy from morning till night, when a native came along and reported that they had captured a large snake and asked if he would buy it. They were in the woods hunting for porcupines and had found this snake in a hollow log and had, with great trouble, captured it and dragged it to the nearest house, where they had it tied to the posts beneath the house. After a very few questions Mr. Worcester perceived that if the snake was as large as they reported, it was an exceedingly valuable specimen, so he immediately agreed upon a price and early next morning with a servant he set out for the house.

On his arrival at the house he was pleased to find that the snake exceeded by six inches the length given by the man, actually measuring 22 feet and 6 inches in length by 24 inches in circumference. With small trouble the powerful animal was chloroformed and then killed. Then came the task of skinning it which was no small one, I assure you. But the work was done, the skin taken off, carried to camp, cleaned and salted before dark. The weather was so favorable that by the end of a week it was well preserved.

We congratulate both the Academy and ourselves on having obtained a snake of this size. That snakes even much larger than this exist here there is no doubt, but we have now spent nearly two years and a half in the tropical jungle and never before have we seen a snake that even approached this one in size. In Mindoro we secured one thirteen feet and eight inches in length and, although we hoped, still we never expected to get one over twenty feet long. But the snake was not the only thing secured at Igwahit. Together we went there the day the mail arrived, and all of that week we were busy putting up birds and animals. Some of these are worth notice.

1. The flying squirrel (Pteromys), of which we obtained thirty-two skins and some skeletons. This squirrel, of which we heard accounts in 1887, is a very pretty animal, a typical flying squirrel, from twenty-two to twenty-eight inches in length, varying to almost pure white. In most cases we have preserved all the bones, so that skeletons can be made in case they prove more valuable than the skins.

2. The ordinary squirrel, Sciurus Steerii, of which we have a number of skins, etc., and some specimens in alcohol.

3. Tupaia (sp.?), known here as the besin. It is abundant and we have a number of specimens.

4. A species of Histrix. In 1887 we obtained a single mounted specimen of this porcupine, by exchange in Manila. We now have seven skins and three complete skeletons, besides most of the bones to go with the skins.

5. Six skins and one skeleton (besides extra bones) of the "pantut."* I can give you no other name for this curious animal. In general appearance it resembles a huge mole. Its fur is very dark brown, almost black, and quite glossy. The legs

* Mydacus Marchei Heut, is the name standing in Occasional Papers, vol. 1, p. 61, Preliminary Notes on the Birds and Mammals collected by the Menage Scientific Expedition to the Philippine IslanEs, by Frank S. Bourns and Dean C. Worcester, 1894.

are short and the feet are armed with long claws for digging, the claws of the front feet being much the longer. The eyes are small, the ears inconspicuous and the tail almost lacking. The snout is very like that of a pig, and from what the natives say, the animal gets its living in much the same way as does the pig. The most noticeable feature of the peculiar animal I have not yet described nor can I. It is the odor, and it is fortunate that I cannot so describe it that you can get an idea of what it is. It is powerful and comes from the liquid contained in two small sacs placed just under the bones of the rudimentary tail. The natives here say that this animal, with its powerful odor, has driven out of the island both the deer and the little Tragulus. This of course is a mere superstition, as we know that both Tragulus and the pantut exist in Balabac. Most of the specimens that we have were caught in lassos.

6. The "manturong," of which we have a single specimen. This also we are unable to classify. The body is covered with coarse hair of a dark gray color. Eyes dark and bright, ears tufted and small, tail long and very broad at base. The head resembles that of a raccoon. Unfortunately the animal had broken off most of the front teeth, so that we could not get a good idea of the dentition.

7. A rare specimen of the melu (Paradoxurus philippinensis). We have specimens from most of the islands visited. Here we have obtained one that differs from all others we have seen in being pure black, the color usually being brownish.

Of most of these animals we have a good number of specimens. Also we have alcoholic specimens of the whole animal, or of parts of it.

The only animal of importance we feel sure exists here, which we did not get, is a species of cat which, from the description given us, is very much like the one we obtained in Panay and Negros.

As already mentioned, stories were told us of the existence of two other animals, a mountain goat or, as they called it, "manda rata," and a large monkey or "pakduh," and it was to prove or disprove these stories that we put in the last week of our time here. The whole country round about is mountainous, the highest peak near Puerto Princesa being called Pulgar. The Spaniards in the town informed us that the mountain had never been climbed and was inaccessible, that various atttempts had been made, but that no one had ever succeeded in getting a third of the way to the top.

The natives also said that the mountain had never been climbed, even by their own people, but they gave us the reason, the fact that the "pakduh" or large monkey lived up near the peak, and they were afraid to go up there. We did not have much faith in their stories, but the opportunity was a good one, for determining the existence both of the "pakduh" and of the "manda rata," or goat, because if the goat existed at all in this part of the island it would very likely be on this wild mountain.

So it was that we decided to make an attempt to climb Pulgar. The details of the ascent probably would not interest you. Mr. Worcester started on a day ahead and established a camp at an altitude of 2,000 feet, the highest point ever reached by the natives. There I joined him the following day and the next morning we set out for the peak. One man with a large woods knife went ahead to clear a path and others followed carrying blankets, provisions, etc. It was hard work, but was by no means so bad as represented, for by two o'clock P. M. we were at the summit. Our success was undoubtedly due to our good fortune in striking a ridge, which we were able to follow to the very top. On all other sides, with possibly one exception, the mountain appeared to be inaccessible. We spent the rest of that day and a part of the next on the peak, but failed to discover any indications whatever of the existence of goat or monkey.

The monkey is undoubtedly a myth, and although it is possible that the goat exists in the northern and more rocky part of the island, it is certain that it does not exist on Mt. Pulgar, nor could it. The mountain is very rocky but is entirely covered with vegetation, which, although stunted at the top, is thick, almost impenetrable to such an animal, and not at all suited to it.

We should like to visit the northern part of the island, as, from all accounts, it is quite different from this part, but are unable to do so. The steamers do not call there and at this time of the year it is almost if not quite impossible to make the voyage in a small boat.

Our trip to Pulgar was not without some results however, as we were able to secure a good collection of ferns and mosses.

As the mountain has never been visited before it is not improbable that there are new species in the collection.

We also found a number of species of shells that we had not obtained below, some of which may possibly be new.

We have in all over 650 specimens, of about 17 species, of which about 150, of 14 species, come from the mountains, the remainder of three species, being the common shells found about the town.

We also obtained a few butterflies while at Igwahit. Among them we have five specimens of a very rare and beautiful species. A German collector who is now here values it so highly that he considers it a good week's work for one of his hunters, if he can catch a single specimen.

We are now awaiting the steamer to take us to Culion, an island situated between Palawan and Mindoro. It is one of a group called the Calamianes. Very little is known about its fauna and we can get no information except that shells are abundant and a species of deer exists there. The largest island of the group, Busuanga, is wooded and it is not improbable that we shall cross over to it. We hope to find something new or interesting during our proposed month's stay. Thence we shall go to Manila, from which point Mr. Worcester or I will write you again.

Yours very truly,

F. S. Bourns.

VI.

Calapan, March 8, 1892.

Since writing you last we have been in Culion and also a week in Manila. Our time in Culion was very short, three weeks of working time. We found very little forest, and that of poor quality and hard to work. The birds and mammals are very similar to those of Palawan. Among the birds there were varieties that, in some cases, might be marked enough to form new species. We cannot say that we have them new however, as, much to our surprise, we learned that the French naturalist, March, was there in 1885.

After a week's work near the town we moved to the centre of the island and for ten days occupied a small native house. Here we hunted birds with poor, and deer with good, success.

We put up fourteen skins of animals of both sexes and all sizes. We never saw anything equal the abundance of deer. We killed them with rifles and with shotguns, and caught them alive with dogs, and one of the party actually succeeded in catching a very young fawn, with his hands alone.

All told we got about 140 birds. An interesting mammal captured was a fine specimen of the Manis, a scaly ant-eater. It is identical with the one found in Palawan. We were able to get only a single very poor skin of native preparation. We secured two specimens of a squirrel which we never before obtained, but presume Mr. March got it before us. We also gathered a number of land shells of good species. Some are identical with Palawan forms, while others are peculiar to Culion or rather to the Calamaines group.

But by far our best success was with large snakes, of which we got two. The first, which is also the larger, we caught while in the interior. We had been told many stories about large snakes, so when we got among the savages we offered a substantial reward to anyone who would find and show to us a large snake. Soon after our arrival, two savages came to the house and said they were ready to take us to the "house" of a big snake, not over a mile and a half away. So we prepared ourselves for work and set out. We were conducted to a large hollow log, lying on the bank of a small stream, and through a crack in the log, we could see a portion of two coils of what seemed to be a snake 16 or 17 feet long. We stopped up both ends of the log, enlarged the hole near the snake, and after some trouble, succeeded in getting several strong rattans around the animal's body. Then the hole was still farther enlarged and we began to pull. That caused the snake to move and we soon saw that we had a larger one than we at first supposed. At first the snake braced the coils so that we could not stir it but finally the strain on its neck became so great that it relaxed its coils and with a rush it was hauled out into the bed of the brook. It was not at all active, so, after admiring it for a few minutes, we killed it by a knife thrust into the heart. It measured 22 feet and 8 inches by 22 inches in greatest circumference.. In the log we found a mass of 89 eggs which the animal had been covering.

It took us the rest of the day to skin it, but by dark we had the skin at the house. The next day we returned and cleaned the bones, so that we have both skin and complete skeleton.

The day we left Culion a snake 19 feet and 11½ inches in length was brought in. We had just started to skin it when the boat came in, so we were obliged to take it on board and skin it there.

We considered ourselves very fortunate to obtain a large snake in Palawan and never expected to get another of the same size. We were therefore very much pleased to obtain two more skins and a complete skeleton for the Academy.

During almost all the time in Culion we were very much handicapped by the fact that Mr. Worcester was troubled with his eyes. What the trouble was we do not know, nor could the doctor in Manila inform us. This trouble prevented him from doing any outdoor work, with the exception of one day on our arrival, and the two days when we were working on the snake, when he went out, against his better judgment. I am pleased to say that he is now much improved and expects to be well in a few days.

We spent a week together in Manila, during which time we were very busy indeed. We had occasion to call on the Governor General, and were very courteously received. The readiness with which the several requests we had occasion to make were granted was very gratifying.

We were unable to finish all of our business in the week before the semi-monthly steamer left for Calapan, so Mr. Worcester stayed to attend to it. He will go to Batangas by steamer and then cross to Calapan by small boat, reaching here five or six days later than the steamer.

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With regards to all, we remain

Very truly yours,

F. S. Bourns.

VII.

Manjuyot, Negros, May 21, 1892.

You may perhaps remember this as the place where the people catch pearly Nautili in deep-sea traps. It is, so far as I know, the only place where they are trapped, and when I was here before I was informed that May was the only month in which they could be obtained to good advantage. Since then we had shaped all our plans with a view of getting back here at this time, and it is needless for me to say that to date we have not preserved any specimens, though I hope soon to do so.

The statement that the pearly nautili can be taken only at this time seems to be untrue, as the inhabitants here say they took fifty odd in a few days' time, some four months ago, and ate them. A lot of fine fresh shells are shown in evidence. They seem to have no doubt of being able to get them now. I arrived here day before yesterday and already have everybody setting baskets. It is now too soon to hear from them.

I hope also to be able to obtain specimens of the wild cat, but cannot expect to do much else, as there is no forest within reach. I may possibly be able to get a number of species of land shells through business men who have natives at work in the mountains of the interior.

Our trip from the time we left Mindoro until Mr. Bourns reached Cebu and I got here to Manjuyot was unexpectedly short. We reached Manila in the afternoon of Monday, May 9th, and left again the following Saturday morning. During our short stay in Manila we had to repack nearly all of our collections, as we had been unable to get good cases and barrels in Calapan. This, with the work of shipping our collections and arranging an exchange with the Jesuits, made every moment more than full. Indeed, we were obliged to spend nearly all of the last night before our departure in the work of packing our equipment and supplies in order to get away.

On my arrival at Iloilo, where I had planned to spend several days, I found there was but one steamer making the run to Bais and that left in the afternoon, so I had to make another desperate rush.

We took upon ourselves the exchange of a timaran with the Jesuits, for material from their museum. They have always been very kind and courteous, and in several instances have rendered us service of great value, notably when we were having trouble with our things in the custom house on our arrival here. They have been very anxious to get a timaran, and as they had much material valuable for the Academy's collections from these islands, we felt that an exchange could be made to good advantage to both parties. The specimen we gave them was an old bull, and perfectly preserved, yet I am sorry to say it was somewhat torn by bullets, being shot through both the head and body.

They gave us in return a collection of two hundred and fifty species of shells, mostly sea shells. We do not set a high value on this collection as most of the species are common, but it will help a good deal when it comes to the identification of the shells we have already sent home. Our exchange was chiefly for arms, implements, ornaments, articles of dress, etc., of savage tribes, largely those of the interior of Mindanao. We also obtained four wooden idols, from the same region. A good many of the articles in question are not to be found except in this collection of the Jesuits. We are to receive, also, a collection of land shells, and to take such specimens as we desire from their set of Philippine birds' eggs. We did not have time to complete the exchange, nor to pack the material. Everything is securely stored however and will be sent home when we reach Manila.

In addition to the foregoing we got a fair set of birds, small but good, including a single specimen of a sunbird which is entirely new unless obtained by Dr. Platen at the time of his visit, and this is, I think, improbable. We secured a fine lot of Mangyan material, including a partial skeleton with a good skull of a man, and a woman's skull in excellent preservation. These were obtained in deserted houses and may be of some ethnologic interest.

We found two very rough images cut out of soft stone by the Mangyans. They were in the woods, near the shore of Nanjan Lake. One was erect, sitting on a large boulder. The other was lying on the ground with its head broken off. What they were made for we could not learn. We appropriated them. We send a bow and poisoned arrow. The latter should be treated with respect.

Two large python skins were sent in the last shipment of material. One is dry, the other in one of the barrels with timaran skins. The skins of a cow and a calf timaran were utterly ruined, owing to natives getting too ambitious, and killing three timaran in one day. We threw the cow skin away, saving only the skeleton. The calf skin we sent, as the taxidermist may want to use some of the hair from it, and it took up little room.

The other skins are strictly first-class in every way, and much more valuable than the dry skins we sent before. This shipment was by the "Jennie Harkness," an American ship bound for New York. If she makes the trip in 150 days, starting at this time of year, she will do well. Like the last ship, the "Jennie Harkness" goes to the National Cordage Co.

Stirred by our success, the Spaniards have made two attempts to get timaran in Mindoro. One of them failed utterly, and the second seemed in a fair way to, when we came along.

Wednesday, May 24. I am very glad to be able to report that the stories about pearly Nautili at this place prove to be entirely true. The natives brought in two night before last, five last night, and my only fear now is that they will bring them in faster than I can preserve them. I wish I knew how many could be used to good advantage, but shall have to use my own judgment in the matter.

Sincerely yours,

DEAN C. WORCESTER.

VIII.

Toledo, Cebu, June 25, 1892.

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Mr. Bourns is at the present moment quite busy with one of the attacks of fever which we have come to consider a part of the regular order of things. I hope however that this will be a light attack of short duration, as is usually the case. The fever which has troubled Mr. Bourns, Mateo, and one of our boys was undoubtedly contracted in Mindoro. Personally I was very fortunate in being ill but once while there, and have had no return.

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Work, since our arrival in the island of Cebu, has been most satisfactory in its results. Mr. Bourns arrived here sometime before I did. He found that the beautiful strip of forest in which we had expected to work had been entirely cleared off during our absence. He spent most of the time before my arrival in scouring the country on horseback, searching for a favorable place to work, and succeeded in finding one just before I arrived.

We are quartered in a small native house, or rather hut, where we suffer much inconvenience from our confined and narrow quarters, being obliged to eat and sleep in the one small room where we skin and dry our birds. We are near the forest however, which is the chief desideratum. Good food is abundant and cheap, and we are greatly indebted to Mr. Pickford, an English sugar planter living near by, for much kindness received. Mr. Bourns stayed with him before my arrival, and we have a standing invitation to come to his house at once if we get run down, and stay as long as we like.

The number of species of birds known to exist in this island before our arrival was fifty-five. These might well be divided into two groups. One, including nearly all the species, consisted of the very common birds frequenting the open fields and groves of palms in well cultivated country. These are worthless to us now, as we have all the duplicates we can hope to handle, the species being nearly all widespread.

The other group included a few peculiar birds found about the year 1876 by an English naturalist. From that day to this no one has been able to rediscover them. We had never even seen specimens, and knew them only by name.

We have found almost every known species, including all of the rare ones but one. The latter is a small owl, of which the only specimen known was shot by myself when we were here before. This can be obtained only by accident.

We have also found just forty species never obtained in this island before, and this in spite of the fact that the island has been visited by nearly all the naturalists who have worked in the Philippines.

We failed almost completely to get the birds we wanted on the occasion of our visit in 1888, and so are the more rejoiced at our success now. This will prove one of the most valuable sets of birds obtained by us, not only because the species are rare or unknown at present, but because it is probable that within ten years the last bit of forest will have been cleared from this island and many species will become extinct. I think we got here in the nick of time. We cannot pile up the number of specimens as rapidly here as in some places, for it is rough, hard country to hunt through, and birds are scarce, but those we do get are worth having.

I may say, also, that we are "on the trail" of another big snake. He is reported to be a foot in diameter when not gorged with food, and we have offered ten dollars for him if he comes up to contract size. This would break the world's record, and if we should get it you had better send it to the "World's Fair." I think you would capture first prize. It is very doubtful if we get him however, as he hides in caves and the natives are not over anxious to crawl into dark holes to look for him. I cannot honestly say that I blame them.

Personally I do not fear the big snakes half so much as I do the venomous ones. A beautiful specimen of a species, the bite of which is said to be fatal in an hour or two, has just been brought in. These creatures give us the crawls always, when we get hold of them, and we are half afraid to go into the woods for a week afterward, but soon grow indifferent again. I had hoped there were none here, and was not so glad to see the specimen as I ought to be from a strictly scientific point of view.

We are glad to know that the Academy is pleased with the big snakes already sent. They ought to make something of an attraction when well mounted. I hope the first skin is in Minneapolis before this.

* * * * * * *

Yours very sincerely,

Dean C. Worcester.

IX.

Manila, September 1, 1892.

We are once more in Manila unpacking, repacking, shipping and generally preparing for another period of work in the "provinces." For the last two months, or since we wrote you last, we have been at work in Cebu and Samar. When we wrote we were very much in doubt as to the length of our stay here, but since then we have received a letter from Mr. Menage, in which he informs us that he has agreed to our proposition to extend the time of the expedition for eight months. This is very gratifying to us and we fully appreciate, as must the Academy also, the generosity shown in thus enabling the expedition to complete the work. As members of the Academy and of this expedition we feel that we are very fortunate in having so liberal, public-spirited and staunch a supporter as Mr. Menage. We hope and expect that the results of the work will fully justify the heavy outlay involved.

Our work in Cebu resulted very satisfactorily. We succeeded in reaching fairly good woods, and secured a good set of birds.

As there remains very little forest in Cebu, birds are difficult to obtain and some have not been found since their discovery years ago. We were very much pleased, therefore, to get good sets of such birds as Phyllernis flavipennis, Oriolus assimilis, Prionochilus quadricola, etc. These birds are even now rare and valuable, and as time goes on they will become more so because the forests of Cebu are rapidly disappearing and in a few years will be gone. We obtained two or three that are probably new, and some others that, although not new to us, are new to science, being identified with new species before obtained by us in Negros, Panay and Siquija. Among these are two small kingfishers of the genus Ceyx and a small sunbird. Another interesting find was that of Aethopygia magnifica. This, one of the most beautiful of the sunbirds, was discovered by Dr. Steere in 1874, in Negros, and up to the time of our arrival here was supposed to be confined to that island. As we wrote at the time, we found it in Panay in October of 1890, and now we find it in Cebu. It seems quite strange that it should have escaped notice in Panay and Cebu from 1784 to 1890, and we are very glad that we have been able to add it to the fauna of these islands.

We are able to report also the existence in Cebu of the "maral" or wild cat, of which you have several specimens in your possession.

On our arrival in the city of Cebu we found awaiting us a fine lot of the Venus' flower basket, Euplectella, which had been collected in compliance with orders left by us some weeks previous.

In Samar we were also quite successful. It was from Samar that so many new birds were obtained by the Steere Expedition in 1888, and as very careful work was done at that time we had very little hope of new birds. But as the birds from Samar are very valuable, we went cheerfully to work, and in order to be near the woods built a small house near the hills, a distance of three or four miles from town.

Living thus on the edge of the woods we were able to get an early start each morning and to spend a longer time in the woods than is usually the case. We were thus enabled to get a large, though not a complete set of the known birds. Two or three of the birds that we desired escaped us. When we were here in 1888 there were many trees in blossom or fruiting, and from these we could frequently get birds that are usually very difficult to obtain. This time the trees were not fruiting, and that advantage was lost to us. We did obtain however three birds that we feel sure are new, and this more than repaid the loss of the known birds. We were enabled to add several to the known list of Samar birds.

An unusually good set of the large hornbills from Samar, including both skins and skeletons, was secured. Our good fortune in capturing these birds was largely due to the discovery, by our Philippine hunter, Mateo, that these birds will answer to a call. The call is an imitation of their own note, being a short "haw" given in a deep bass and very short. It was very amusing to hear the replies of the birds and see them come flying down to find out the cause of all the disturbance. We also secured a good series of the smaller hornbill Penelopides.

On our arrival in Manila, we made the exchange with the Jesuit Museum and secured a fine collection of shells, Moro arms and utensils, native idols, charms, etc. We were much pleased to get hold of this material, as most of it is very valuable and difficult to obtain.

We have just made another shipment of sixteen cases, four kegs and one bundle. You will find in this shipment the birds collected during the last three months; alcoholics, including all of the specimens of the pearly Nautilus collected by Mr. Worcester in Negros; the Venus' flower basket from Cebu; a large number of land shells from Negros, Cebu and Samar; all of the material obtained by exchange; a lot of bows, arrows, etc., from Mindoro and Culion, and a collection of pottery purchased in Manila. The shipment is a valuable one and will interest not only the members of the Academy but others as well.

It was our intention, when we reached Manila, to go directly to North Luzon and the Babuyanes and Batanes islands; but we learned that during the rainy season we could not work to advantage, so we were compelled to change our plans entirely.

Mr. Worcester, with Mateo, goes to Romblon, Sibuyan and Tablas, then back to Manila and down to Culion and, about January first, up to North Luzon and the adjacent islands. I go to Sulu, Tataan (Tawi Tawi), Cagayan de Sulu, and then without returning to Manila cross over to Singapore and into Borneo.

In this way we are enabled to avoid the worst part of the rainy season and cover the ground we desire.

It is of course not so pleasant this way, as we are compelled to be alone. But the work required it, so we made the change. I don't expect to speak English again until I reach Singapore in December.

I shall write to you from time to time, as will Mr. Worcester, so you will be posted as to our work.

Yours very truly,

F. S. Bourns.

X.

Romblon, October 23, 1892.

I am waiting for a steamer for Manila which will very likely arrive before I can finish this letter; but I will at least begin. Mr. Bourns wrote the last letter we have sent you, from Manila, just before we separated. Since that time I have visited the islands of Romblon, Tablas and Sibuyan.

I arrived in Romblon seven weeks ago to-day, and was very shortly in a comfortable house. Romblon is an island almost entirely under cultivation, and I had not hoped to be able to do much here, expecting merely to make it a base of operations in visiting Tablas and Cibuyan. A steam launch left for Cibuyan shortly after my arrival, but I could not take it, as it was necessary for me to make my usual call on the Governor, and there was no time to do so before the launch left. A heavy storm of wind and rain set in at once, and lasted with little interruption for two weeks. The launch was unable to get back from Cibuyan, and I was stranded here.

I was able however to put in my time to much better advantage than I had expected. There is one bit of forest near the town, and we were so anxious to see what could be found that we hunted without much regard to the weather. The first day's work resulted in the discovery of two new birds, a "fruit-thrush"* and a flower pecker."† These were the only new birds we got, but we shot a good many old ones that were well worth having. We are well pleased, in these days, with an island that gives us even two new birds. We found forty-five species here. These three islands are famous also for their land shells, and this wet season is the very time to get them.

*Iole cinereiceps B. & W.

†Dicæum intermedia B. & W.

I shortly had all the small boys of Romblon in my service, and during our two weeks' stay made a large and, I think, a very complete collection of the land shells of the island. In Tablas and Sibuyan we made fine collections of shells also. We have about eight thousand specimens.

The shells are brought in alive, a few at a time. To sort out the good from the bad, bargain for the good ones, kill the animals and remove them from their shells, wash the shells, and then wrap each one in paper, and pack them all, has been a good deal of an undertaking. The shells are a very fine set, right through, and as we got none of these species when in the Philippines the first time, I think they will be valuable to the Academy, both for exhibition and exchange. Each of these three islands has its own set of shells.

Just two weeks from our arrival in Romblon, we left for Tablas, on the steam launch. We established ourselves in a town called Badajos. The forest was conveniently near, birds and shells were abundant and we put in two very profitable weeks. We were fortunate in having uninterruptedly fine weather during our entire stay. We found immediately two species of birds of great interest. One is a new Diarurus,* the other a flycatcher. I am not prepared to say that the latter is new, as there has been a species of this genus, Philentoma, recorded from the Philippines for some years, and while I have never seen a specimen of the bird, nor a description of it, the name fits, and I am inclined to think that we have found out at last where "Philentoma cyaniceps" came from. If not, a fine new species of the genus is discovered. The two new species found in Romblon are also abundant in Tablas. We shot a single specimen of an owl likely to prove new, and found seventy-four species in all. I have always feared that the birds of this island might prove identical with those of Panay. Prof. Steere felt so sure they would be the same that he did not think the island worth visiting. Fact is better than theory, however. The island differs from Panay not only in the occurrence of a number of species of birds entirely distinct from Panay representatives of the same genera, but in the absence of whole families, as hornbills and woodpeckers, as well as in the absence of deer, which abound in Panay.

We were very fortunate in making connections on returning from Tablas. Arrived in Romblon one evening in a native boat, we left the next morning, in the launch for Sibuyan. The distance from here to Tablas is short, and the passage reasonably safe in the native boats, but it is much farther to Sibuyan, and the passage at this time of the year a very dangerous one for sail-boats of any description. Had we not caught the launch we should have been obliged to wait until it made another trip.

We got to work without loss of time, and shortly found several interesting species of birds. The three which especially attracted our attention are a woodpecker, a kingfisher and a "flower-pecker." We found a magnificent flycatcher which has the colors of Cyanomyas coelestis, but the splendid crest on the head is longer than in any specimen of C. coelestis I have ever seen, and that bird has never been found in any of the islands near these. We secured sixty-four species of birds in all, and they are a queer set, quite different from those of Romblon and Tablas. I should have been glad to remain in Sibuyan another week, but we had to choose between leaving at the end of two weeks and the risk of being stranded for some time, and it seemed best to go.

Since our arrival we have been busy packing our specimens and rearranging baggage preparatory to another trip, so that we may be able to make a quick move in Manila if it is necessary to do so. I now expect to go next to Masbate.

The result of our work for the last seven weeks may be briefly summed up by saying that we have discovered a number of species of birds, possibly new; have made a larger and more varied collection of land shells than we ever did in the same length of time before, and have found what birds and animals exist in three islands where the birds and animals had never been studied before, and concerning which nothing was previously known.

The fauna of this island was probably once identical with that of Tablas, so far, at least, as birds and mammals are concerned. The present differences have been brought about by the destruction of the forest here. The fauna of Sibuyan is quite distinct. All three islands are poor as regards number of species, the difference being apparently made up, in many cases, by the great abundance of representatives of the species which do exist.

Manila, October 30, 1892. Our steamer was four days late in Romblon, and we had to wait all that time with baggage packed, which was exasperating. We arrived here Thursday noon, and leave tomorrow (Monday) morning, having had barely time to do the necessary work here.

We are in the best of health, and hope to rush business in Masbato and Ticao. Shall be back here in five or six weeks and I will then report again.

We very heartily appreciate Mr. Menage's generosity in allowing us the extension of time, and hope that both he and the Academy may be satisfied with the results of it.

With many thanks for your kind expressions and good wishes,

Very truly yours,

DEAN C. WORCESTER.

XI.

Manila, December 8, 1892.

Since my last letter to you I have spent five weeks in the island of Masbate. The month of November is usually the worst in the year here, and this year has been no exception to the general rule. We had one typhoon, rain often fell uninterruptedly for days at a time, the fields were flooded and the paths nearly impassable from mud.

However, we raised the number of species of birds known to inhabit the island from 32 to 102, and made some valuable finds, the best of which is a fine species of Cittocincla entirely new to science.* The discovery of this bird was a great surprise, as I did not in the least look for a representative of the genus in the island. Many of our specimens are both interesting and valuable, and we are now in position to put Masbate in its proper place among the other islands.

I hoped to visit Ticao, but was unable to do so, as the sea remained so rough as to make it impossible to get across. Ticao is a small, heavily wooded island close to Masbate, and probably has the same fauna, but it would have been interesting to make sure.

We made a hard attempt to get specimens of the spotted deer of Masbate, riding clear across the island to reach the place where they are found, but when we arrived at our destination we found the grass where they feed and hide to be higher than our heads, and, though we hunted in the pouring rain for four days, obtained but one young specimen.

*Cittocincla superciliaris B. & W.

The rain was favorable to the collecting of land shells, and we were very successful, getting a large collection, among which are several large and fine species not previously known from this island. One of our land shells from Sibuyan proves to be new. Unfortunately we could secure only a single specimen, but the Academy will at least have the only one in existence.

I leave day after tomorrow for a second visit to the Calamianes. I hope to be able to reach the forest said to exist in the interior of Busuanga, and to find there some birds we did not find in Culion. I propose to spend several days at first in putting into practice my ideas about securing specimens of big snakes, though I do not care to make any promises as to results. I expect also to visit the Tagbanoa burying caves, and make a collection of skulls at least. I probably shall not be able to report myself for some time, but hope to have good news to communicate. Mateo and I are both strong and in the best of health, and if the weather improves, as it ought to in December, I think we can give a good account of ourselves.

Yours most sincerely,

Dean C. Worcester.

XII.

Sebangan, Borneo, January 12, 1893.

As I am just about to start on a month's trip, away from all mail facilities, I shall drop you a line now. I am much gratified to hear that you feel pleased with the collections so far received. That, when they are all in, they may be satisfactory is the end toward which we are working. As I have already written both you and Mr. Menage about my Sulu and Tawi Tawi collections, I will not repeat much here. There are one hundred and eight cases in all, which I hope you will receive in good condition. The Moro arms, clothes, etc., I did not send, as I had not the collection made when the other boxes were shipped. They are now in Singapore and will be sent with my Borneo collections.

I arrived in Kuching, the capital of Sarawak island, Borneo, on December 17th. By advice of Mr. Maxwell, the Resident of Sarawak, I decided to try the Sadeng River, as the orang-outang (here called the mias) was reported to be abundant there. I left on the first opportunity, embarking on the 23rd on a small coal schooner bound to the Sadeng coal mines. Christmas was spent at sea, pitching about in the schooner. We reached Sadeng on the 26th. A week about Sadeng convinced me that it was not the place for my work, so on January 2nd I loaded all of my goods on a small boat and started for the Sibuyan river. On reaching the mouth of the Sadeng river we met bad weather and were compelled to turn back. Not to lose time, I decided to make a short trip up a small river that empties into the Sadeng almost at its mouth. The baggage was unloaded and put in a small empty house on the bank, and on the 4th, with a light outfit and provisions for a week, I started. That night we reached a Dyak house, where I was very hospitably received. I was presented with a fowl and four plates of rice (one from each family) and in return presented each of the leading men with a little tobacco, with which I had of course supplied myself for this special purpose. Then we talked ordinary orang-outang (mias). The men were of the opinion that a mias might be obtained on a hill, an hour's walk from the house. So I decided to try it on the following day. After another two hours' talk on various subjects, I spread my sleeping mat and tried to rest. Very poor success however, as the floor was hard and the people talked and laughed till past midnight. It is the season of the rice harvest and they were all busy pounding, winnowing and assorting rice.

In the morning, with one Malay and two Dyaks, I started for the hill. The path was through the swamps and was very hard indeed to travel. A misstep sent one into soft mud from one to three feet deep. It was a rather long hour's walk, but we reached the hill at last and began to look for mias. One Dyak went on one side while the other with the Malay kept with me. About the middle of the forenoon we heard the report of a gun, the signal agreed upon, and retraced our steps until we came up with the Dyak. He was following two mias that he had found on the edge of the swamp below. They were in very high trees, but no tree is too high for a Winchester, and soon I had both mias on the ground, dead. They fell with a great crash and the larger one struck so heavily that some of its bones were broken. They were not of the largest size, evidently a young pair just started out, but were in good condition and furnished good skins and skeletons. The following day we continued on up the river to another hill, where we put up a rude shelter as protection against rain and sun. That afternoon one of the Dyaks brought in a female mias, which we skinned next day. The next two days brought in nothing but a tupia, two squirrels and a few good birds. Two mias were seen by the men but were gone before I could get to them. So I decided to return the next day. Early in the morning it was raining, but about seven it stopped; we broke camp and loaded the boats. With two men I started ahead in the small boat and soon ran across a flock of long-nosed monkeys. I gave chase, and wading through the swamp, up to the waists in water, we ran across another mias, which we secured. Farther on down the river I shot two black monkeys, a female and a young one a month old. We arrived at the house about two o'clock, making a quick trip as we were favored by the tide, this being a tidal river.

I found that a large male mias had been brought in by some Dyaks from the Sadeng. It had been killed for at least twenty-four hours, so that my boy, whom I had left in charge of the house, was not able to save the skin. He saved the skeleton, a fine one, in good condition. Had I been on the spot the moment the animal arrived I might possibly have saved the skin by means of a warm salt and alum bath, but it is doubtful, as twenty-four hours in this climate is usually enough to start the epidermis on almost any animal.

This is a brief account of my work up to date in Borneo. I expect to start in a day or two for the Sibuyan river where I hope to get ten or a dozen good mias, besides other mammals of interest. While there I shall be beyond the reach of mails.

With kind regards to yourself and all inquiring friends, I am,

Yours very truly,

F. S. Bourns.

XIII.

AN ORANG HUNT IN BORNEO.

By Frank S. Bourns.

Mr. William T. Hornaday, in his interesting book of travels, "Two Years in the Jungle," gives the habitat of the orang-outang as Northern Sumatra and Borneo. As it is limited to a small area in the former island, he considers Borneo the true home of this great ape. Nor is it evenly distributed over Borneo. Mr. Hornaday gives its range as the great plain of the west and north; but it is also quite abundant in the northeast and east, the territory occupied by the British North Borneo company.

Fairly well defined areas of this vast region however seem to be avoided by the orang. For example, in Sarawak, where all of the orangs now in the possession of the Minnesota Academy of Natural Sciences were obtained, in the region between the Sarawak and the Sadeng rivers, very few if any orangs can be found. But in the adjacent territory between the Sadeng and the Batang Lupar rivers, they are fairly abundant, while still farther on to the northeast they again disappear or become very scarce, the reason given being that the natives of this region use them for food and thus keep down the number. This practice is not followed in the regions about the upper Sadeng, Simunjan, and Lingga rivers.

In the region between the Sadeng and the Batang Lupar rivers, the orang is probably more plentiful than in any other part of Sarawak. The country is for the most part a huge swamp for fifty miles back from the sea. A few ridges of high land run down from the mountains towards the coast, and at intervals of a few miles, isolated hills or groups of hills, rise from the swamp. The water varies in depth from a few inches to several feet, being greater of course during the rainy season. For several miles back the tide has a decided influence, backing the water up for several feet and causing a reverse current in all the rivers and streams. The whole region, both swamp and highands, is densely wooded.

This is where the orang makes his home. Home is hardly an accurate word to use, for the orang's home is wherever night happens to overtaken him. When darkness falls, the animal selects some small tree with a bushy top, where he soon builds his nest. This nest, or "lampin," as the Dyaks call it, is a platform of leaf-covered branches placed in a secure place in the tree. In making it, the animal reaches out in every direction and breaks off or bends over all of the branches it can grasp. These are arranged in a careless manner so as to form a rude but substantial platform or nest, the smaller leafy branches serving to make it quite comfortable. Here the orang-outang sleeps, flat on his back, one or both feet firmly grasping a limb of the tree, with perhaps one hand similarly employed. Mr. Hornaday is of the opinion that the same nest is occupied for several successive nights, but careful inquiries among the Dyaks lead me to believe that it is more probable it is used but once, the animal preferring to build a new nest, to returning, even for a short distance, to an old one. These deserted nests are very abundant in the jungle, especially along the edges of small streams. A wounded orang will often betake itself to some high tree and hastily built a nest as a protection against the bullets of its pursuers. If these happen to be Dyaks, with their old rusty flintlocks, such protection serves its purpose admirably, but of course it is worthless against 45-90 Winchesters.

Two or three methods may be followed in hunting the orang-outang. The best is by boat, using a small "dug-out," with two Dyaks to paddle. By following along the small streams and water ways cut through the swamps by the Dyaks, one can move very quietly and can cover a long distance in a day. The chances of success are good, as the orangs frequently resort to the edges of these small streams for the purpose of feeding on the tender shoots of the "bladdin," or screw pine. Another method is to hunt over the hills, or just along the edge of the swamp, while the third is to wade right into the swamp after the game. This method is not very satisfactory, and involves the hunter in exceedingly hard work. It is much more successfully done by the almost naked Dyaks, who have spent the most of their lives wading in these very swamps.

My first successful hunt after orangs was comparatively easy work. We had gone a full day's journey up the Simangang river, stopping over night at the last Dyak house. This happened to be situated within four or five miles of a "gunong," or hill, and the Dyaks thought that an orang, or mias as they called it, might be obtained there. So, accompanied by a locally celebrated Dyak hunter named Pasang, the Orang Kaya (head man of the village), and "Kadir," my Malay guide, we started early in the morning following what, by courtesy, the Dyaks called a road. This consisted of a row of poles from half an inch to two or three inches in diameter, placed end to end over the worst places in the swamp. One is supposed to walk these as a rope walker does a rope. This my barefooted companions did very successfully. I soon got so that I could balance myself fairly well, but about once in every hundred rods would slip and go in up to the hips. We finally reached the hill and then divided into two parties, Pasang going on one side of the hill, we on the other. Many nests were seen and any number of small monkeys, but no orangs. About noon however we heard a faint signal which the Orang Kaya said was from Pasang. Half an hour later we found him carefully following two mias, which he had met far down in the swamp, and which he had tried to kill with his old flintlock. In this he had failed, and as the orangs had quickly fled to the high trees, they were quite safe from the clumsy bullets of Pasang's old gun. A fine male orang in one of the highest trees was now pointed out to me. I had with me both a 38- and a 45-caliber rifle, and not wishing to injure the skeleton more than was necessary, I took the 38 and fired. The orang uttered a low growl and hastily made off through the treetops. This caused great excitement and fearing to lose him, I quickly took the 45 Winchester from one of the men, and as the orang was swinging himself along hand over hand, aimed at his huge hairy breast and fired. For a moment he hung there, and then came crashing down, a distance of 80 feet or more, falling with a loud thud, and with such force as to break several bones. The fall knocked out of him what little life he had, so we went up to him immediately. What a fine fellow! Not one of the very largest, but a well-grown orang weighing more than one hundred pounds, with hair several inches long hanging from his arms and shoulders.

We admired him for a moment then turned our attention to his mate which we soon found and brought down. Elated with our success we bound the animals up and started home, Pasang carrying the larger and the Orang Kaya the smaller of the two. The animals were both the "mias rombi" of the Dyaks. They recognize three distinct varieties, the "mias chappin" or largest, the "mias rombi" or medium and the "mias Kassa," or smallest variety. The "mias chappin" is always a huge beast with very long red hair on the breast, shoulders and arms, and is characterized by large cheek callosities. These give the face a peculiarly ugly and ferocious expression. The canine teeth are long, projecting far beyond the others, so that the expression of an enraged animal is extremely ferocious.

The female of this variety does not posses the cheek callosities, nor is she so large. The "mias rombi" is very similar to the "mias chappin" but lacks the cheek callosities. Usually too it is somewhat smaller and has shorter hair. The "mias Kassa" is quite small, almost a dwarf. These are the varieties recognized by the Dyaks. Among naturalists some difference of opinion has existed as to the number of species of the orang, and two have usually been recognized, "Simia satyrus" and "Simia wurmbii." Mr. Charles Hose, in his recent monograph on the "Mammals of Borneo," recognized but a single species. This is the opinion now held by many naturalists, the differences in size, length of hair, cheek callosities, etc., being partly sexual and partly accidental.

The day after the successful hunt, we continued on up the river almost to its source, as far as Gunong Bulan (moon hills). After four or five days of hard work we had captured but one orang, a thin sickly-looking female which the Dyaks insisted had malarial fever. They maintain that the orang is as much subject to fever as is man, that when afflicted the animal will lie in the nest for days, groaning loudly during this time, and that as a result of the fever, it becomes greatly emaciated. We had here a positive proof of one of these facts, for this animal looked as poor as did many a native whom I had seen, who had had malarial fever for some weeks. That the animal groans I afterwards had a chance personally to verify. In fact it seems perfectly rational that the orang can be afflicted with this disease, just as can any person who is so unfortunate as to live in the swamp, where the malarial plasmodium is ubiquitous.

On our way back we secured one more orang, and its capture shows well the pleasures of hunting in a Borneo swamp.

We were floating slowly down stream when we came upon a flock of "rasongs" or proboscis monkeys. As they are valuable animals it was desirable to secure some, so I ordered the men to follow into the swamp and get within range. After going fifty yards I got a long range shot at one big fellow, but hit him too low so that he was able to make off. The boat followed a short distance, but soon became fast in the roots and vines, and, as there was nothing else to do, we went over the side, at first going in up to the shoulders. Wading cautiously along, avoiding briars and thorns as much as possible, we followed the wounded animal, but each time we approached him he would make off before we could get a shot. Going in this way we were soon a quarter of a mile away from the boat. Just then while peering anxiously up into a tree over our heads, we sighted an orang carefully concealed in the top. He was so well hidden that it was impossible to tell where to aim, so I fired at a venture expecting to take him again when he disclosed himself. The bullet broke his leg, and as he hastily started to make off I took quick aim and pulled the trigger. Click! That empty click that makes a hunter's heart sink was the only response. The rifle was empty, not a cartridge in my pocket, the boat a quarter of a mile away and the orang slowly making off. I well knew that I could not find my way to that boat and back again, so told Pasang that I would follow the animal while he returned for cartridges. At first the animal got ahead of me, but after a while it stopped and rested in the crotch of a tall tree. I carefully concealed myself and keeping perfectly quiet awaited the return of my guide. The animal did not attempt to go farther until again disturbed by the noise made by the returning Dyak, when a bullet quickly brought him down. In time we got back to the boat with our prize, but I was sore for a week from the scratches and bumps I got while struggling through that bog.

A few days later found us up the Sibuyan river far beyond Dyak houses. As there was no high ground in the region we wished to work, we were compelled to build a rough shanty directly over the swamp. From this place as a center, aided by the good hunters, we worked the surrounding country with good success. Orangs, proboscis monkeys, black monkeys and other animals came in quite rapidly. But at the end of the week I was seized with a annoying combination of fever and articular rheumatism. For a couple of days I stayed in camp, but the third day, feeling no better, I decided to go out in the boat, believing that recovery would come as quickly while being paddled about over the swamp, as it would lying on a platform of poles three feet above it. We took one of the small branches of the river and paddled along until past noon, without seeing anything. Then the order to return was given and we started back. An hour later as I was lying flat on my back, wondering how much more quinine it would require to conquer that fever, and wishing for an ounce or two of salicylate of soda for the rheumatism, I was aroused by the man in the bow of the boat, who cautiously whispered, "Mias Tuan, mias bazar" (an orang, sir, a big orang). The boat was cautiously stopped as I arose to a sitting position and grasped my rifle. Sure enough, there fifty yards down the stream was a large animal working his way through a dense thicket of screw pines that was between the forest and the channel. He had sighted us and slowly, and apparently without fear, was making his way towards the jungle. He was partially concealed by the thicket, so we dropped down the stream so as to get on the other side of him before he could gain the large trees of the jungle proper. We came in sight of him again, just as he was getting into the branches of the first large tree. For a moment we stopped and gazed at each other. What a monster! A face over twelve inches wide, a huge chest and broad shoulders, and arms having a reach of over eight feet from tip to tip. He growled and showed his long canine teeth, just as I raised my Winchester and fired. Slowly one leg dropped, then the other, then one hand loosened its firm grasp of the limb above, and for a moment he hung there by one long hairy arm. Then the other hand slowly relaxed its firm hold and down he came with a great splash. A few minutes later and not without much trouble, we had in our boat one of the largest orang-outangs ever killed. He weighed 151 pounds and was a prize in every way.

Usually it is not very dangerous sport hunting the orang-outang, as the living animal almost never comes to the ground and is quite helpless when it does. It is perfectly at home in the treetops, swinging along from tree to tree with the greatest ease. One seldom meets with more than one at a time. Sometimes a pair of rather young ones may be found, or perhaps. an old female with a young one of two years and another in arms. My hunter Pasang said that he once met four feeding together, but they were all small. The old males always go alone, meeting occasionally, when a royal battle in the trees is apt to follow. The marks of these fierce conflicts can usually be found on an old male, a finger bitten off or a piece of the lip gone showing how savagely they fight.

Stories of orangs throwing cocoanuts at hunters are all travelers' tales. Their only foundation is in the fact that an old female with young, if attacked, will break off large branches from the tree, and drop them down at any one who happens to be underneath. This I have myself seen, and so active was the animal in her work, that it was dangerous to remain under the tree as branches as thick as one's wrist came crashing down at frequent intervals.

The most remarkable instance of sagacity, or, as it seemed to me, reason, that I ever saw exhibited by an orang, was by an old female carrying a young one of two or three months. The young is always carried astride the hip, the little one holding on to the long hair of its mother with both hands and feet. On the occasion referred to, we met an old female with young, and as we were desirous of securing the young one alive I aimed to inflict a fatal wound without injuring the little one. On being struck the mother loosed the hold of her feet and hung at full length by the arms. Seeing that she would fall in a few moments, I refrained from firing a second shot in spite of repeated requests from my guide Pasang, who seemed much concerned because I did not shoot again. Presently one arm dropped and I held myself in readiness to rush forward and secure the young one before it could drown. But just at that moment the mother, realizing that she herself must fall, reached up grasped the young one, tore it forcibly from her, and, after placing it carefully on the branch above, fell. It may have been instinct, but certainly nothing better could have been done under similar circumstances, by a human being.

A young one of six months, purchased of the Dyaks, though at first very savage, soon became a great pet with me. It was never so happy as when close by me, and if I would permit it, would sleep contentedly with its arms about me. The only time it ever attempted to bite was when it was being taken away to its box. Many a frolic we had and many a pleasant half hour I spent, while watching its quaint ways. On one occasion while riding in an uncovered boat, it began to rain. The little orang, which had been sitting by my side, seemingly lost in deep thought, quietly reached over and attempted to take from me the paper I was reading. This I resisted for a while, but as it persisted I let it have it to see what new whim it had in mind. The paper was carefully pulled over its head and arranged as a shelter, next followed my broad-brimmed sun hat which was lying near, and there sat the little fellow, quite happy in having a good protection against the rain. Many such acts of intelligence led me to become quite attached to my little pet, and it was a sad day indeed when he sickened and died.

Just a few words in regard to the size attained by the orang-outang. Mr. Hornaday in his book discusses the question at length, citing Mr. Alfred R. Wallace in his work on the "Malay Archipelago." Mr. Wallace places the maximum size of specimens seen by him, or by reliable authorities, at 4 ft. 2 in. Mr. Hornaday records no less than seven specimens collected by himself, that exceeded this height, the largest being 4 ft. 6 in. While at Saudakan for a few days, I was told by Mr. W. B. Pryer, a well-known resident of British North Borneo, of an orang that had been killed and measured, whose height was 4 ft. 10 in. As this information was perfectly reliable, I was prepared somewhat against surprise when I succeeded in getting three specimens over 4 ft. 6 in. in height. One of these was 4 ft. 6½ in., another 4 ft. 8½ in., and the third 4 ft. 10¾ in.

As I had Mr. Hornaday's book with me, and therefore his figures, I was particular to make all measurements in conformity with the rules he gives, repeating two or three times the principal measurements to avoid error. The measurements of the largest orang I secured in Borneo, as taken at the time, are:

Length, head to heel....................	4 ft.	10¾	in.
Spread to arms..........................	8 "	3½	"
Length of arm...........................	3 "	7	"
" " hand................................	1 "	½	"
" " foot................................	1 "	2½	"
Breadth of face.........................	1 "	1	"

Circumference of neck	2 "	3¼	in.
" " chest	3 "	3¼	"
" " abdomen	3 "	1	"
" " arm	1 "	½	"
" " forearm	1 "	3	"
" " thigh	1 "	9½	"
" " leg (calf)	1 "	0	"

In regard to weight, Mr. Hornaday estimates the weight of the largest animal at 185 pounds. The actual weights of the largest two secured by me were 147 and 151 pounds, the tallest animal lacking four pounds of the weight of the next tallest. If Mr. Hornaday was correct in his estimate of the weight of his orangs, they were certainly in prime aldermanic condition.

PROCEEDINGS

OF THE

MINNESOTA ACADEMY OF SCIENCES

VOLUME IV. BULLETIN II.

221st Meeting, January 8, 1895.

ANNUAL MEETING.

Nine persons present, Vice President Sudduth presiding.

Secretary C. W. Hall reported $169 collected during the year, of which $129 was in dues of members.

The corresponding secretary reported accessions to the library for 1894, as follows:

United States publications	521
Foreign publications	523
Total	1,054

Of this total 501 were bound volumes.

Report of the Corresponding Secretary of publications received during the year 1894:

Agram, Hungary.—Jugoslavenska Akademija. Ljetopis, Vol. 7; 8; Rad, 16, 17.

Agricultural College, Mich.—Michigan Agricultural College and Exper. Station.

Bulletins, Nos. 96-112.

Albany, N. Y.—State Library. Annual Reports, 74 and 75.

State Museum: Annual Report, 45 and 46. Report of the Entomologist, 4-9, p. 184. Bulletin, Vol. III, No. 11.

University of New York: Extension Bulletin, Nos. 5, 7, 8; Regents' Report No. 106.

Altenburg, Germany.—Naturforschende Gesellschaft des Osterlandes. Mittheilungen, Vol. VI.

Amiens, France.—Société Linnéenne du Nord: Bulletin, Vol. XI, Nos. 247-258.

Baltimore, Md.—Johns Hopkins University: University Circular, Nos. 106-114.

Bamberg, Germany.—Naturforschende Gesellschaft: Bericht, Vol. XVI.

Basel, Switzerland.—Naturforschende Gesellschaft. Verhandlungen, 1892.

Berlin, Germany.—R. Friedländer & Sohn: Naturae novitates, 1893, Nos. 21-24. 1894, Nos. 1-18.

Bern, Switzerland.—Entomologische Gesellschaft: Mittheilungen, Vol. IX, Nos. 1, 3.

Béziers, France.—Société d' Etude les Sciences Naturelles: Bulletin, Vol. XV.

Bologna, Italy.—Accademia delle Scienze dell' Instituto di Bologna. Memorie, Ser. V, Vol. II.

Bombay, India.—Royal Asiatic Society: Journal, Vol. XVIII, Nos. 49 and 50.

Bône, Africa.—Academia d' Hippone: Comptes Rendus, 1893.

Bonn, Germany.—Naturhistorischer Verein: Verhandlungen, Vol. L.

Boston, Mass.—American Academy of Arts and Sciences: Proceedings, Vols. XXVIII, XXIX.

Boston, Mass.—Boston Society of Natural History: Proceedings, Vol. XXVI.

Boston, Mass.—Horticultural Society: Transactions, 1893.

Bremen, Germany.—Naturwissenschaftlicher Verein: Abhandlungen, Vol. XIII, Part 1.

Brisbane, Queensland.—Geological Survey of Queensland: Report of Annual Progress, 1891, 1892, 1893.

Brisbane, Queensland.—Royal Society of Queensland: Proceedings, Vol. X. Index to Vols. VII to IX.

Brünn, Austria.—Naturforschender Verein: Bericht, Vols. X and XI. Verhandlungen, Vols. XXX and XXXI.

Bruxelles, Belgium.—Société Belge de Microscopie: Annales, Vol. XVII, Part 2; Vol. XVIII, Part 1; Bulletin, Vol. XIX, No. 10; Vol. XX, Nos. 1-9.

Bruxelles, Belgium.—Société Entomologique de Belgique: Annales, Vo.l XXXVIII, Parts 7, 8, 9, 10, 11.

Bruxelles, Belgium.—Société Royale de Botanique de Belgique: Bulletin, Vols. XXX and XXXI.

Buenos Aires, Argentine.—Instituto Geographico, Argentino: Bulletin, Vol. XIV, Nos. 5-8; Vol. XV, Nos. 1-8.

Buenos Aires, Argentine.—Sociedad Cientifica Argentina: Annales, Vols. XXXV and XXXVI.

Cairo, Egypt.—Institut Egyptien: Bulletin, Vol. IV, Nos. 6-10. Index.

Calcutta, India.—Geological Survey of India: Records, Vol. XXVII, Nos. 1, 2, 3; Memoirs, Vol. II, No. 1.

Cambridge, Mass.—Museum of Comparative Zoology: Annual Report 1892-'93; Bulletin, Vol. XVI, Nos. 13, 14, 15; Vol. XXIV, Nos. 4-7; Vol. XXV, Nos. 1-12.

Cardiff, England.—Naturalist's Society: Report and Trans., Vols. XXIV and XXV.

Catania, Italy.—Accademia Gioenia di Scienze Naturali: Bulletin, Vols. XXXII-XXXV.

Chapel Hill, N. C.—Elisha Mitchell Scientific Society: Journal, Vol. X.

Chicago, Ill.—Field Columbian Museum: Guide to Museum.

Chicago, Ill.—Journal of Geology: Vols. I and II.

Chur, Switzerland.—Naturforschende Gesellschaft Graubündes: Jahresbericht, Vol. XXXVI.

Cincinnati, Ohio.—Society of Natural History: Journal, Vol I, Nos. 1 and 2; Vol. III, Nos. 3 and 4; Vol. IV, Nos. 1-4; Vol. XVI, No. 4; Vol. XVII, Nos. 1, 2, 3.

College Hill, Mass.—Tufts College: College Studies, Nos. 1 and 2.

Denver, Col.—Colorado Scientific Society: Gold Bearing Quartz; Solution of Equation; Standard Value; Cripple Creek Ores; Artesian Waters; Camp Floyd District; A Suspected New Mineral.

Des Moines, Iowa.—Geological Survey of Iowa: Annual Report, Vols. I and II.

Des Moines, Iowa.—Iowa Academy of Science: Proceedings, Vol. I, Part 4.

Emden, Germany.—Naturforschende Gesellschaft: Jahresbericht, Vol. LXXVII.

Firenze, Italy.—Biblioteca Nazionale Centrale: Bulletin, Nos. 188-213.

Frankfurt, a d Oder, Germany.—Naturwissenschaftlicher Verein: Helios, Vol. XI, Nos. 6-12; Vol, XII, Nos. 1-6. Societatum Litteræe, Vol. VII, Nos. 4-12; Vol. VIII, Nos. 1-9.

Geneve, Switzerland.—Société de Géographie: Le Globe, Vol. XXXIII.

Georgetown, South Africa.—Royal Agricult. and Commercial Society: Journal, Vol. VIII.

Glasgow, Scotland.—Natural History Society of Glasgow: Proc. and Trans., Vol. III, Part 3.
Görlitz, Germany.—Naturforschende Gesellschaft: Abhandlungen, Vol. xx.
Graz, Austria.—Naturwissenschaftlicher Verein: Mittheilungen, 1893.
Greifswald, Germany.—Naturwissenschaftlicher Verein: Mittheilungen, 1893.
Gueret, France.—Société des Sciences Naturelles: Memoires, Ser. 2, Vol. III.
Guströw, Germany.—Verein die Freunde der Naturgeschichte: Archiv, Vol. XLVI and XLVII.
Habana, Cuba.—Academia di Ciencias. Anales, Vol. xxx.
Halifax, Nova Scotia.—Nova Scotia Institute of Science: Proc. and Trans., Vol. I, Part 3.
Halle a d Saale, Germany.—Kais. Leopold. Carol. Akademie: Leopoldiana, Parts 27, 28 and 29. Nova Acta, Vol. LVI, No. 3.
Hamburg, Germany.—Naturwissenschaftlihcer Verein: Verhandlungen, 1893.
Hamilton, Canada.—Hamilton Association: Journal and Proceedings, No. 10.
Hannover, Germany.—Naturhistorische Gesellschaft: Jahresbericht, Vols. XLII and XLIII.
Harlem, Netherlands.—Musée Teyler: Archives, Vol. IV, Parts 1 and 2.
Indianapolis, Ind.—Indiana Academy of Sciences: Proceedings, 1892 and 1893.
Innsbruck, Austria.—Naturwissenschaftlich-Medizinischer Verein: Berichte, Vol. XXI.
Iowa City, Iowa.—Iowa Historical Society: Record, Vol. x. Documentary Material, Parts 1 and 2.
Jefferson City, Missouri.—Geological Survey of Missouri: Reports, Vols. 4, 5, 6, 7.
Kassel, Germany.—Verein für Naturkunde: Abhandlungen und Berichte, Vol. XXXIX.
Kharkow, Russia.—Société Naturalistes à l' Université Imp. de Kharkow: Travaux, Vol. XXVII.
Kief, Russia.—Kief Society of Naturalists: Memoires, Vol. 12.
Kiel, Germany.—Naturwissenschaftlicher Verein für Schleswig-Holstein: Schriften, Vol. x, No. 1.
Kjöbenhaven, Denmark.—Naturhistoriske Förening: Meddelelser. 1894.
Krakowie, Austria.—Akademie der Wissenschaften: Rosprawy, Vol. II.
Landshut, Germany.—Botanischer Verein: Berichte, Vol. XIII.
Lansing, Mich.—State Agricultural College: Bulletin Experiment Station, Nos. 96-112.
Lausanne, Switzerland.—Société Vandoise des Sciences Naturelles: Bulletin, Vol. XXIX.
Lawrence, Kans.—Kansas State University: University Quarterly, Vol. II, Parts 1 and 4; Vol. III, Parts 1 and 2.

Le Havre, France.—Société de Geologique de Normandie: Bulletin, Vol. XIV.

Liége, Belgium.—Société Geologique de Belgique: Annales, Vols. XVIII, XVIX, XX.

Lyon, France.—Société Linnéenne de Lyon: Annales, 1891, 1892, 1893.

Madison, Wis.—Wisconsin Academy of Sciences, Arts and Letters: Transactions, Vol. IX.

Manchester, England.—Manchester Literary and Philosophical Society: Memoirs and Proceedings, Vol. VII, Nos. 2, 3. Vol. VIII, Nos. 1 and 2.

Melbourne, Australia.—Public Library, Museum and National Gallery· Report of Trustees, 1892.

Melbourne, Australia.—Royal Geographical Society of Australasia: Transactions, Vol. XI.

Milano, Italy.—Società Italiana di Scienze Naturali: Atti, Vol. XXXIV, Nos. 3, 4.

Milwaukee, Wis.—Public Museum of Milwaukee: Annual Report, Vol. XI.

Minneapolis, Minn.—Geological and Natural History Survey of Minnesota: Annual Report, Vols. XX, XXI. Bulletin, Nos. 8 and 10.

Montevideo, Uruguay.—Museo Nacional: Annales, 1894.

Montgomery, Ala.—Geological Survey of Alabama: Blount Mt., 1893.

Montreal, Canada.—Canadian Record of Science: Record, Vol. v, Nos. 6 and 7.

Moskva, Russia.—Imp. Moscow Society of Naturalists: Bulletin, 1892, Nos. 3, 4. 1893 and 1894, No. 1.

Münster, Germany.—Provincial-Verein für Wissenschaft und Kunst: Jahresbericht, Vol. XXI.

Nashville, Tenn.—State Board of Health: Bulletin, Vol. IX, Nos. 3-11. Vol. X, Nos. 1-5.

Neuchatel, Switzerland.—Société des Sciences Naturelles: Bulletin, Vols. XVIII, XIX, XX.

New York, N. Y.—American Geographical Society: Bulletin, Vol. XXV, Part 4. Vol. XXVI, Parts 1-3.

New York, N. Y.—American Museum of Natural History: Annual Report, 1893. Bulletin, Vol. V.

New York, N. Y.—Linnean Society: Abstracts of Proceedings, Nos. 5 and 6.

New York, N. Y.—New York Microscopical Society: Journal, Vol. IX, No. 4. Vol. X, Nos. 1, 2, 3.

New York, N. Y.—Torry Botanical Club: Bulletin, Vol. XX, Nos. 7-12. Vol. XXI.

Nürnberg, Germany.—Naturhistorische Gesellschaft: Abhandlungen, Vol. X, No. 2.

Ottawa, Canada.—Geological and Natural History Survey of Canada: Annual Reports, Vols. V, VI. Maps.

Padova, Italy.—Società Veneto-Trentina di Scienze Naturali; Atti, Vol. 1, No. 2. Bulletin, Vol. v, Nos. 3, 4.

Penzance, England.—Natural History and Antiquarian Society: Report and Transactions, 1893-94.

Penzance, England.—Royal Geological Society of Cornwall: Transactions, Vol. xi, Part 8.

Philadelphia, Pa.—Academy of Natural Sciences: Proceedings, 1894.

Philadelphia, Pa.—Wagner Free Institute of Science: Transactions, Vol. iii, Part 3.

Port Louis. Mauritius.—Royal Alfred Observatory: Annual Report, 1892. Meteorological Observations, 1892.

Prag, Bohemia.—K. Böhmische Gesellschaft der Wissenschaften: Jahresbericht, 1892, 1893. Sitzungsberichte, 1892, 1893.

Providence, R. I.—Rhode Island Historical Society: Publication, Vol. i, No. 4.

Regensburg, Germany.—Naturwissenschaftlicher Verein: Berichte, Vol. iv.

Reichenberg, Bohemia.—Verein der Naturfreunde: Mittheilungen, Vols. xxiv, xxv.

Riga, Russia.—Naturforscherverein: Korrespondenzblatt, Vol. xxxvi.

Rio De Janeiro, Brazil.—Instituto Historico, Geographico y Ethnographico: Revista Trimensual, Vol. lv, Part 2.

Rio De Janeiro, Brazil.—Museu Nacional: Archivos, Vol. viii.

Rovereto, Austria.—Accademia degli Agiati in Revereto: Atti, 1892, 1893.

Sacramento, Cal.—California State Mining Bureau: Report, Vol. xi. Bulletin, No. 4.

St. Gall, Switzerland.—Naturwissenschaftliche Gesellschaft: Bericht, 1891-1892.

St. John's New Brunswick.—Natural History Society: Bulletin, No. 11.

Saint-lô, France.—Société d' Agriculture et d' Histoire Naturelle de la Manche: Memoires et Docum. Vol. xi.

St. Louis, Mo.—Missouri Botanical Garden: Annual Report, 1894.

St. Louis, Mo.—St. Louis Academy of Science: Transactions, Vol. vi, Nos. 8-18.

Sankt Peterburg, Russia.—Imp. Academy of Sciences: Memors, Vol. xxxix, No. 1; Vol. xl, No. 1.

Sankt Peterburg, Russia.—Geological Committe: Bulletin, Vol. xi, Nos. 5-10; Vol. xii, Nos. 1-7; Memoirs, Vol. 4:3, 9:2; 10:2; 11:2; 12:2.

San Francisco, Cal.—California Academy of Sciences: Proceedings, Vol. iv, Part 1, 2.

Santiago, Chile.—Société Scientifique du Chile: Actes, Vol. iii, Nos. 1-5.

Semur-en-Auxois, France.—Société des Sciences Historiques et Naturelles: Bulletin, No. 7.

Sydney, New South Wales.—Australian Museum: Report of Trustees, 1892.

Sydney, New South Wales.—Geological Survey: Annual Report, 1893; Memoirs, No. 5; Records, Vol. IV, Part 1, 2; Index to Vol. III.

Sydney, New South Wales.—Royal Society of New South Wales: Journal, Vol. XXVII.

Stavanger, Norway.—Stavanger Museum: Aarsberetning, 1892.

Stockholm, Sweden.—Geologiska Byron: Afhandlingar, C. Nos. 116-134. Maps.

Stockholm, Sweden.—Kongl. Svenska Vetenskaps-Akadamien: Bihang, Vol. XVIII; Ofversigt, 1889-1892.

Strassburg, Germany.—Geologischen Landes-Untersuchung von Elsase-Lothringen, Mitteiluhgen, Vol. IV, Nos. 2, 3.

Thorn, Germany.—Copernicus Verein fur Wissenschaft: Mitteilungen, Vols. VIII, IX.

Tokio, Japan.—Deutsche Gesellschaft für Natur und Völkerkunde: Mitteillungen, Vol. VI, Nos. 52, 53, 54.

Topeka, Kans.—Kansas Academy of Sciences: Transactions, Vol. XIII.

Torino, Italy.—Museo Zoologico: Bulletin, Vol. VII, Nos. 133-150. Vol. IX. Nos. 166-192.

Toronto, Canada.—Canadian Institut: Annual Report, 1892; 1893. Transactions, Vol. III, Nos. 1, 2; Vol. IV, No. 1.

Toulouse, France.—Academie des Sciences: Memoires, Vol. V.

Toulouse, France.—Revue de Botanique. Revue, Vols. 6-11.

Urbana, Ill.—Illinois State Laboratory of Natural History: Ornithology, Vol. I.

Washington, D. C.—Bureau of American Ethnology: Annual Reports, Vols. VIII, IX, X; The Maya Year; Wabashan Language; Salishan Languages; Chinookan Language.

Washington, D. C.—U. S. Geological Survey: Annual Reports, 1889, 1890, 1891; Monographs, Vols. XVII-XXII. Mineral Resources, 1891, 1892, 1893. Bulletins, Nos. 83-86, 90-117. Survey of the Terr., Vol. XII. Atlas of Eureka District.

Washington, D. C.—United States National Museum: Bulletin, Nos. 43-46; Proceedings, Vols. XV, XVI.

Washington, D. C.—Department of the Interior—Patent Office: Official Gazette, Vols. LXV, LXVIII, LXIX, Nos. 1-11.

Washington, D. C.—Smithsonian Institution: Annual Report, 1891.

Wiesbaden, Germany.—Naturhistorischer Verein für Naturkunde: Jahresbucher, Vol XLVII.

Winnipeg, Manitoba.—Historical and Scientific Society: Annual Report, 1892, 1893; Transactions, Nos. 44-47.

Zurich, Switzerland.—Naturforschende Gesellschaft: Vierteljahrschrift, Vol. XXXVIII, Nos. 3, 4; Vol. XXXIX, Nos. 1, 2.

Zwickau, Germany.—Verein für Naturkunde: Jahresbericht, 1892, 1893.

National.—American Association for the Advancement of Science: Proceedings, Vol. XLII, 1893.

International.—Australian Association for the Advancement of Science: Report, Vols. III, IV, V.

The Secretary was directed to cast the ballot of the Academy for the following officers:

President, - - - - - - - -	H. L. Osborn.
Vice President, - - - - -	W. X. Sudduth.
Recording Secretary, - - -	C. W. Hall.
Treasurer, - - - - - - -	E. C. Gale.
Corresponding Secretary, - -	C. P. Berkey.
Trustees for three years, -	H. V. Winchell. Verdine Trusdell.

A paper on The Classification of the Sexual Affinities of Prunus americana, by C. W. H. Heideman of New Ulm, was presented.

[ABSTRACT]

The uncertainty of regular annual fruiting of plums in the Northwest, where only the native *Prunus americana* in its many varieties has been found sufficiently hardy to endure the climatic conditions, has long been a difficult problem in Horticulture. The author undertook to determine the causes underlying this recurring non-productiveness in certain trees.

An examination of plum flowers showed that the following types occurred:

Hermaphrodite—Stamens and pistil present and maturing at same time.

Proterogynous—Receptive period of stigma expiring before pollen matures.

Proterandrous—Pollen discharged before stigma becomes receptive.

Long-styled—Style nearly twice as long as stamens.

Short-styled—Stamens nearly twice as long as styles.

Gyndoioecious—Anthers aborted.

Andromonoecious—Pistils aborted.

Hermaphrodite flowers are the only ones capable of self pollination, all the other types requiring cross-pollination. Trees with hermaphrodite flowers are now rarely found in the wild state.

By his experiments the author found that certain crosses produced large, fine fruit while other crosses resulted in the production of inferior fruit, or even no fruit at all. Of all the crosses possible between plants bearing these different types of flowers he found that only the eight following combinations would yield a desirable fruit:

Hermaphrodite X Hermaphrodite.
Hermaphrodite X Proterandrous.
Hermaphrodite X Proterogynous.

Proterandrous X Proterogynous.
Short-styled X Long-styled.
Short-styled X Gynodioecious.
Long-styled X Gynodioecious.
Andromonoecious X Gynodioecious.

222d Meeting, February 5, 1895.

Fifteen persons present, Vice President Sudduth presiding.

A paper on Special Forms of Ossification, by Dean W. X. Sudduth, was read, illustrated from specially prepared lantern slides.

223d Meeting, March 6. 1895.

The Minnesota Academy having accepted an invitation from the St. Paul Academy of Science to unite with them in a joint meeting of the two Academies for the month of March, it convened with the St. Paul Academy in the rooms of the St. Paul Commercial Club, Germania Bank Building, St. Paul, by invitation of that body. About 35 persons present. Rev. C. E. Mitchell, President of the St. Paul Academy of Science, presided.

The following program was presented:

The Physical Features of the Lake of the Woods, by Professor MacMillan, State Botanist of Minnesota.

Psychic Effects of the Weather, by Edw. A. Beals, Observer U. S. Weather Bureau.

Geology and Flora of the Mountain Region of Northeastern Montana, by R. G. McGinnis, Secretary of the St. Paul Commercial Club.

At the close of the meeting Secretary Hall, on behalf of the Minnesota Academy of Natural Sciences, invited the St. Paul Academy of Science to join them in a meeting to be held in the public library, Minneapolis, on April 2nd. The invitation was very cordially accepted.

224th Meeting, April 2, 1895.

Twenty-one persons present; President Osborn presiding.

The St. Paul Academy of Science, as the guest of the Academy, was represented by several members. The museum was opened and lighted for the inspection of members of the Academy and visiting friends.

The following program was presented:

Some Queer Forms of Shell Fish, by President Osborn.

The Relation of Fatigue to Social, Moral and Educational Progress, by H. S. Baker:

[ABSTRACT.]

All movements of mind or muscle result in the destruction of some kind or kinds of tissue, and the products of metabolism are thrown into the blood. The prompt removal of this debris of brain or muscle, is necessary for the health and happiness of the individual and for the best work of mind and body, because it is decidedly toxic to all organs. The brain is the motive power, and all fatigue is brain fatigue. The cells of some center are exhausted by every muscular movement. The liberal use of proteids helps the system to rally after fatigue.

Since all fatigue is brain fatigue, we should remember that we cannot do both mental and muscular work well at the same time. The student should do as little physical work as possible, before he begins his daily tasks. Continued hard work of mind and body in the same day, brings in its train disease of the brain, heart, stomach. We do not feed a horse when he is very tired because the stomach will not digest the food.

Physiological Psychology of the Emotions: The emotions produce fatigue rapidly. Emotions which are evil and violent, as anger and covetousness, consume the brain cells most rapidly and throw into the blood compounds containing nitrogen, which are very poisonous. Each emotion throws into the blood a different substance, or ash, as it may be called. Those which are holy, as worship and the social feelings, throw into the circulation substances which are good tonics to the entire system. The child who is praised for good conduct, by that act, has his intellect improved. Both the scold and the scolded become more stupid by their feelings. Each emotion produces a different odor in the perspiration, which enables a dog to follow his master in a crowd. To be disagreeable to a person is to give him blood-poison. Use of the intellect is reasonably tonic.

The higher feelings, such as the religious and social, first feel the effect of fatigue. A tired man may lose interest in his Bible and be cross to his family, but still be able to think connectedly. A man may drive a sharp bargain long after he can appreciate a painting or do an unselfish act. The man, benevolent on Monday morning, may be miserly Saturday afternoon. Self control also disappears with the advent of fatigue and the tired woman cries for nothing, the brakes are off so to speak, and the feelings run riot.

Both teachers and children should sit whenever possible. The teacher who stands all day before her school, is cross and stupid in the afternoon.

The brain cells are repaired during sleep. But it is important to note that in any one night there cannot be complete recuperation. Thirty-six hours are required for the cells to become normal after fatigue. That is, the physiological no less than the religious Sabbath extends from Saturday evening to Monday morning. Sabbath breakers are less moral, less intellectual than they would be if they observed the Sabbath. They shorten their lives by Sabbath desecration: while they live they crowd the offices of specialists in nervous diseases.

The following persons were elected to membership, subject to the rules of the Academy:—Rev. John Grueiner, St. Paul; Harlow Gale, and Geo. C. Christian, Minneapolis.

The secretary read an invitation from Josephine D. Peary, inviting the Minnesota Academy of Natural Sciences to send a naturalist on the Greenland Scientific Expedition of 1895, which expedition is being fitted out for the purpose of bringing home Mr. Peary and his assistants from northwestern Greenland where they are at present engaged in scientific observations, particularly in Meteorology. The secretary was directed to express the interest of the Academy in the enterprise and its regrets that circumstances would not permit participating in the expedition.

The secretary announced the mounting of the group of Orangs by the Ward Natural History Establishment in Rochester, N. Y., and that this group would soon be shipped to Minneapolis.

225th Meeting, May 7, 1895.

Fifteen persons present; President Osborn in the chair.

The St. Paul Academy of Science was again the guest of the Academy, pursuant to invitations extended.

The following program was presented:

An Observation of Ants, by O. W. Oestlund.

Remarks on Some Birds New to Minnesota, by Dr. T. S. Roberts.

An Amine compound of gold, by H. B. Hovland.

The Chemical characters of the Minnesota sandstones, by Chas P. Berkey.

A review of known facts of the Chemistry of local Sandstones.

226th Meeting, October 15, 1895.

Nine persons present; C. P. Berkey presiding pro tem.

L. E. Griffin was elected to membership.

Program:

A Review of the Springfield meeting of the American Association for the Advancement of Science, by Herbert W Smith.

The Suppression of Crime, by Dr. Albert Schneider (read by Secretary Hall).

Some Geological Features of the vicinity of Franconia, Minn., by Chas. P. Berkey.

[ABSTRACT.]

Attention was called to the physiographic features at Franconia, Minn. A gorge is cut in the sedimentary series to the depth of 150 to 200 feet below the adjacent upland plain and extends westward from the St. Croix river gorge proper about half a mile. It is the lower portion of a small creek which sinks into the sand some distance above the gorge and issues as springs within the gorge itelf. The gorge is considered entirely post-glacial and due to the work of the present stream supplemented by the powerful springs issuing at the lower horizons. The rock formation being composed of fine sand of the St. Croix series is readily disintegrated and easily transported by such agencies.

227th Meeting, January 7, 1896.

Afternoon session at 2 P. M., in the lecture room of Professor of Public Health, University of Minnesota, Engineering Building. Thirty persons present. Dr. Chas. N. Hewitt, Chairman of the Section of Sanitary Science, presided and gave an address on the qualities of good water supply for public use. The address was a resumé of the present methods of examining, in a sanitary way, a water supply. It was illustrated by a large number of cultures, by slides showing the more common mechanical impurities under the microscope, and a large number of slides to show the more common bacilli of diseases connected in a more or less direct way with drinking waters.

C. W. Hall enumerated the chief artesian basins of the northwestern states, particularly of the Dakotas, Minnesota, and Wisconsin. The conditions of successful supply were discussed, and the more pronounced chemical characters named particularly as they appear in the shallower wells receiving their water supply from the glacial drift.

The evening session was held in the directors' room of the Public Library.

Thirty-five persons present; Dr. C. N. Hewitt in the chair.

Public water supplies were described:

St. Paul, by City Engineer Rundlett.

Minneapolis, by City Engineer Cappelan.

Winona, by City Engineer Housten.

St. Cloud, by City Engineer White.

Stillwater, by Hon. E. W. Durant.

228th Meeting, January 15, 1896.

Adjourned annual meeting, Pillsbury Hall, University of Minnesota.

Five persons present; Dr. U. S. Grant president pro tem.

Reports of the secretaries were read, and ordered filed.

The following officers were elected:

President, - - - - - - -	Dr. Thomas S. Roberts.
Vice President, - - - - -	Dr. U. S. Grant.
Recording Secretary, - - -	Alonzo D. Meeds.
Corresponding Secretary, - -	Chas. P. Berkey.
Treasurer, - - - - - - -	Edward C. Gale.
Trustees for three years, -	C. W. Hall. Herbert W. Smith.

Report of the Corresponding Secretary for the year 1895:

[ABSTRACT.]

Agram, Hungary.—Jugoslavenska Akademija: Ljetopis, Vol. IX. Rad, Nos. 18, 19.

Agricultural College, Mich.—Michigan Agricultural College and Exper. Station. Bulletin, Nos. 113-128.

Albany, N. Y.—State Library: Annual Report, 1893. Bulletin, No. 5.

State Museum: Annual Report, 1893; Bulletin, Vol. III, Nos. 12 and 13.

University of New York: Regents' Report, 1894.

Angers, France.—Académie des Sciences et Belles Lettres: Memoirs, Vol. I.

Amiens, France.—Société Linnéenne du Nord de la France: Bulletin, Vol. XII, Nos. 259-270.

Austin, Texas.—Texas Academy of Science: Transactions, Vol. I, No. 3.

Baltimore, Md.—Johns Hopkins University: Circular, Nos. 115-122.

Belfast, Ireland.—Natural History and Philosophical Society: Report and Proceedings, 1893-1894.

Berlin, Germany.—R. Friedländer & Sohn: Naturæ Novitates, 1894: 19-24, 1895: 1-18.

Bern, Switzerland.—Entomologische Gesellschaft, Mittheilungen, Vol. IX, Nos. 5-9.

Bèziers, France.—Société d' Etude les Sciences Naturelles: Bulletin, Vol. XVI.

Bologna, Italy.—Accademia delle Scienze dell' Instituto di Bologna: Memorie, Vol. III.

Bombay, India.—Royal Asiatic Society: Journal, Vol. XIX, No. 51

Bône, Africa.—Académie D' Hippone: Comptes Rendus, 1894: Bulletin, No. 26.

Boston, Mass.—Massachusetts Horticultural Society: Transactions, 1894.

Bremen, Germany.—Naturwissenschaftlicher Verein: Abhandlungen, Vol. XIII, Part 2. Beitrage, Vol. XV, No. 1.

Brisbane, Queensland.—Geological Survey of Queensland: Annual Report, 1894; Bulletin, Nos. 1, 2.

Brünn, Austria.—Naturforschender Verein: Bericht, Vol. XII. Verhandlungen, Vol. XXXII.

Bruxelles, Belgium.—Société de Microscopie: Annales, Vols. 18:2; 19:1. Bulletin, Vol. XXI: 1-6.

Bruxelles, Belgium.—Société Entomologique de Belgique: Annales, Vol. XXXVIII: 12, 13.

Bruxelles, Belgium.—Société Malacologique de Belgique: Proces Verbal de Sciences, Vols. XXII, XXIII, XXIV.

Buenos Aires, Argentine.—Instituto Geographico Argentino: Bulletin, Vols. XV: 9-12; XVI: 1-4.

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College Hill, Mass.—Tufts College: College Studies, No. 4.
Colorado Springs, Col.—Colorado College: College Studies, Vol V.
Denver, Col.—Colorado Scientific Society: The Costilla Meteorite; Geology of Saugen de Cristo Range; History and Studies of Chemistry; The Dyke in Ward District; The Volcanic Rock of Alum Hill; The Occurrence of Tellurium; Vein Structure in Enterprise Mine; Precipitation by Means of Zinc; Bismuth in Refined Lead; Sampling and Measuring of Ore Bodies; Proceedings.
Des Moines, Iowa.—Geological Survey of Iowa: Vol. III.
Des Moines, Iowa.—Iowa Academy of Sciences: Vol. II.
Ekaterinburg, Russia.—Société Ouralienne des amis des Sciences Naturelles: Bulletin, Vol. XIII, No. 2.
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Harlem, Netherlands.—Musée Teyler: Archives, Vol. IV: 3,4.
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Lincoln, Neb.—University of Nebraska: Studies, Vol. II: 1.
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Lüneberg, Germany.—Naturwissenschaftlicher Verein: Jahresbericht, Vol. XIII.
Madison, Wis.—Academy of Sciences, Arts and Letters: Transactions, Vol. X.
Manchester, England.—Manchester Literary and Philosophical Society: Memoirs and Proceedings, Vols. VIII: 3; IX: 1, 2.
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Milwaukee, Wis.—Public Museum of Milwaukee: Annual Report, Vol. XII.
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Montevideo, Uruguay.—Museo Nacional: Annales, Vol. II: 2, 3.
Montgomery, Ala.—Geological Survey of Alabama: The Coosa Coal Field; Maps.
Montreal, Canada.—Canadian Record of Science. Vol. VI: 1, 2; VII: 1-4.
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New York, N. Y.—Microscopical Society: Journal, Vols. X: IV; XI: 1, 2, 4.
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Portland, Maine.—Portland Society of Natural History: Proceedings, Vol. II: 3.

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St. Gall, Switzerland.—Naturwissenschaftlicher Gesellschaft: Berichte, 1892, 1893.

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St. Paul, Minn.—Minnesota Historical Society: Historical Collections, Vol. VI: 3; Biennial Report, 1895.

Sankt Peterburg, Russia.—Imp. Academy of Sciences: Bulletin, Vol. 1, 2; Memoirs, Vols. XXXIX, 2; XLI, 5, 8, 9; XLII, 2, 3, 5, 11, 12; N. S. Vol. I. 1, 4.

Sankt Peterburg, Russia.—Geological Committee: Bulletin, Vols. XII: 8, 9; XIII: 1-3; Memoires, Vols. VIII: 2, 3; IX: 3.

Semur-en-Auxois, France.—Société des Sciences Historiques et Naturelles: Bulletin, No. 8.

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Sydney, New South Wales.—Royal Society of New South Wales: Journal and Proceedings, Vol. XXVIII.

Stavanger, Norway.—Stavanger Museum: Aarsberetning, 1893.

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Stockholm, Sweden.—Kongl. Svenska Vetenskaps-Akadamein: Bihang, Vol. XIX. Ofversigt, 1893, 1894.

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Toulouse, France.—Académie des Sciences, Inscriptions et Belles-Lettres: Memoires, Vol. VI.

Washington, D. C.—United States Geological Survey: Annual Report, Vol. XIV; Bulletin, Vols. CXVIII-CXXII; Monographs, Vols. XII, XXIV.

Washington, D. C.—Patent Office: Official Gazette, Vols. LXIX: 12, 13; LXX; LXXI; LXXII; LXXIII: 1-12.

Washington, D. C.—Weather Bureau: Monthly Weather Review, 1892, 1893, 1894; Report, 1891, 1892, 1893; Bulletin, B. and C.

Zurich, Switzerland.—Naturforschende Gesellschaft: Vierteljahrschrift, Vols. XXXIX: 3, 4; XL: 1, 2.

Zurich, Switzerland.—Physikalischen Gesellschaft: Jahresbericht, 1893-1894.

National, United States.—American Association for the Advancement of Sciences, Vol. XLIII.

229th Meeting, March 3, 1896.

Four members present.

Program:

Paper on An Exploring Expedition in the Rockies of Northwestern Montana, by Professor L. W. Chaney of Carlton College, Northfield.

Short talk on Geological Excursions and Field Work in a German University, by F. W. Sardeson.

Some notes on analyses of clays were given by C. P. Berkey.

230th Meeting, December 8, 1896.

Fifteen persons present; President Dr. Thos. S. Roberts presiding.

The secretary was directed to send a vote of thanks to Dr. Dunsmoor for the present of the vertebra of a whale.

Professor Hall spoke of the death of Verdine Truesdell, a member of the Board of Trustees; a committee was appointed to draw up resolutions.

Prof. Winchell brought up the matter of establishing a state academy of natural sciences to receive some support from the state, and suggested the advisability of making the Minnesota Academy the state academy.

Mr. H. C. Hanke suggested that action should be taken by the Academy recommending to the Legislature some change in the game laws in order more fully to protect the game of the state. Mr. Hanke and the President were appointed a committee to investigate and report to the Academy.

Program:

Some Features in the Geology of Northeastern Minnesota, by Prof. N. H. Winchell.

[ABSTRACT.]

The features noted in detail related to; (1) *The nature of the transition from the crystalline schists to the Laurentian.* After the description of the field facts to be observed on the dull point in Vermilion lake which embraces the corners of sections 13, 14, 21 and 32, T 63-17, the author concluded that the transition from the crystalline schists to the igneous and granite was of the nature of a gradual conformable change accompanied by silicification, and by a change of the schists themselves to gneisses, in the first place, and finally to granite by hydro-thermal fusion, and that the granitic rock penetrated the schists by generation in them of granitic minerals, in the first place, and later, or nearer the seat of greater heat, by actual intrusion in a molten form. (2) The *nature of the relations of the Stuntz conglomerate of Vermilion lake.* The author stated that evidence was discovered in a late excursion to Vermilion lake to demonstrate that this rock is a true conglomerate and not a breccia. It graduates into a quartzite and into a graywacke and the graywacke into argilliceous slate, these latter, constituting with the conglomerate, an upper formation non-conformable on the Vermilion iron-bearing formation. (3) *The nature and the position of the conglomerate in the Puckwunge valley.* This is composed of quartz pebbles, essentially, which are referable to the Animikie, some of them being composed of cryptocrystalline silica like that in the rock taconyte, and as a formation it lies above a peculiar greenish graywacke (named the Puckwunge slate) and is overlain by trap and amygdaloidal rock resembling the Keweenawan traps. It wah found that this conglomerate constitutes the base of an important part of the Keweenawan, or separates the Keweenawan into two great members.

(This paper is printed in full in the American Geologist for July, 1897.)

Notes on Saganaga Granite, by U. S. Grant.

The August meeting of the American Association for the Advancement of Science, by Prof. C. W. Hall.

231st Meeting, January 5, 1897.

ANNUAL MEETING.

Nine persons present; Vice President Grant in the chair.

Claude Hafer was elected a member of the Academy.

The Secretary reported $64 collected.

The Corresponding Secretary reported the library accessions as 272 domestic and 399 foreign, total of 672, as follows:

Agram, Hungary.—Jugoslavenska Akademija: Ljetopis, Vol. x. Rad, Vol. xx.

Agricultural College, Mich.—Michigan Agricultural College and Exp. Station. Bulletin, Nos. 129-134.

Albany, N. Y.—State Library: Annual Report, 1894; Bulletin, No. 6.
State Museum: Annual Report, 1894; Entomologists' Report, Vol. x; Bulletin, Vol. III, Nos. 14-15.
University of N. Y.: Regents' Report, 1895.

Amiens, France.—Société Linnéenne du Nord: Bulletin, Vol. XII, No. 271; XIII: 272-282.

Baltimore, Md.—Johns Hopkins University: Circular, Nos. 123-127.

Berlin, Germany.—R. Friedländer und Sohn: Naturæ novitates, 1895: 19-24; 1896: 1-19.

Béziers, France.—Société d' Etude des Sciences Naturelles: Bulletin, Vols. XVII, XVIII.

Bologna, Italy.—Accademia delle Scienze dell' Instituto di Bologna. Memorie, Vol. IV.

Bombay, India.—Asiatic Society: Journal, Vol. XIX, No. 52

Bône, Algeria.—Académie d' Hippone: Comptes Rendus, 1895; Bulletin, No. 27.

Boston, Mass.—American Academy of Arts and Sciences: Proceedings, Vols. XXX, XXXI.

Boston, Mass.—Boston Society of Natural History: Proceedings, Vol. XXVII.

Boston, Mass.—Horticultural Society: Transactions, 1895.

Bremen, Germany.—Naturwissenschaftlicher Verein: Abhandlungen, Vol. XIII, No. 3.

Brisbane, Queensland.—Geological Survey of Queensland: Annual Progress, 1895; Bulletin, Nos. 3, 4; Water Supply, 1890, 1891, 1894.

Brisbane. Queensland.—Royal Society of Queensland: Proceedings, Vol. XI.

Brünn, Austria.—Naturforschender Verein: Bericht, 1893; Verhandlungen, 1895.

Bruxelles, Belgium.—Société Belge de Microscopie: Annales, Vols. XIX: 2, 20; Bulletin, Vol. XXII.

Bruxelles, Belgium.—Société Entomologique de Belgique: Annales, Vol. XXXIX.

Bruxelles. Belgium.—Société Royale de Botanique de Belgique: Bulletin, Vol. XXXIV.

Buenos Aires, Argentine.—Instituto Geographico Argentino: Bulletin, Vols. XVI: 5-12; XVII: 1-12.

Buenos Aires. Argentine.—Museo Nacional: Annales, Vol. IV.

Buenos Aires, Argentine.—Sociedad Cientifica Argentina: Annales, Vols. XL: 5-6; XLI: 1-6.

Buffalo. N. Y.—Buffalo Historical Society: Annual Report, 1895.

Cairo. Egypt.—Institut Egyptien: Bulletin, Vol. V: 8, 9.

Calcutta, India.—Geological Survey of India. Memoirs, Vols. XIII: 2; XV: 2; XXVII: 1; Records, Vol. XXIX: 2, 3.

Cambridge, Mass.—Harvard College Observatory: Annals, Vol. XXXIV: 1; Annual Report, 1895.

Cambridge. Mass.—Museum of Comparative Zoology: Annual Report, 1894-1895; Bulletin, Vols. XXIX, XXX.

Cape Town. Africa.—South African Philosophical Society: Transactions, Vol. VIII: 2.

Cardiff. England.—Naturalists' Society: Report and Transactions, Vol. XXVIII.

Catonia. Italy.—Accademia Giœnia di Scienze Naturali: Bulletin, Nos. 41-47.

Chapel Hill. N. C.—Elisha Mitchell Scientific Society: Journal, Vol. XII.

Cherbourg, France.—Société Nationale des Sciences Naturales: Memoirs, Vol. XXIX.

Chicago. Ill.—Chicago Academy of Sciences: Annual Report, Vol. XXXVIII.

Chicago. Ill.—Field Columbian Museum: Publications, Nos. 7-11.

Chicago. Ill.—Journal of Geology: Vol. IV, 1896.

Christiania. Norway.—Videnskabs Selskab: Förhandlingar, 1894. Oversigt, 1894.

Chur, Switzerland.—Naturforschende Gesellschaft Graubündens. Jahresbericht, Vols. XXXIX, XL.

Cincinnati. Ohio.—Cincinnati Society of Natural History: Journal, Vols. XVIII: 3, 4; XIX: 1.

Colorado Springs. Col.—Colorado College. Studies, Vol. VI.

Denver, Col.—Colorado Scientific Society: Uranite in Colorado; Pearcite; San Miguil Formation; Concretions, etc.

Ekaterinburg. Russia.—Société Ouralienne des Amis des Sciences: Bulletin, Vols. XIV: 1-4; XV: 1, 2.

Emden, Germany.—Naturforschende Gesellschaft: Jahresbericht, Vols. LXXIX, LXXX.

Firenze, Italy.—Bibliotica Nazionale Centrale: Bulletin, Nos. 239-274.

Frankfurt a d Oder, Germany.—Naturwissenschaftlicher Verein: Helios, Vol. XIII: 8-12: Societatum Litterae, Vol. X: 5-6.

Geneve, Switzerland.—Société de Geographie: Le Globe, Vol XXXV.

Georgetown, British Guiana.—Royal Agricultural and Commercial Society: Journal, Vol.

Glasgow, Scotland.—Natural History Society of Glasgow: Proceedings and Transactions, Vol. IV, Nos. 2, 3.

Görlitz, Germany.—Naturforschende Gesellschaft: Abhandlungen, Vol. XXI.

Graz, Austria.—Naturwissenschaftlicher Verein: Mitteilungen, Vol. XXXII.

Greifswald, Germany.—Naturwissenschaftlicher Verein: Mitteilungen, Vol. XXVII.

Guströw, Germany.—Verein der Freunde der Naturgeschichte: Archiv, Vol. XLIX.

Halifax, Nova Scotia.—Nova Scotia Institute of Science: Proceedings and Transactions, Vols. VIII; IX: 1.

Halle a d Saale, Germany.—Kais. Leopold. Carol. Akademie. Leopoldiana, 1895.

Hamburg, Germany.—Verein für Naturwissenschaftlicher Unterhaltung: Verhandlungen, Vol. IX.

Hamilton, Canada.—Hamilton Association: Journal and Proceedings, Vol. XI.

Harlem, Netherlands.—Musee Teyler: Archives, Vol. V: 1, 2.

Hermanstadt, Austria.—Siebenbürgischer Verein für Naturwissenschaften: Verhandlungen, Vol. XLIV.

Iowa City, Iowa.—Iowa Historical Society: Historical Record, Vol. XII.

Jefferson City, Mo.—Geological Survey of Missouri: Report, Vols. VIII, IX.

Kief, Russia.—Kief Society of Naturalists: Memoires, Vol. XIV.

Kiel, Germany.—Naturwissenschaftlicher Verein: Schriften, Vol. X: 2.

Krakowie, Austria.—Akademie der Wissenschaften: Rosprawy, Vols. VII, IX.

Landshut, Germany.—Botanischer Verein: Bericht, Vol. XIV.

Lansing, Mich.—State Agricultural College: Bulletin Exp. Station, Nos. 131-134.

Lawrence, Kans.—Kansas State University: Quarterly, Vol. V.

Le Havre, France.—Société de Géologique de Normandie: Bulletin, Vols. XVI, XVII.

Liverpool, England.—Geological Society: Proceedings, Vol. VII: 3.

Lyon, France.—Société Linnéenne de Lyon: Annales, 1894.

Manchester, England.—Manchester Literary and Philosophical Society: Memoirs and Proceedings, Vols. IX: 3-6; X: 1-3.

Melbourne, Victoria.—Public Library, Museum and National Gallery: Report of Trustees 1893-1894; 1894-1895.

Melbourne, Victoria.—Royal Geographical Society of Australasia: Transactions, Vol. XII, 1896.

Mexico, Mexico.—Instituto Geologico Nacional: Bulletin, No. 11.

Milano, Italy.—Società Italiana di Scienze Naturali: Atti, Vol. XXXVI: 3, 4.

Montevideo, Uruguay.—Museo Nacional: Annales, Vol. II: 4, 5.

Montgomery, Ala.—Geological Survey of Alabama: Bulletin, No. 5.

Moskva, Russia.—Imp. Moscow Society of Naturalists: Bulletin, 1894; 4; 1895.

Münster, Germany.—Provincial-Verein für Wissenschaft und Kunst: Jahresbericht, Vol. XXIII.

Nantes, France.—Société Académique de la Loire-Inferieure: Annales, Vol. VI.

Nashville, Tenn.—State Board of Health: Bulletin, Vols. XI: 5-12; XII: 1-4.

New York, N. Y.—American Geographical Society: Bulletin, Vols. XXVII: 4; XXVIII: 1-3.

New York, N. Y.—American Museum of Natural History: Annual Report, 1895; Bulletin, Vols. VII, VIII.

New York, N. Y.—New York Microscopical Society: Journal, Vol. XII: 1-3.

New York, N. Y.—Torry Botanical Club: Bulletin, Vols. XXIII, XXIV.

Nürnberg, Germany.—Naturhistorische Gesellschaft: Abhandlungen, Vol. X: 4.

Oberlin, Ohio.—Oberlin College: Bulletin, Vol. III: 7, 8.

Ottawa, Canada.—Geological and Natural History Survey of Canada: Annual Report, Vol. VII; Catalogue of Collection of Minerals.

Padova, Italy.—Società Veneto-Trentina di Scienze Naturali: Atti, Vol. II: 2; Bulletin, Vol. VI: 2.

Paris, France.—Museum d' Histoire Naturelle: Bulletin, 1896.

Penzance, England.—Royal Geological Society of Cornwall: Annual Report, 1896.

Philadelphia, Pa.—Academy of Natural Sciences: Proceedings, 1896.

Pisa, Italy.—Società Toscana di Scienze Naturali: Atti, Vols. IX, X.

Port Louis, Mauritius.—Royal Alfred Observatory: Annual Report, 1894; Meteorological Observations, 1894.

Providence, R. I.—Rhode Island Historical Society: Publications, Vols. III: 4; IV: 1.

Regensburg, Germany.—Naturwissenschaftlicher Verein: Berichte, Vol. V.

Riga, Russia.—Naturforscherverein: Korrespondenzblatt, Vol. XXXVIII.

Rio De Janeiro, Brazil.—Instituto Historico, Geographico y Ethnographico: Revista, Vols. LVI, LVII, LVIII.

Rovereto, Austria.—Imp. R. Accademia degli Agiati in Rovereto: Atti, Vol. II: 3.

St. Gall, Switzerland.—Naturwissenschaftlicher Gesellschaft: Bericht, 1893-'94.

St. John's, New Brunswick.—Natural History Society: Bulletin, No. 13.

Saint-lo, France.—Société d' Agriculture, et d' Histoire Naturellede la Manche: Memoires et Docum. Vol. XIII.

St. Louis, Mo.—St. Louis Academy of Sciences: Transactions, Vol. VII: 1-9.

Sankt-Peterburg, Russia.—Imp. Academy of Sciences: Bulletin, Vol. III; Memoirs, Vols. II: 1, 2; III: 2, 6, 8; IV: 1, 2, 4.

Sankt-Peterburg, Russia.—Geological Committee: Bulletin, Vols. XIII: 4-9; XIV: 1-9; XV: 1, 2. Memoirs, Vols. IX: X: 3, 4; XI: 2; XIII: 2; XIV: 1, 3.

San Francisco, Cal.—California Academy of Sciences: Proceedings, Vol. V: 1, 2.

Santiago, Chile.—Société Scientifique du Chile: Actes, Vols. II: 5; VI: 1.

Sydney, New South Wales.—Australian Museum: Report of Trustees, 1895.

Sydney, New South Wales.—Geological Survey of New South Wales: Annual Report, 1895; Records, Vol. IV: 3, 4.

Sydney, New South Wales.—Royal Society of New South Wales: Journal and Proceedings, Vol. XXIX.

Stavanger, Norway.—Stavanger Museum: Aarsberetning, 1894, 1895.

Stockholm, Sweden.—Kongl: Svenska Vetenskaps-Akademien: Bihang, Vol. XX; Oefversigt, 1895.

Thorn, Germany.—Copernicus Verein für Wissenschaft und Kunst: Jahresbericht, Vols. XXXVI-XLII.

Tokio, Japan.—Deutsche Gesellschaft für Natur und Völkerkunde: Mitteilungen, Vol. VI, No. 57; Suppl. 3.

Torino, Italy.—R. Museo Zoologico di Torino: Bulletin, Vol. X: 211-221.

Toronto, Canada.—Canadian Institut: Transactions, Vol. IV: 2.

Toulouse, France.—Académie des Sciences de Toulouse: Memoires, Vol. VII.

Toulouse, France.—Société Francaise de Botanique: Revue, Vol. XII.

Upsala, Sweden.—Geological Institute University of Upsala: Bulletin, Vols. I, II.

Urbana, Ill.—Illinois State Laboratory of Natural History: Bulletin, Vol. III: pp. 483-501; Index; IV: p. 149-398.

Washington, D. C.—United States Geological Survey: Bulletin, Nos. 123-126, 128, 129, 131-134.

Washington, D. C.—National Museum: Bulletin, Nos. 39, I. J. K, H; 48. Proceedings, Vols. XVII, XVIII. Oceanic Ichthyology.

Washington, D. C.—Patent Office: Official Gazette, Vols. LXXIII: 13, 14; 74-78.

Washington, D. C.—Smithsonian Institution: Annual Report, 1893.

Washington. D. C.—Weather Bureau: Monthly Weather Review, 1895-1896.

Wiesbaden, Germany.—Naturhistorische Verein: Jahrbuch, Vols. XLVIII, XLIX.

Winnipeg, Manitoba.—Manitoba Historical and Scientific Society: Annual Report, 1894, 1895; Transactions, No. 48.

Zurich, Switzerland.—Naturforschende Gesellschaft: Vierteljahrschrift, Vols. XL: 3, 4; XLI: 1, 2.

Zurich, Switzerland.—Physikalischen Gesellschaft: Jahresbericht, 1895-1896.

Zwickau, Germany.—Verein für Naturkunde: Jahresbericht, 1894.

American Association for the Advancement of Science, Proceedings, Vol. XIV.

Australian Association for the Advancement of Science, Report, Vol. VI.

Election of officers resulted as follows:

President, - - - - - - -	Professor N. H. Winchell
Vice President, - - - - -	U. S. Grant.
Recording Secretary, - - -	A. D. Meeds.
Corresponding Secretary, - -	C. P. Berkey.
Treasurer, - - - - - -	Edw. C. Gale.
Trustees for three years, -	T. B. Walker. Dr. T. S. Roberts.
Trustee for unfinished term, of V. Truesdell, - - -	Edward C. Gale.

The following resolution was adopted:

Whereas, The Minnesota Academy of Natural Sciences in the death of Verdine Truesdell has lost one of its most steadfast and earnest members, helpful in every place he was called upon to fill, and honored by every one,

Resolved: That the Academy do hereby express its sincere sorrow at the loss of a most respected member, that a copy of this memorandum be sent to the family of the deceased, and that a minute be spread upon the records of the Academy.

C. W. Hall,
U. S. Grant,
A. D. Meeds,
Committee.

The matter of a state academy, or state aid for the Academy, was introduced, and the following committee was appointed: Prof. N. H. Winchell, T. B. Walker, Dr. T. S. Roberts, and H. W. Smith.

Professor Hall announced that at the next annual meeting the Academy will have been in existence a quarter of a century; it was carried that a committee should be appointed for the proper celebration of the anniversary.

232d Meeting, February 2, 1897.

Eleven persons present; President Winchell in the chair.

Hon. Frank Ives of Crookston was elected to membership.

The committee on a state academy reported some progress, and, as it needed some legal advice, E. C. Gale was added to the committee.

Program:

Revision of Moraines North of Lake Superior, by A. H. Elftman.

Glacial Lakes of St. Louis and Nemadji, by Prof. N. H. Winchell.

[ABSTRACT.]

At the extreme western end of Lake Superior are beaches showing that that lake has been at higher levels and that it left distinct traces of itself. The first lake formed by the damming of the St. Louis river by the ice of the Lake Superior glacial lobe was a small lake wholly confined within Carlton county, about 523 feet higher than the present level of Lake Superior. It had its outlet to the southward, uniting with the waters of the St. Croix and thence reached the Mississippi river. Lake Nemadji was due to the same agent and was the first lake water, the residum of which remains to the present as a constituent part of the area of Lake Superior. This lake covered, in general, the valley of the Nemadji river and its level was 468 feet above the present level of Lake Superior. Its outlet was in secs. 16 and 17, T. 46, R. 18.

These glacial lakes are describel in Vol. 4 of the Final Report of the Geological Survey of Minnesota, pp. 18-21.

The eastern limit of Glacial Lake Agassiz, by U. S. Grant.

[ABSTRACT.]

The waters of Lake Agassiz are thought to have extended eastward so as to include the area now occupied by Rainy Lake. From the fact that the lacustrine deposits of the former lake extend eastward practically only to the western edge of the latter lake, it seems probable that the evtreme altitude of Lake Agassiz was in this area but a few feet

above the present level of Rainy Lake, or that such an extreme altitude was of short duration. The shores of Rainy Lake are generally rocky, and over much of them there are practically no deposits of unconsolidated materials, the bed rock coming to the surface wherever the thin forest soil is pushed aside. At the western end of the lake this rocky surface suddenly gives way to a plain of clays, through which the bed rock rarely emerges. These clays are regarded in the main as deposits made in the waters of Lake Agassiz. The change from the rocky country on the east to this clay plain on the west is abrupt and very striking, and is intensified by asudden change in the flora; the lake shores have a forest largely of evergreen and boreal in aspect, while to the west of the lake a forest largely deciduous and of less boreal aspect appears.

233d Meeting, February 9, 1897.

Six persons present; President Winchell in the chair.

Special meeting called to hear the report of the committee on a state charter. After two meetings of the committee and consultation with Judge Hicks of the Hennepin delegation it was found that the charter desired was special legislation and therefore unconstitutional. To get a state charter it would be necessary to transfer all the property of the Academy to the state, as well as to give complete control of its affairs to state officers. The committee was continued and instructed to report again.

A. D. Roe was elected to membership.

It was ordered that $10 be expended for the purpose of preserving some of the specimens, purchase of material, etc.; and that L. E. Griffin's offer to do certain necessary work in lieu of his current dues be accepted.

Communications from E. L. Brown of Warren, touching a collection of birds and animals, and Mr. Worcester, asking for the loan of several specimens of the Philippine Island collection. The latter communication was referred to the Trustees.

234th Meeting, March 2, 1897.

Eight persons present; President Winchell in the chair.

The president reported for the charter committee that it had drawn up a new charter and had submitted it to Capt. Cross, who had declared it unconstitutional. The committee was continued.

Program:

Some Reported Gold Discoveries in the Northwestern States, by C. W. Hall..

Dr. U. S. Grant gave an account of the Rainy Lake gold region.

[ABSTRACT.]

Rainy Lake lies in an area of crystalline and highly folded rocks, which have been separated by Lawson into two series called Coutchiching and Keewatin. The former series consists mainly of mica-schists, while the latter consists of various slates and schists, among which greenstone schists and also massive greenstones are common. Traversing these rocks are quartz veins, some of which carry values in gold. The best veins lie either in the green schists or in other rocks of igneous origin, and the most promising prospects occur on the Canadian shores of the lake. (An account of this district has been published in the 23d Annual Report of the Geological and Natural History Survey of Minnesota, pp. 36-105, 1895, under the title "Preliminary Report on the Rainy Lake Gold Region," by H. V. Winchell and U. S Grant; also in Vol. 4 of the Final Report of the same survey, pp. 192-211, 1899.)

C. P. Berkey read a paper on An Improved Method for Quantitative Determination of Antimony, Zinc, Iron, Copper, and Lead in an impure Galena ore.

[ABSTRACT.]

The investigation and experiences resulting in these notes arose over a particular ore brought from the Kootenai country in British Columbia. Mr. Stevenson, a special student in the laboratories of the University of Minnesota, was equally interested in them.

The ore contains from 50% to 80% metallic lead which is in the form of the natural sulphate, PbS. The impurities which make up the rest of the required amount are antimony, zinc, iron, copper and siliceous gangue matter. Antimony is the most common impurity and occurs in largest amount next to lead. It is in the form of sulphide $Sb_2 S_3$. It was chiefly in the effort to determine this constituent that the first and greatest difficulty arose. The natural association seemed to have so thoroughly satisfied the chemical affinities that the usual methods of solution were ineffectual, and separation did not occur where it was calculated to. Iron and zinc occur in similar amount, both in sulphate form, FeS_2 and ZnS. Copper is not always present in quantity of importance, but occasionally in considerable amount with iron as chalcopyrite, $CuFeS_2$. The siliceous gangue is present in amount varying from 0 to 15% according to quality of the ore.

The first difficulty was in securing complete solubility of the ore, the next was the almost constant failure to obtain precipitates of any

of the compounds entirely free from either lead or antimony or both.

No less than twenty different variations of process recommended by authors of texts and practical chemists were tried with no complete success. At last the following plan was devised which at least for the ore in question works with entire satisfaction.

PROCESS.

1. Digest one gram of ore in strong hydrochloric acid containing a little nitric acid, for half an hour. Then if necessary add more hydrochloric acid and about 5cc of nitric to complete the solution. Heat a few minutes and dilute. Filter and weigh residue as insoluble siliceous gangue.

2. Boil the filtrate and add enough dilute sulphuric acid to precipitate all of the lead in the form of $PbSO_4$. Add alcohol and allow to stand several hours, or better, evaporate till white fumes appear. Dilute cautiously, filter and weigh.

3. To the filtrate from the precipitation in (2) add ammonium chloride and ammonia in considerable excess. The precipitate contains the iron in the form of $Fe_2\ O_6\ H_6$ which is filtered and ignited and weighed as $Fe_2\ O_3$.

4. Pass $H_2\ S$ gas through the filtrate from (3). A grayish white precipitate of zinc, ZnS, and of copper, CuS, are formed. Filter. The filtrate contains antimony still in solution, the two mixed precipitates must be treated for separation.

5. To the filtrate from (4) add hydrochloric acid to acid reaction and H2S gas. Antimony sulphide $Sb_2\ S_3$ forms. Filter and follow the usual method of handling this precipitate.

6. Dissolve the precipitate from (4) in hydrochloric acid. To this add H_2S gas which will precipitate copper as CuS. Filter and ignite weighing as either $Cu_2\ S$ or $Cu_2\ O_2$. (The amount of copper is the same in each.)

7. To the filtrate from (6) add ammonia to strong reaction and pass $H_2\ S$ gas through. Zinc is precipitated, ZnS. Weigh as Zn O.

Analysis of the ore made after this scheme separated easily and completely, and the results checked within the usual limits of error.

The list of delinquent dues was referred to Professor Hall and Secretary Meeds.

Hon. Frank Ives of Crookston, Minn. was elected delegate of the Academy to the International Congress of Geologists to be held at St. Petersburg during the coming summer.

235th Meeting, April 5, 1897.

Twenty-one persons present.

President Winchell in the chair.

Program:

An Account of a Glacier in the Montana Rockies, by Prof. L. W. Chaney, Jr.

The Stillwater Oolite and its Fossils, by A. D. Roe.

Sketch of the Life of Verdine Truesdell.

A case was asked for the display of a collection of Indian curiosities which were offered on loan by Mrs. Leach; referred to a committee of Dr. Roberts and the secretary.

236th Meeting, May 4, 1897.

Six persons present.

President Winchell in the chair.

Amendment to the By-Laws, notice of which was given at the last meeting, was adopted by which the dues of resident members was reduced from $5.00 to $3.00 per annum.

Moved and carried that all delinquent dues up to January 1, 1897, be remitted.

Professor F. P. Leavenworth was elected to membership.

Dr. U. S. Grant read a paper on Minnesota Lakes having more than one Outlet.

[ABSTRACT.]

Among the numerous lakes in the northeastern portion of the state are several which have two outlets each. Such are: Brulé Lake in Cook County; a small lake on the International boundary between Gunflint and Saganaga lakes in Cook County; three lakes along the Kawishiwi river in Lake County; Iron Lake, Lac la Croix, and Namekan lake on the International boundary on the northern edge of St. Louis County. The origin of two outlets in a lake of this class is due to inequalities of drift deposition such that a basin is left with two depressions of about equal altitude in its rim. In case of at least one of the larger lakes,—Brulé lake,—it is possible that the western outlet is of quite recent date and is due to the westward canting of the basin by the general tilting which has been taking place in the Great Lake region since near the end of Glacial time.

(This paper has been published in the American Geologist, Vol. 19, pp. 407-411, June, 1897, under the title "Lakes With Two Outlets in Northeastern Minnesota.")

237th Meeting, October 5, 1897.

Fourteen persons present.

President Winchell in the chair.

Acceptance and thanks were ordered for the gifts to the Academy of a fine Tarpon from Florida by M. B. Koon and R. R. Rand, and of a valuable collection from Mr. J. C. Eliel.

Mr. E. C. Gale moved that a committee of five, of which the President shall be chairman, be appointed to provide a fitting reception and entertainment for Dr. Nansen upon the approaching occasion of his visit to Minneapolis.

An account was given by Dr. H. T. Eddy of the meetings of the American Association for the Advancement of Science at Detroit and the British Association for the Advancement of Science at Toronto.

238th Meeting, November 2, 1897.

Six persons present.

President Winchell in the chair.

Dr. H. T. Eddy was elected to membership.

A paper on the Driftless Area was read by Dr. F. W. Sardeson; discussion by Warren Upham.

(See Glacial Deposits in the Driftless Area, American Geologist, Vol. xx, 1897, pp. 392-403).

The following committee was announced for the proper celebration of the twenty-fifth anniversary of the founding of the Academy: President N. H. Winchell, Warren Upham, H. V. Winchell, E. C. Gale, and A. D. Roe.

A public reception was held November 19, 1897, in honor of Dr. Nansen, the Arctic explorer, in the Public Library, to which the Academy's committee, President Winchell, E. C. Gale, F. W. Sardeson, H. V. Winchell, and H. T. Eddy, had sent invitations. One hundred persons were present.

239th Meeting, December 7, 1897.

Eleven persons present.

President Winchell in the chair.

C. M. Dorsett and Wm. Twing were elected to membership.

It was moved and carried that the committee for securing state aid for the Academy be instructed to formulate a plan fulfilling statutory requirements for bringing the Academy under control of the Board of Regents of the University, present the same to the Regents, and report back to the Academy. Plans for the 25th anniversary were discussed.

240th Meeting, January 4, 1898.

ANNUAL MEETING.

Eight persons present.

President Winchell in the chair.

Reports of the Nansen reception and twenty-fifth anniversary committees were received.

D. T. MacDougal was elected to membership.

The Secretary reported $81 collected from 32 persons.

The Treasurer reported $4.64 on hand January 1, 1897, and received during 1897 $81; total of $85.64. Bills had been paid during the year of $79.15, leaving a balance of $6.49 on hand. But bills amounting to considerably more than this balance remained unpaid.

The Curator of the museum reported the condition of the museum, the effort he had made to receive and label the collections, the large number of daily visitors and the great interest shown.

Report of the Corresponding Secretary of accessions to the Library received during 1897:

Agram, Hungary.—Jugoslavenska Akademija: Ljetopis, Vol. XI; Rad, Vols. XXII, XXIII.

Agricultural College, Mich.—Michigan Agricultural College and Exp. Station: Bulletin Nos. 135-144.

Albany, N. Y.—State Library: Annual Report, 1895; Bulletin, Nos. 7, 8.

State Museum: Annual Report, 1895; Bulletin.

University of New York: Regents' Report, 1896.

Altenburg, Germany.—Naturforschende Gesellschaft des Osterlandes: Mitteilungen, Vol. VII.

Austin, Texas.—Texas Academy of Science: Transactions, Vol. II: 1.

Baltimore, Md.—Johns Hopkins University: Circular, Nos. 128-131.

Belfast, Ireland.—Natural History and Philosophical Society: Report and Proceedings, 1895-1896.

Berlin, Germany.—R. Friedländer und Sohn. Naturæ novitates, 1896: 20-24; 1897: 1-8.

Bombay, India.—Royal Asiatic Society: Journal, Vol. XIX, No. 53; Memoirs, Vols. XVI, XXVI.

Bône, Algeria.—Academia d' Hippone: Comptes Rendus, 1896.

Boston, Mass.—American Academy of Arts and Sciences: Proceedings, Vol. XXXII.

Boston, Mass.—Horticultural Society: Transactions, 1896.

Bremen, Germany.—Naturwissenschaftlicher Verein: Abhandlungen, Vol. XIV: 1.

Brisbane, Queensland.—Geological Survey of Queensland: Bulletin, Nos. 5, 6.

Brisbane, Queensland.—Royal Society of Queensland: Proceedings, XII.

Brünn, Austria.—Naturfoschender Verein: Bericht, Vol. 14; Verhandlungen, Vol. XXXIV.

Brúxelles, Belgium.—Société Belge de Microscopie: Annales, Vol. XXI. Bulletin, Vol. XXIII.

Bruxelles, Belgium.—Société Royale de Botanique de Belgique: Bulletin, Vols. XXXV, XXXVI.

Buenos Aires, Argentine.—Sociedad Cientifica Argentina: Annales, Vols. XLII, XLIII.

Calcutta, India.—Geological Survey of India: Memoirs, Vol. XXV; Records, Vol. XXIX: 4.

Cambridge, Mass.—Harvard College Observatory: Annals, Vols. XXV: 2; XXXVI; XXXVIII.

Cambridge, Mass.—Museum of Comparative Zoology: Annual Report, 1897; Bulletin, Vols. XXXI: 1-5; XXXII: 1-9.

Chapel Hill, N. C.—Elisha Mitchell Scientific Society: Journal, Vol. XIII.

Chicago, Ill.—Chicago Academy of Sciences: Annual Report, 40th; Bulletin, Vol. II, Nos. 1, 2.

Chicago, Ill.—Field Columbian Museum: Publications, Nos. 15-22; 24.

Chicago, Ill.—Journal of Geology: Journal, Vol. V.

Christiania, Norway.—Videnskabs Selskab: Förhandlinger, 1896; Skrifter, 1895.

Cincinnati, Ohio.—Cincinnati, Society of Natural History: Journal Vol. XIX: 2, 3.

Denver, Col.—Colorado Scientific Society: Ferric Sulphate, etc.; Circular, No. 1.

Des Moines, Iowa.—Geological Survey of Iowa: Annual Report, Vol. VII.

Des Moines, Iowa.—Iowa Academy of Science: Proceedings, Vol. III.

Dorpat, Russia.—Naturforscher Gesellschaft bei der Universität: Sitzungsberichte, Vol. XI.

Ekaterinburg, Russia.—Société Ouralienne des Amis des Sciences Naturelles: Bulletin, Vols. XIV: 5; XV.; Memoirs, Vols. XIV, XV.

Emden, Germany.—Naturforschende Gesellschaft: Jahresbericht, Vol. LXXXI.

Genéve, Switzerland.—Société de Geographi: Le Globe, Vol. XXXVI.

Graz, Austria.—Naturwissenschaftlicher Verein: Mitteilungen, Vol. XXXIII.

Gueret, France.—Société des Sciences Naturelles: Memoirs, 1895-'96.

Guströw, Germany.—Verein der Freunde der Naturgeschichte: Archiv, Vol. L.

Halifax, Nova Scotia.—Nova Scotia Institute of Science: Proceedings and Transactions, Vol. IX: 2.

Halle a d Saale, Germany.—Kais. Leopold. Carol. Akademie. Leopoldiana, 1896.

Harlem, Netherlands.—Musee Teyler: Archives, Vol. V: 3, 4.

Hermannstadt, Austria.—Siebenburgischer Verein fur Naturwissenschaften, Verhandlungen, Vol. XLV.

Iowa City, Iowa.—Iowa Historical Society: Historical Record, Vol. XIII.

Kharkow, Russia.—Société Naturalistes a l'Universite: Travaux, Vol. XXX.

Kjöbenhavn, Denmark.—Naturhistoriske Förening: Meddelelser, 1896.

Krakowie, Austria.—Akademie der Wissenschaften: Rosprawy, Vols. X-XII.

Lansing, Mich.—State Agricultural College: Bulletin Exp. Station, Nos. 139-144.

Lausanne, Switzerland.—Société Vandoise des Sciences Naturelles: Bulletin, Vols. XXXII, XXXIII.

Lawrence, Kans.—Kansas State University: Geological Survey, Reports, Vols. I, II. Quarterly, Vol. VI.

Lincoln, Neb.—University of Nebraska: University Studies, Vol. II: 2.

Liverpool, England.—Geological Society: Proceedings, Vol. VII: 4.

Manchester, England.—Literary and Philosophical Society: Memoirs and Proceedings, 1896.

Montevideo, Uurguay.—Museo Nacional: Annales, Vol. II: 6, 7.

Moskva, Russia.—Imp. Moscow Society of Naturalists: Bulletin, 1896.

Nantes, France.—Société Académique de la Loire-Inferieure: Annales, Vol. VII.

Nashville, Tenn.—State Board of Health: Bulletin, Vols. XII: 5, 6; XIII: 1, 2,.

New York, N. Y.—American Geographical Society: Bulletin, Vols. XXVIII: 4; XXIX.

New York, N. Y.—New York Microscopal Society: Journal, Vols. XIII: 4; XIV: 1.

Oberlin, Ohio.—Oberlin College: Laboratory Bulletin, Nos. 5, 6, 7, 9. Wilson Bulletin, Vol. IV.

Osnabrück, Germany.—Naturwissenschaftlicher Verein: Jahresbericht, 1896.

Paris, France.—Museum d' Histoire Naturelle: Bulletin, 1897.

Philadelphia, Pa.—Academy of Natural Sciences: Proceedings, 1897.

Philadelphia, Pa.—Zoological Society: Annual Report, 24, 25.

Portland, Maine.—Portland Society of Natural History: Proceedings, Vol. II: 4.

Port Louis, Mauritius.—Royal Alfred Observatory: Meteorological Observations, 1895.

Riga, Russia.—Naturforscherverein: Korrespondenzblatt, Vol. XXXIX.
Roverto, Austria—Accademia degli Agiati in Rovereto: Atti, Vol. II: 4.
Sacramento, Cal.—California State Mining Bureau: Report, Vol. XIII; Bulletin, Nos. XI, XII.
St. Gall, Switzerland.—Naturwissenschaftliche Gesellschaft: Bericht, 1894-1895.
St. John's, New Brunswick.—Natural History Society: Bulletin, Vol. XIV.
Saint-lô, France.—Société d' Agriculture et d' Histoire Naturelle de la Manche. Memoirs et Docum, Vol. XIV.
St. Louis, Mo.—Missouri Botanical Garden: Annual Report, Vol VII.
St. Louis, Mo.—St. Louis Academy of Science: Transactions, Vol. VII: 10-16.
St. Paul, Minn.—Minnesota Historical Society: Historical Collections, Vol. VII: 1, 2.
Sankt Peterburg, Russia.—Imp. Academy of Sciences: Bulletin, Vol. IV.
Sankt Peterburg, Russia.—Geological Committee: Bulletin, Vol. XV: 3-5; Memoirs, Vols. XIV: 2, 4; XV: 2.
Sankt Peterburg, Russia.—Société Imp. Mineralogique: Verhandlungen, 1895.
San Francisco, Cal.—California Academy of Sciences: Proceedings, Vol. VI; New Ser., Vol. I: 1-3.
Sydney, New South Wales.—Geological Survey of New South Wales: Annual Report, 1896; Records, Vol. V: 1.
Stockholm, Sweden.—Kongl. Svenska Vetenskaps-Akademien: Bihang, Vol. XXI; Oversight, 1896.
Topeka, Kans.—Kansas Academy of Sciences: Transactions, Vol. XIV.
Torino, Italy.—Museo Zoologico di Torino: Bulletin, Vol. XI
Toronto, Canada.—Canadian Institute: Proceedings, Nos. 1, 2; Transactions, Vol. V: 1.
Toulouse, France.—Société Française de Botanique: Revue, Vol. XIII.
Urbana, Ill.—Illinois State Laboratory of Natural History: Bulletin, Voi. V: 1, 2, 5.
Washington, D. C.—Bureau of American Ethnology: Annual Report, Vol. XIV, XV.
Washington, D. C.—United States Geological Survey: Annual Report, Vols. XVI, XVII; Bulletin, Nos. 87, 127, 130, 135, 136, 138-148. Monographs, Vols. XXIII, XXV-XXVIII.
Washington, D. C.—United States National Museum: Bulletin, Vol. XLIX; Proceedings, Vol. XIX.
Washington, D. C.—Patent Office: Official Gazette, Vols. LXXIX-LXXXI.
Washington, D. C.—Weather Bureau: Monthly Weather Review, 1897.
Zurich, Switzerland.—Naturforschende Gesellschaft: Vierteljahrschrift, Vols. XLI: 3, 4; XLII: 1, 2.

Officers elected as follows:

President, - - - - - -	Professor N. H. Winchell.
Vice President, - - - -	Dr. D. T. MacDougal.
Recording Secretary,- - - -	A. D. Roe.
Corresponding Secretary, - -	C. P. Berkey.
Treasurer, - - - - - - -	E. C. Gale.
Trustees for three years, -	E. C. Gale. C. P. Berkey.
Trustee to succeed H. W. Smith	Dr. H. T. Eddy.

241st Meeting, April 5, 1898.

Nine persons present.

Vice President MacDougal presiding.

G. B. Aiton, U. S. Cox, and C. E. Bond were elected to membership.

A box of specimens and a letter from Hon. Frank Ives, with promise of his report as delegate to the International Congress of Geologists at St. Petersburg, was duly received and ordered acknowledged.

The following amendment to Section I, Article I of the By-Laws, duly announced at the last meeting, was adopted. "The annual meeting of the Academy shall be held on the first Tuesday after the first Monday in January. The regular meetings of the Academy shall be held on the first Tuesday after the first Monday in the months of January, April and October in each year. Five members shall constitute a quorum."

The invitation of the Mankato Board of Trade to hold a special meeting of the Academy in that city was accepted; a committee, Drs. MacDougal and Sardeson, was empowered to use what money was necessary up to $25, for incidental expenses.

242d Meeting, January 3, 1899.

ANNUAL MEETING.

Twelve persons present; Vice President MacDougall presided.

The following were elected to membership:

Dr. J. K. Hosmer and F. J. Warvelle of Minneapolis.

Oscar Halvorson, Two Harbors.

H. F. Burchard, St. Paul.

The reports of the Secretary and Treasurer showed a balance in the treasury at the beginning of the year of $6.49, receipts $64.92; disbursements $65.91. Balance now in treasury, $5.51 with no debts.

The report of the Corresponding Secretary was omitted. (See pages 221-7).

Officers were elected as follows:

President, - - - - - - - -	Prof. D. T. MacDougal.
Vice President, - - - - -	O. W. Oestlund.
Recording Secretary, - - -	A. D. Roe.
Corresponding Secretary, - -	C. P. Berkey.
Treasurer, - - - - - - -	E. C. Gale.
Trustees for three years, -	C. W. Hall. H. T. Eddy.

Program: Terrace Gravels about St. Anthony Falls, by F. W. Sardeson.

[ABSTRACT.]

The occurrence of terraces younger than the Glacial drift and older than St. Anthony falls and gorge of the Mississippi river was indicated with considerable detail. In particular a terrace gravel containing shells of mollusks 100 feet above the present level of the river below the falls was described and specimens were exhibited. This occurrence has been described by Hall and Sardeson, Bulletin Geological Society Am. Vol. x, p. 358 and Fig. 2, November, 1899.

Unusual Occurrences of Copper in Minnesota, by C. P. Berkey.

Antennal Sense Organs of the Aphididae, by O. W. Oestlund.

[ABSTRACT.]

Attention was called to the great variety of sense organs on the antennæ of the Aphididæ, and their value for distinguishing species. The most conspicuous are the so called sensoria, small membranous areas scattered over the surface. Of these three distinct types may be distinguished: 1. *Apical Sensorta*, a single large sensoria close to the apex of the fifth and the sixth joints. The first to appear in the larva and the most constant sensoria present. 2. *Marginal Sensoria*. a group of very small sensoria near the margin of the apical sensoria of the sixth joint. 3. *Circular Sensoria*, more or less scattered over the surface of the third and sometimes also on the fourth and fifth joints. The circular sensoria show considerable variation in the different genera, and may be transverse, annulate, tuberculate, etc.

The hairs of the antennae are also undoubtedly sense organs, of which several different forms may be distinguished: 1. A group of short spine-like hairs on the apex of the spur, (the narrow prolongation of the sixth joint). 2. Hairs scattered over the surface of the antennæ, long and slender in *Lachnus Chaitophorus*, etc.; short and spine-like in *Aphis*; club-shaped in *Nectarophora.*

A Mineral Resembling Meerschaum, from the Serpentine Range of Hampden County, Mass., by A. D. Roe. [See paper J.]

The Sugar Beet Industry at St. Louis Park, by C. C. Hafer.

243d Meeting, April 4, 1899.

Eleven present; President MacDougal in the chair.

John Skinner elected to membership.

A committee, Dr. J. K. Hosmer, Dr. F. W. Sardeson, and A. D. Roe, was appointed to consider paying a curator of the Academy museum.

The President reported informally on the proposition of the Omaha Exposition corporation for the mounting, exhibition, and subsequent return to the Academy at this city of the Menage Philippine Expedition material stored at the State University buildings.

Brief papers were read by Dr. F. W. Sardeson and Dr. U. S. Grant.

244th Meeting, October 3, 1899.

President Oestlund in the chair.

Ten persons present.

The disposition of the collections of the Menage Expedition to the Philippine Islands on their return from Omaha, was considered. A committee was appointed, consisting of Messrs. Roe, Winchell and Burchard.

The following program of papers was presented:

A Theory of the Origin of Copper in the Lake Superior district, by C. P. Berkey.

River Collecting of Zoological Material, by J. E. Guthrie.

The chairman was authorized to arrange for a series of popular meetings.

245th Meeting, January 2, 1900.

ANNUAL MEETING.

Ten persons present.

The Secretary presided.

Dr. C. P. Berkey gave a lecture on Cripple Creek and Aspen; their Geology, Mining, History, and Scenery.

[ABSTRACT.]

The paper presented was the result of a trip to these camps as a member of the field expedition of the School of Mines of the University of Minnesota. The geologic structure of each camp was outlined, its history as a producing camp was sketched, and these features together with the magnificent scenery of these mountainous districts was illustrated by a series of photographs and lantern slides. A series of the characteristic ores and rock types of the districts was exhibited.

246th Meeting, February 5, 1900.

ADJOURNED ANNUAL MEETING.

Room 21 Pillsbury Hall.

Six persons present.

Vice President Oestlund presiding.

The Recording Secretary reported $57 dues collected.

A. D. Roe, elected curator by the board of trustees, reported that the Philippine exhibit was opened at the Academy Museum on Nov. 5, 1899, with an admission fee of ten cents, children under 12, five cents, and that the receipts for the nine weeks from Nov. 5, 1899, to Feb. 5, 1900, had been $358.85. He had turned over $280 of this to the Treasurer.

Report of the Corresponding Secretary of exchanges received for the two years, 1898 and 1899:

Agram, Hungary.—Jugoslavenska Akademija: Ljetopis, Vols. XII, XIII; Rad, Vols. XXIV, XXV.

Albany. N. Y.—State Library: Annual Report, Vols. LXXIX, LXXX; Bulletin, Nos. 9-12.

State Museum: Annual Report, Vols. L, LI; Bulletin, , Vols. IV: 16-19; V: 20-23.

University of New York: Regents' Report, 1897, 1898.

Amiens, France.—Société Linnéenne du Nord de la France: Bulletin, Nos. 283-302; Memoirs, Vol. IX.

Austin, Texas.—Texas Academy of Science: Transactions, Vol. I: 4

Baltimore, Md.—Johns Hopkins University: Circular, Nos. 132-141.

Barcelona, Spain.—Real Academia di Ciencias y Artes: Bulletin, Vol. I: 15-23; Nomina, 1898-1899.

Basel, Switzerland.—Naturforschende Gesellschaft: Verhandlungen, Vols. XI: 3; XII: 1.

Belfast, Ireland—Natural History and Philosophical Society: Report and Proceedings, 1896, 1897.

Berlin, Germany.—R. Friedländer und Sohn. Naturæ novitates, 1897, Nos. 9-20; 1898, 1899.

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Toronto, Canada.—Canadian Institut: Proceedings, Vols. i: 6; ii: 1, 2; Transactions, Vol. v: 2.

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Urbana, Ill.—Illinois State Laboratory of Natural History: Bulletin, Vol. v: 4, 5.

Washington, D. C.—United States Geological Survey: Annual Report, Vol. xviii; Bulletin, Nos. 51, 88, 89, 149; Monographs, Vols. xxix, xxx, xxxi, xxxv.

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Zwickau, Germany.—Verein für Naturkunde: Jahresbericht, 1895, 1896.

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Election of officers:

President, - - - - -	Dr. H. T. Eddy.*
Vice President, - - - - - -	O. W. Oestlund.
Recording Secretary, - - -	F. G. Warville.
Corresponding Secretary, - -	C. P. Berkey.
Treasurer, - - - - - - -	E. C. Gale.
Trustees for three years, -	Dr. J. K. Hosmer. A. D. Roe.

247th Meeting, April 8, 1900.

Thirty-two persons present.

Vice President Oestlund in the chair.

Dr. Berkey reported that material had been sent to the Duluth Scientific Association and Moorhead Normal School.

Curator Roe reported that free Saturday admission to the museum had reduced receipts, but that March still gave a profit of $16.

H. W. Howling, Wm. Kilgore, Alfred Humphrey, J. H. Gill, and Paul M. Glasoe were elected to membership.

Program:

The Bad Lands of Wyoming, by F. W. Sardeson, illustrated by original photographs taken by his expedition of last year to Big Horn county.

Personal Observations on Ants, by O . W. Oestlund.

[ABSTRACT.]

An account of an observation on ants was given that seems to be exceptional, or at least not recorded by any student on the habits of ants as far as can be ascertained by the author.

A nest found on a burnt-over place on the border of the woods had a space of smooth and hard ground around it, about a foot in diameter, free from grass or any vegetation. The whole colony, of 150

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*Dr. Eddy declined to serve as President of the Academy and Vice President Oestlund was Acting President for the year.—EDITOR.

to 200 individuals, was apparently above ground on the open space. The ants showed great excitement and were running about in all directions. Their actions appeared at first to be aimless, due to fear, danger or some other cause that had thrown the whole colony in commotion. But on closer observation it was seen that when two of them met they would clasp antennæ and forelegs and rise up on the hind legs, would swing around two or three times, on which they would separate, each one going in search for a new partner to repeat the same action.

The interpretation given to this unusual procedure was that the ants were at play, or, to express it as man would, they had a dance.

248th Meeting, October 2, 1900.

Ten persons present.

Vice President Oestlund presided.

Program:

The Geology of the Pembina Mountains, by C. P. Berkey, with specimens of brick made from their sand.

Glacial Plowing in the Vicinity of Minneapolis, by F. W. Sardeson.

[ABSTRACT.]

This paper is based on a series of observations made during excavation of Glacial drift. The results to date were shown by aid of photographs. This paper with drawings instead of reproduced photographic illustrations has been published elsewhere. ("A Particular Case of Glacial Erosion," The Journal of Geology, Vol. XIII, No. 4, p. 351-357, May-June, 1905.)

249th Meeting, November 13, 1900.

Thirteen present.

Vice President Oestlund presiding.

Program: Surface Features of Minnesota, by C. W. Hall.

250th Meeting, December 4, 1900.

About fifteen present.

Vice President Oestlund presiding.

Program:

A demonstration of original micro-photographs as lantern slides, showing the late progress in finer anatomy and in the physiology of the brain, by Harlow Gale.

251st Meeting, January 8, 1901.

ANNUAL MEETING.

Twelve present.

Vice President Oestlund presiding.

Corresponding Secretary Berkey reported the year's accessions to the library as 371 domestic and 417 foreign publications.

List of exchanges received during the year 1900:

Agram, Hungary.—Jugoslavenska Akademija: Ljetopis, Vol. XIV; Rad, No. 140.

Agricultural College, Mich.—Agricultural College and Exp. Station: Bulletin, Nos. 166-181. Annual Report, 37, 38.

Albany, N. Y.—State Library: Annual Report, 1899.

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University of New York: Regents' Report, 1899.

Amiens, France.—Société Linnéenne du Nord de la France: Bulletin, Vol. XIV, Nos. 303-322.

Baltimore, Md.—Johns Hopkins University: Circular, Nos. 142-149.

Bamberg, Germany.—Naturforschende Gesellschaft: Bericht, Vol. XVII.

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Cambridge, Mass.—Museum of Comparative Zoology: Vols. XXXVI: 7, 8; XXXVII: 1, 2; XXXVIII: 1.

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Cardiff, England.—Naturalists' Society: Report and Transactions, Vol. XXXI.

Catania, Italy.—Accademia Giœnia di Scienze Naturali: Bulletin, Nos. 60-63.

Chapel Hill, N. C.—Elisha Mitchell Scientific Society: Journal, Vol. XVI.

Chemnitz, Germany.—Naturwissenschaftlicher Gesellschaft: Bericht, Vol XIV.

Chicago, Ill.—Botanical Gazette: Vols XXVIII, XXIX, XXX.

Chicago, Ill.—Chicago Academy of Sciences: Report, Vol. XL; Bulletin, Vol. II: 3.

Chicago, Ill.—Field Columbian Museum: Birds of Eastern N. America, Part 2; Publications, No. 44.

Chicago, Ill.—John Crerar Library: Annual Report, Vol. V.

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Cincinnati, Ohio.—Cincinnati Society of Natural History: Journal, Vol. XIX: 5, 6.

College Hill, Mass.—Tufts College: College Studies, Vols. V, VI.

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Genève, Switzerland.—Société de Géographie: Le Globe, Vol. XXXIX.

Graz, Austria.—Naturwissenschaftlicher Verein: Mitteilungen, Vols. XXXIV-XXXVI.

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Montreal, Canada.—Canadian Record of Science: Vol. VIII: 2-4.

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Upsala, Sweden.—Geological Institute University of Upsala: Bulletin, Vol. IV: 2.

Urbana, Ill.—Illinois State Laboratory: Bulletin, Vol. V: 7-11.

Washington, D. C.—U. S. Geological Survey: Annual Report, Vols. XIX, XX; Bulletin, Nos. 157-162; Memoirs, Vols. XXVI, XXXII-XXXVII.

Washington, D. C.—Patent Office: Official Gazette, Vols. LXXXIX-LXLIII.

Washington, D. C.—Weather Bureau: Monthly Weather Review, Vol. XXVIII.

Wiesbaden, Germany.—Naturhistorischer Verein: Jahresbericht, Vols. LI-LII.

Winnipeg, Manitoba.—Manitoba Historical and Scientific Society: Annual Report, 1899; Transactions, Vols. LV, LVI.

Zurich, Switzerland.—Naturforschende Gesellschaft: Vierteljahrschrift, Vols. XLIV: 3, 4; XLV: 1, 2.

American Association for the Advancement of Science: Proceedings, XLVIII.

The following officers were then elected:

President, - - - - - - - -	C. W. Hall.
Vice President, - - - - -	O. W. Oestlund.
Recording Secretary, - - -	F. G. Warvelle.
Corresponding Secretary, - -	C. P. Berkey.
Treasurer, - - - - - - - -	E. C. Gale.
Trustees for three years, - -	Dr. T. S. Roberts. O. W. Oestlund.

Dr. Berkey was instructed to correspond with the officers of the East Side Library in regard to obtaining a permanent home for the Academy library.

252d Meeting, February 5, 1901.

Forty-five members and visitors present.

President Hall in the chair.

Harlow Gale was elected to membership.

The Treasurer's report showed receipts of $592.50; expenses $291.61; balance in treasury $296.99.

The By-Laws were amended so that Sec. II, Art. 2 shall read: "The sections shall cover the following sciences: Astronomy and Mathematics, Botany, Chemistry, Geology, Mineralogy, Physics, Zoology."

Heads of sections were advised to subdivide their sections dependent upon the amount of work being carried on by their associates.

Program:

The Retreat of the Ice Margin across Minnesota, by Professor N. H. Winchell.

Giant Kettles in the Interstate Park, Taylor's Falls, by Warren Upham. (Abstracts of these papers appeared in Science, for March 29, 1901, Vol. xiii, N. S. p. 509).

253d Meeting, April 12, 1901.

Fifty members and visitors present.

E. C. Gale was elected trustee for the unexpired term of C. W. Hall.

F. K. Butters read a paper describing some of the lower forms of plant life emphasizing particularly the fungi and their allies. Illustrated.

254th Meeting, May, 1901.

Lecture room of Chemistry, University of Minnesota.

Seventy-five persons present.

Professor Geo. B. Frankforter gave a lecture on Color Photography, illustrated by many views, diagrams and experiments.

255th Meeting, October 8, 1901.

Directors' room, Public Library.

President Hall presiding.

The thanks of the Academy were voted to the donors of late gifts.

W. F. Decker and W. F. Kunze were elected members.

The program was the experiences of the members during the summer in research work or at the meetings of scientific gatherings. Dr. C. P. Berkey told of his work in Utah, Montana, and Idaho.

Dr. H. T. Eddy spoke of the meetings of the American Mathematical Society and the Institute of Electrical Engineers.

Prof. John Zeleny described the work of the Physics section, A. A. A. S. at Denver; Drs. Frankforter and Harding of the Chemical section; Dr. A. H. Elftman of mining in Colorado.

Prof. E. P. Leavenworth of his research work in Astronomy; A. D. Roe of geodes, and Prof. N. H. Winchell of the Geological section of the A. A. A. S., which brought forth a discussion of Chamberlin's theory of Celestial Mechanics and Van Hise's theory of Ore Deposits.

256th Meeting, January 7, 1902.

ANNUAL MEETING.

Nine present.

President Hall in the chair.

Report of Treasurer E. C. Gale:

By balance from 1900.......................	$ 269.99
By Museum receipts, Mar. 6, 1900, to Mar. 31, 1901	707.65

By Dues	46.00	
	$1,050.54	
April 6—To services for museum, March 6, 1900, to Mar. 31, 1901		$ 577.58
April 6—To services for museum, Mar. 31, 1901, to April 6, 1901		5.50
May 6—To T. H. Colwell for printing bulletin		266.80
May 6—To stamps for bulletin		10.00
May 6—To C. P. Berkey for services		13.20
May 28—To Prof. Hall for sundries		5.35
May 28—To Franklin Printing Co. for Exhibition placards		6.00
May 31—To sundries and postage for Secretary		6.06
Oct. 2—To Franklin Printing Co		3.00
Oct. 2—To Leslie Paper Co		6.13
Jan. 7, 1902—Cash on hand		151.64
		$1,050.64

The Corresponding Secretary reported: "accessions to the library as 292 domestic, 310 foreign publications, total 602. The issue of Vol. iii, Bulletin 3, of the Bulletins was distributed early in the year to members of the Academy and American Institutions; later in the year to foreign societies through the Smithsonian Institution. The Academy library is partly on shelves at the State University, partly in the Public Library, and partly boxed up at the University. Only a small part is available for reference."

Corresponding Secretary's report of accessions during the year 1901:

Agram, Hungary.—Jugoslavenska Akademija: Ljetopis, Vol. xv; Rad, No. 143.

Agricultural College, Mich.—Michigan Agricultural College: Bulletin, Nos. 182-192.

Albany, N. Y.—State Library: Annual Report, 1900.
State Museum: Annual Report, 1898; Bulletin, Nos. 35-42.
University of New York: Regents' Report, 1900.

Amiens, France.—Société Linnéenne du Nord de la France: Bulletin, Nos. 323-332.

Austin, Texas.—Texas Academy of Science: Transactions, Vols. III: IV: 1.

Baltimore, Md.—Johns Hopkins University: Circular, Nos. 150-154.

Bamberg, Germany.—Naturforschende Gesellschaft: Bericht, Vos. XVIII.

Barcelona, Spain.—Real Academia de Ciencias y Artes: Bulletin, Vol. I: 27-30; Nomina Personal, 1900-1901.

Basel, Switzerland.—Naturforschende Gesellschaft: Verhandlungen, Vol. XIII: 1.

Berlin, Germany.—R. Friedländer & Sohn: Naturæ novitates, Vol. XXII, XXIII.

Béziers, France.—Société d' Etude des Sciences Naturelles: Bulletin, Vol. XXII.

Bombay, India.—Royal Asiatic Society: Journal, Vol. XX: 56.

Boston, Mass.—American Academy of Arts and Sciences: Proceedings, Vol. XXXVI.

Boston, Mass.—Horticultural Society: Transactions, 1900.

Brisbane, Queensland.—Royal Society of Queensland: Proceedings, Vol. XVI.

Bruxelles, Belgium.—Société Belge de Géologie: Bulletin, Vol. XIV.

Bruxelles, Belgium.—Société Malacologique de Belgique: Bulletin, 1900, 1901.

Bruxelles, Belgium.—Société Royal de Botanique de Belgique: Bulletin, Vol. XXXIX.

Buenos Aires, Argentine.—Instituto Geographico Argentino: Bulletin, Vol. XX: 7-12.

Buenos Aires, Argentine.—Museo Nacional: Com's. Vol. I: 7, 8.

Buenos Aires, Argentine.—Sociedad Cientifica Argentina: Anales, Vols. L, LI, LII.

Calcutta, India.—Geological Survey of India: Memoirs, Vols. II: 2; III: 1, 2; XXVIII: 2; XXX: 2; XXXIII: 1.

Cambridge, Mass.—Harvard College Observatory: Annals, Vols. XXXVII: 1; XXXVIII: 2; XLVIII: 7; Annual Report, 1900.

Cambridge, Mass.—Museum of Comparative Zoology: Bulletin, Vols. XXXVI: 7, 8; XXXVII: 3; XXXVIII: 2; XXXIX: 1.

Cape Town, South Africa.—South African Philosophical Society: Transactions, Vols. XI: 2; XII, pp. 1-563.

Cardiff, England.—Naturalists' Society: Report and Transactions, Vol. XXXII.

Catania, Italy.—Accademia Gioenia di Scienze Naturali: Bulletin, Nos. 64-70.

Chapel Hill, N. C.—Elisha Mitchell Scientific Society: Journal, Vol. XVII.

Cherbourg, France.—Société National des Sciences Naturelles: Memoirs, Vol. XXX, XXXI.

Chicago, Ill.—Botanical Gazette: Vols. XXXI, XXXII.

Chicago, Ill.—Field Columbian Museum: Publications, Nos. 45, 51-59.

Chicago, Ill.—John Crerar Library: Annual Report, Vol. VI.

Chicago, Ill.—Journal of Geology: Vol. IX.
Christiania, Norway.—Videnskabs Selskab: Skrifter, 1900.
Chur, Switzerland.—Naturforschende Gesellschaft Graubündens: Jahresbericht, Vols. XLIII, XLIV.
Colorado Springs, Col.—Colorado College: Studies, Vol. IX.
Columbia, Mo.—University of Missouri: University Studies, Vol. I: 1.
Denver, Col.—Colorado Scientific Society: Proceedings, Vols. VI; VII, pp. 13-40.
Des Moines, Iowa.—Geological Survey of Iowa: Annual Report, Vol. XI.
Des Moines, Iowa.—Iowa Academy of Sciences: Proceedings, Vols. VI, VII.
Emden, Germany.—Naturforschende Gesellschaft: Jahresbericht, Vol. LXXXV.
Firenze, Italy.—Biblioteca Nazionale Centrale: Bulletin, Nos. 357-360.
Frankfurt a d Oder, Germany.—Naturwissenschaftlicher Verein: Helios, Vol. XVIII.
Fribourg, Switzerland.—Société Fribourgioise des Sciences Naturelles: Bulletin, Vol. VIII; Memoirs, 1901.
Genève, Switzerland.—Société de Géographie: Le Globe, Vol. XL.
Georgetown, British Guiana.—Royal Agricultural and Commercial Society: Journal, Vol. XII.
Görlitz, Germany.—Naturforschende Gesellschaft: Abhandlungen, Vol. XXIII.
Graz, Austria.—Naturwissenschaftlicher Verein: Mitteilungen, Vol. XXXVII.
Guéret, France.—Société des Sciences Naturelles: Memoirs, 1900.
Guströw, Germany.—Verein der Freunde der Naturgeschichte: Archiv, Vols. LIV: 2; LV: 1.
Halifax, Nova Scotia.—Nova Soctia Institute of Science: Proceedings, Vol. X: 2.
Hamilton, Canada.—Hamilton Association: Journal and Proceedings, No. 16.
Hannover, Germany.—Naturhistorische Gesellschaft: Jahresbericht, Vols. XLVIII, XLIX.
Harlem, Netherlands.—Musée Teyler. Archives, Vol. VII: 2, 3.
Hermannstadt, Austria.—Siebenbürgischer Verein für Naturwissenschaften: Verhandlungen, Vols. XLVIII, XLIX.
Innsbruck, Austria.—Naturwissenschaftenlich-Medizinischer Verein: Berichte, Vol. XXV.
Iowa City, Iowa.—Iowa Historical Society: Records, Vol. XVII.
Kassel, Germany.—Verein für Naturkunde: Abhandlungen, Vols. XLIV, XLV.
Kiel, Germany.—Naturwissenschaftlicher Verein: Schriften, Vol. XII: 1.
Kjöbenhavn, Denmark.—Naturhistoriske Förening: Meddelelser, 1900.
Lansing, Mich.—State Agricultural College: Bulletin Exp. Station, Nos. 182-184, 186, 191.

Lausanne, Switzerland.—Société Vandoise des Sciences Naturelles: Bulletin, Vol. XXXVI.

Lawrence, Kans.—Kansas State University: Bulletin, Vols. I: 4-8; II: 1.

Liège, Belgium.—Société Géologique de Belique: Annales, Vols. XXVI, XXVII.

Liverpool, England.—Geological Society: Proceedings, Vols. VIII: 4; IX: 1.

Lüneberg, Germany.—Naturwissenschaftlicher Verein: Jahresheft, Vol. XV.

Madison, Wis.—Wisconsin Academy of Sciences, Arts and Letters: Transactions, Vol. XII.

Manchester, England.—Manchester Literary and Philosophical Society: Memoirs and Trans., Vol. XLV.

Mexico, Mexico.—Instituto Geologico Nacional: Bulletin, No. 14.

Milwaukee, Wis.—Public Museum: Annual Report, Vol. XVIII.

Montevideo, Uruguay.—Museo Nacional: Anales, Vols. II: 16, 17; III: 18, 20, 21.

Montgomery, Ala.—Geological Survey of Alabama: Plant-life of Alabama.

Montreal, Canada.—Canadian Record of Science: Vol. VIII: 5, 6.

Moskva, Russia.—Imp. Moscow Society of Naturalists: Bulletin, 1900: 1-3; 1899; 2-4.

New Haven, Ct.—Connecticut Academy of Arts and Sciences: Transactions, Vol. X.

New York, N. Y.—American Geographical Society: Bulletin, Vol. XXXIII.

New York, N. Y.—American Museum of Natural History: Bulletin, Vol. XIII.

Nürnberg, Germany.—Naturhistorische Gesellschaft: Abhandlungen, Vol. XIII.

Oberlin, Ohio.—Oberlin College: Library Bulletin, No. 5. Wilson Bulletin, Vol. VII.

Offenbach, Germany.—Verein für Naturkunde: Bericht, Vols. XXXVII-XLII.

Osnabrück, Germany.—Naturwissenschaftlicher Verein: Jahresbericht, 1899, 1900.

Ottawa, Canada.—Geological and Natural History Survey of Canada: Catalogue of Canadian Birds.

Pris, France.—Museum d' Histoire Naturelle: Bulletin, 1901.

Penzance, England.—Royal Geological Society of Cornwall: Transactions, Vol. XII: 6.

Philadelphia, Pa.—Academy of Natural Sciences: Proceedings, Vol. LIII.

Philadelphia, Pa.—Wagner Free Institute of Science: Transactions, Vol. III: 5.

Philadelphia, Pa.—Zoological Society of Philadelphia: Annual Report, Vol. XXIX.

Port Louis, Mauritius.—Royal Alfred Observatory: Meteorological Observations, 1898.

Prag, Bohemia.—Böhmische Gesellschaft der Wissenschaften: Jahresbericht, 1899; Sitzungsberichte, 1899, 1900.

Reichenberg, Bohemia.—Verein der Naturfreunde: Mitteilungen, Vol. XXXI.

Riga, Russia.—Naturforscherverein: Korrespondenzblatt, Vols. XLIII, XLIV.

Rochester, N. Y.—Rochester Aacdemy of Natural Science: Proceedings, Vol. IV, pp. 1-64.

Rovereto, Austria.—Accademia degli Agiati in Rovereto: Atti, Vol. VI: 3, 4.

St. Gall, Switzerland.—Naturwissenschaftliche Gesellschaft: Bericht, 1899.

St. John's, New Brunswick.—Natural History Society: Bulletin, No. XIX.

Saint-lô, France.—Société d' Agriculture et d' Histoire Naturelle de la Manche: Memoirs and Docum., Vol XVIII.

St. Louis, Mo.—Missouri Botanical Garden: Annual Report, Vol. XII.

St. Louis, Mo.—St. Louis Academy of Science: Transactions, Vols. X: 8-11; XI: 1-6.

Sankt Peterburg, Russia.—Imp. Academy of Sciences: Bulletin, Vol. XII.

Sankt Petersburg, Russia.—Geological Committee: Bulletin, Vol. XIX: 1-6; Memoirs, XIII: 3.

Sankt Peterburg, Russia.—Imp. Minerological Society: Verhandlungen, Vol XXXVIII.

San Francisco, Cal.—California Academy of Sciences: Proceedings, Vols. I: 8, 9; II: 4-11; III: 1; Occasional Papers, Vol VIII.

Santiago, Chile.—Société Scientifique du Chile: Actes, Vols. X: 2; XI: 1.

Sydney, New South Wales.—Australian Museum: Report, 1899; Records, Vol. IV: 1, 3, 4.

Sydney, New South Wales.—Geological Survey of New South Wales: Annual Report, 1899; Mineral Resources, No. 9.

Sydney, New South Wales.—Royal Society of New South Wales: Proceedings, Vol. XXXIV.

Stavanger, Norway.—Stavanger Museum: Aarsberetning, 1900.

Stockholm, Sweden.—Kongl. Svenska Vetenskaps-Akademien: Bihang, Vol. XXVI; Ofversigt, 1900.

Strassburg, Germany.—Geologische Landes-Untersuchung: Mitteilungen, Vol. V: 3.

Torino, Italy.—Museo Zoologico di Torino. Bulletin, Vol. XV.

Toronto, Canada.—Canadian Instituto: Proceedings, Vol. II, 4; Transactions, Vol. VII: 1.

Upsala, Sweden.—Geological Institute University of Upsala: Bulletin, Vol. V: 1.

Urbana, Ill.—Illinois State Laboratory: Bulletin, Vol. V: 12.

Washington, D. C.—Bureau of American Ethnology: Annual Report, Vols. XVI, XVII.

Washington, D. C.—United States Geological Survey: Annual Report, Vol. XXI; Bulletin, Nos. 163-176.

Washington, D. C.—National Museum: Bulletin, Vols. XLVII: 4; L: 1; Proceedings, Vol. XXII.

Washington, D. C.—Patent Office: Official Gazette, Vols. XCIV-XCVII.

Washington, D. C.—Smithsonian Institution: Annual Report, 1898.

Washington, D. C.—Weather Bureau: Monthly Weather Review, Vol. XXIX; Report, 1899.

Wiesbaden, Germany.—Naturhistorischer Verein für Naturkunde: Jahrbuch, Vol. LIII.

Winnipeg, Manitoba.—Manitoba Historical and Scientific Society: Annual Report, 1900; Transactions, Nos. 57-59.

Zurich, Switzerland.—Naturforschende Gesellschaft: Vierteljahrschrift, Vols. XLV: 3, 4; XLVI: 1, 2.

The following officers were elected:

President, - - - - - - -	C. W. Hall.
Vice President, - - - - -	O. W. Oestlund.
Recording Secretary, - - -	G. S. Beane.
Corresponding Secretary, - -	C. P. Berkey.
Treasurer, - - - - - - -	E. C. Gale.
Trustees, - - - - - - -	H. T. Eddy. E. C. Hale

President Hall then addressed the Academy on the Progress and Results of Scientific Research in Minnesota

257th Meeting, February 11, 1902.

Seven present.

Dr. J. K. Hosmer in the chair.

Program:

Studies in the Classification of Insects, by O. W. Oestlund.

Origin and Distribution of Minnesota Clays, by C. P. Berkey.

[ABSTRACT]

The paper presented was the result of the gathering of data on the clay industry of Minnesota, together with a review of the known geology of the state. The types of clays found and their occurrences were enumerated and the origin of each type outlined.

The classification made for Minnesota clays is:

1. Residuary Clays—
    - a.—From decay of feldspathic rocks,—unimportant.
    - b.—From residues of soluble rocks,—driftless area.
2. Transported Clays—
    - A.—Sedimentary Formations used as clays.
        - 1.—Argillaceous Slates:
          Huronian slates—unimportant.
        - 2.—Clay Shales:
          Ordovician shales—Southeastern Minnesota.
          Cretaceous shales—local.
    - B.—Glacial Clays:
        - 1.—Glacial till—very widely distributed.
        - 2.—Glacial Lake clays—many important deposits.
        - 3.—Glacial stream deposits—many occurrences along the Mississippi and Minnesota Rivers.
    - C.—Recent Alluvial Deposits.
    - D.—Loess or Wind Deposits,—the loam clays of Red River valley and other places.

The complete paper has been published in the American Geologist for March, 1902. Vol XXIX, pp. 171-177.

Drs. Eddy and Hosmer were appointed a committee to be associated with A. D. Roe in the management of the museum.

The President and two Secretaries were appointed a membership committee.

258th Meeting, March 10, 1902.

Chemistry Lecture room, University of Minnesota.

President Hall presiding.

A good audience was present.

A paper on A Study of the Relation between Animal Structure and its Surroundings was read by Professor H. L. Osborn of Hamline University, and illustrated by charts and specimens.

259th Meeting, April 10, 1902.

Chemistry Lecture room, University of Minnesota.

President Hall in the chair.

Eighty persons present.

Dr. F. W. Sardeson gave an illustrated lecture on The History of Vertebrata from the Devonian age to Mamamalia and Man.

A communication from the Carnegie Institute of Chicago was read and referred to the Astronomical section with power to act.

260th Meeting, May 20, 1902.

Chemistry Lecture room, University of Minnesota.

President Hall in the chair.

A good audience present.

J. P. Magnusson of Brainerd, S. J. Race of Redwood Falls, C. W. Sage, of Fountain, and C. W. Jackson, of Hallock, were elected members.

Professor H. T. Eddy gave a lecture on Attenuation and Distortion of Long-Distance Telephone and Power Transmission Lines regarded as Hydrodynamic Phenomena.

[ABSTRACT.]

The analogy of a steady flow of water in a long pipe under the action of a constant head and a continuous current of electricity under a constant pressure such as is furnished by one or more cells of a battery, has often been employed to give a clear elementary physical conception of the mathematical relations expressed by Ohm's law. In this case the applied pressure is gradually consumed by the resistance experienced by the current, and in strict analogy with the flow of water, the loss per unit of length is proportional to the product of the square of the current and the first power of the resistance. So far as the mathematical relations are concerned the two problems are identical.

The object of this paper was to extend this hydrodynamic analogy to the more complicated case of long distance transmission of alternating currents in general.

Telephone transmission was specifically mentioned in the title in order to include the general case of variable frequency. The importance of thus extending and enlarging this analogy is evident when we reflect that all the complicated phenomena of long distance lines and cables with their sending and receiving apparatus may be completely reproduced in all its details of operation by simple pumping machinery with its transmission pipes and air chambers, whose manner of operation may be made clear to any one without the aid of higher analysis.

In conclusion, it may readily be shown that in both of the two extreme cases already considered, viz., those in which either friction or inertia is disregarded, the logarithm of the reciprocal of the amplitude, or intensity of wave at any point, varies directly as the product of the distance of the point from the source of the wave by its velocity. Since this velocity has already been shown to be constant in case the fluid friction may be disregarded and to increase with the frequency in case the inertia be disregarded, it is evident that the

attenuation depends upon frequency in case of fluid friction without inertia, but it is independent of frequency in case of inertia without fluid friction. Such unequal attenuation in the telephone obliterates to a greater or less extent tones of high pitch before it does those of lower pitch. It is therefore necessary to distinct transmission that the self induction of the line should be large enough to store a large amount of kinetic and potential energy in the wave motion along the line, which in all its aspects is strictly analogous to the wave motion propagated in the water in the apparatus just described.

261st Meeting, October 7, 1902.

Public Library; President Hall presiding.

Seven persons present.

A committee of Messrs Gale, Winchell, Eddy, and Hall was appointed to consider the property interests of the Academy.

F. C. Kent, H. L. Lyons, and F. K. Butters were elected members.

O. W. Oestlund read a paper on the Classification of Insects.

[ABSTRACT.]

A preliminary account was given on an extended work on the classification of insects. Attention was called to the value of some of the early writers on the taxonomy of insects as interpreted from a modern standpoint. Linné in his first edition of his *Sytema Naturae* divided the insects into three orders, (excepting the *Aptera*): 1. *Coleoptera*, including the Orthoptera. 2. *Hemiptera*. 3. *Angioptera*, indicating three main divisions of the class. In later editions Linné did not recognize the broad characters of the Angioptera. Latreille gave more exact interpretation to the same idea in his division of the orders in two main groups, the *Elytroptera* (including Orthoptera, Coleoptera, and Hemiptera), and *Gymnoptera*, equivalent to Linné's Angioptera.

It was pointed out that the so-called incomplete and complete metamorphosis has not the taxonomic value usually ascribed to it in dividing the insects into two series, the Heterometabola and the Holometabola. Metabolism is characteristic of the class and is undoubtedly monophyletic. The heterometabola are more primitive than the holometabola, but the holometabolous condition is polyphyletic, arising separately in several cases as in the Coleoptera, the males of the Coccidæ, and probably also for the Hymenoptera.

Paleontology also indicates some fundamental characters in the fact that the Paliodictyoptera contain three distinct lines of development: the Orthopteroidea, Hemipteroidea, and Neuropteroidea of Scudder. From the Orthopteroidea line of development we have the mod-

ern orders Orthoptera, and Coleoptera; the Hemipteroidea give us the Hemiptera and Homoptera; the Neuropteroidea have split up into the orders Neuroptera, Hymenoptera, Lepidoptera, and Diptera. Adopting Latreille's terms for the first and the third, and that of Fabricius for the second we have the three series Elytroptera, Rhynchota and Gymnoptera.

The three lines of modifications are also indicated by their habitat as one of the underlying causes. The Elytroptera are ground insects, hence their modification of the front wings for protection. The Rhynchota are semi-parasitic on plants, hence their main line of modification is seen in the formation of the jointed beak for piercing and sucking. The suctorial Hemiptera existed long before the suctorial trophi of the other orders had come into existence, and is a more primitive type than those of Diptera. The Gymnoptera are mainly arborial or aerial in habitat, the birds among the insects, hence their peculiar modifications of the wings so distinct from the first.

There are also some ontogenetic facts that point the same way. The embryonic membranes of primitive insects were temporary organs and did not persist to the time of hatching. Blastokenesis is characteristic of primitive Orthoptera, Hemiptera and Neuroptera. It is only in the more modern orders that one or both of the membranes persist to the time of hatching. Based upon these and other facts that await a future and more extended treatment, the following arrangement of the orders of insects into series was proposed.

Series *Elytroptera*. Ground insects; wings dissimilar, front pair elytra, hind pair membranous and folded when at rest, of primary importance in flight; trophi mandibulate. Orders:

Orthoptera, s. l.
Coleoptera.

Series *Rhynchota*. Semiparasitic; trophi forming a jointed rostrum adapted for piercing and sucking. The sucking trophi already present at the time of hatching. Wing modification of secondary importance in comparison with the Elytroptera, and Gymnoptera. Metamorphosis gradual. Orders:

Hemiptera.
Homoptera.

Series *Gymnoptera*. Arborial or aerial insects; the two pair of wings similar, the front pair of primary importance in flight; the hind pair often reduced or lost. Trophi mandibulate in Neuroptera; suctorial in the Hymenoptera, Lepidoptera, and Diptera. Orders:

Neuroptera, s. l.
Hymenoptera.
Lepidoptera.
Diptera.

The recognition of a larger number of orders, as the 17 of Brauer, or in a probable still greater division of the future, in no way invalidates the recognition of three series in place of two, but brings out a number of additional facts in its favor.

262d Meeting, January 5, 1903.

ANNUAL MEETING.

Secretary Berkey presiding.
Nine persons present.
The officers elected were:

President. - - - - - - - -	T. B. Walker.
Vice President, - - - - -	C. P. Berkey.
Corresponding Secretary, - -	O. W. Oestlund.
Recording Secretary, - - -	Geo. S. Beane.
Treasurer, - - - - - - - -	Edw. C. Gale.
Trustees for three years, - -	A. D. Roe. J. K. Hosmer.

Dr. A. H. Elftman read the outline of a paper prepared by him last year for presentation before the Geological Society of America on Moraines of Glacial Retreat across Minnesota.

263d Meeting, February 3, 1903.

President Walker in the chair.
Eight persons present.

The retiring Corresponding Secretary, C. P. Berkey, reported library accessions for the year 1902, as 393 foreign and 373 domestic publications, coming from 92 foreign and 60 domestic societies.

The total number of publications in the Academy Library to January 1, 1903, was 10,674:

Report of the Corresponding Secretary of accessions during 1902:

Agram, Hungary.—Jugoslavenska Akademija: Ljetopis, Vol. xvi; Rad, Nos. 147, 149.

Agricultural College, Mich.—Michigan Agricultural College: Bulletin Exp. Station, Nos. 193-202.

Albany, N. Y.—State Library: Annual Report, 1901.
State Museum: Annual Report, 1899; Bulletin, Nos. 48-57.
University of New York: Regents' Report, 1901.

Altenburg, Germany.—Naturforschende Gesellschaft: Mitteilungen, Vol. x.

Amiens, France.—Société Linnéenne du Nord de la France: Memoirs, Vol. x.

Baltimore, Md.—Johns Hopkins University: Circular, Nos. 155-160.

Barcelona, Spain.—Academia de Ciencias y Artes: Bulletin, Vol. II: 1-4; Memoirs, Vol. IV: 1-27; Nomina Personal, 1901.

Basel, Switzerland.—Naturfoschende Gesellschaft: Verhandlungen, Vols. XIII: 2, 3; XIV.

Belfast, Ireland.—Natural History and Philosophical Society: Report, 1900, 1901.

Berlin, Germany.—R. Friedländer & Sohn: Naturæ novitates, 1902.

Bombay, India.—Royal Asiatic Society: Journal, Vol XXI, No. 57.

Bône, Algeria.—Academie d' Hippone: Comptes Rendus, 1900.

Bonn, Germany.—Naturhistorische Verein: Verhandlungen, Vols. LVII: 1, 2; LVIII: 1; Sitzungsberichte, 1900, 1901.

Boston, Mass.—American Academy of Arts and Sciences: Proceedings, Vols. XXXVII; XXXVIII: 1-9.

Boston, Mass.—Boston Society of Natural History: Proceedings, Vol. XXX.

Boston, Mass.—Horticultural Society: Transactions, 1901.

Boulder, Col.—University of Colorado: Studies, Vol. I: 1, 2.

Bremen, Germany.—Naturwissenschaftlicher Verein: Abhandlungen, Vol. XVII: 1.

Brisbane, Queensland.—Geological Survey of Queensland: Publications, Nos. 127-178.

Brisbane, Queensland.—Royal Society of Queensland: Proceedings, Vol. XVII: 1.

Brünn, Austria.—Naturforschender Verein: Bericht, Vols. XVIII, XIX; Verhandlungen, Vols. XXXVIII, XXXIX.

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A committee of T. B. Walker, N. H. Winchell, and C. P. Berkey was appointed to seek recognition and financial aid from the State Legislature.

264th Meeting, March 3, 1903.

Vice President C. P. Berkey in the chair.

Twenty persons present.

Program:

Some Minnesota Glacial Problems, by Dr. A. H. Elftman.

Review of the Question of the Age of the Fossil Man of Lansing, by Prof. N. H. Winchell.

265th Meeting, February 2, 1904.

ADJOURNED ANNUAL MEETING.

Secretary pro tem Roe presiding.

Reports of Treasurer E. C. Gale for 1902 and 1903 were read and approved.

Report of 1902:

Balance from 1901	$151.64	
Receipts from museum from April, 1901, to September 14, 1902	900.70	
		$1,052.34

Contra:

Cash paid Curator Roe for museum services April 1, 1901, to September 14, 1902	$698.95

To insurance for for three years	11.00	
" Fisher Paper Box Co	5.55	
" University Press, printing	4.00	
" Franklin Printing Co.	3.00	
" cleaning museum	8.00	
" postal cards to G. S. Beane	1.75	
Balance on hand	320.09	
		$1,052.34

Report of 1903:

Balance from 1902	$320.09	
Contra:		
To Cor. Sec'y. Berkey for clerk hire and expenses	$ 26.25	
Jan. 30—To Rec. Sec'y. for printing and postage,	3.80	
May 28—To expenses on publications from Univ. of State of N. Y.	1.69	
May 30—To Rec. Sec'y. Beane for printing and postage	5.50	
Jan. 5, 1904—Cash on hand	282.85	
		$ 320.09

Report of the Corresponding Secretary of accessions for the year 1903:

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Austin, Texas.—Texas Academy of Science: Transactions, Vol. V.

Baltimore, Md.—Johns Hopkins University: Circular, Nos. 162-165.

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Cape Town, South Africa.—South African Philosophical Society: Transactions, Vols. XII, pp. 561-920; XIV: 1, 2.

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Madison, Wis.—Geological and Natural History Survey: Bulletin, Nos. 8-10.

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Stockholm, Sweden.—Kongl. Svenska Vetenskaps-Akademien: Bihang, Vols. XXVII, XXVIII; Archiv, Bot. 1: 1-3; Kemi 1: 1; Math. 1: 1, 2; Zool. 1: 1, 2; Arsbok, 1903.

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Sydney, New South Wales.—Royal Society of New South Wales: Journal, Vol. XXXV.

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Urbana, Ill.—Illinois State Laboratory: Bulletin, Vol. VI; Index to Vol. V; Biennial Report, 1899- 1900.

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Washington, D. C.—Patent Office: Official Gazette, Vols. CII-CVI.

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Winnipeg, Manitoba.—Manitoba Historical and Scientific Society: Annual Report, 1902; Transactions, No. 63.

Zurich, Switzerland.—Naturforschende Gesellschaft: Vierteljahrschrift, Vols. XLVII: 3, 4; XLVIII: 1, 2.

Zurich, Switzerland.—Physikalischen Gesellschaft: Mitteilungen, Nos. 3-5.

The foregoing report summarized shows 798 accessions from 143 societies and institutions.

The election of officers resulted as follows:

President, - - - - - - -	Professor C. W. Hall.
Vice President, - - - - -	Dr. A. H. Elftman.
Recording Secretary, - - -	Harlow Gale.
Corresponding Secretary, - -	O. W. Oestlund.
Treasurer, - - - - - - - -	E. C. Gale.
Trustees for three years, -	N. H. Winchell. Dr. T. S. Roberts.
Trustee for two years, To succeed Dr. Hosmer -	T. B. Walker.

Professor Hall then gave a resume of the papers and discussions on the Mississippi river in Section D, St. Louis meeting of the American Association for the Advancement of Science.

266th Meeting, March 8, 1904.

Psychological Laboratory of H. Gale, 812 S. 4th St.

Seven persons present.

President Hall in the chair.

The President announced that the Articles of Incorporation of the Academy were filed on March 31, 1876.

Professor John Zeleny read a paper on The Rate of Propagation of Smell.

[ABSTRACT.]

The speed with which smell is propagated through air was investigated for some substances by letting the smell pass through tubes where the disturbzing influence of convection currents in the air is practically avoided.

It was found that the speed is quite small, showing that the rapid propagation ordinarily observed in free space is due almost entirely to convection currents. For example with ammonia diffusing through a glass tube 1.5 meters long and .76 cms. in diameter, over two hours elapsed before the smell could be detected at the other end of the tube. With different lengths of tubing it was found for ammonia and hydrogen sulphide that the time required for the diffusion of the smell was roughly proportional to the square of the length.

The presence of ammonia could be detected chemically at a given point in a tube in about the same time as when the sense of smell was used for a detector.

The rate of propogation of the smell of ammonia was not markedly different when this had to pass along the same tube either horizontally or vertically upward or vertically downward. With camphor, however, while the rates horizontally and vertically downward were about the same, the speed upward was about twice as great.

The smell given to brass and iron by rubbing them with the fingers was also tried but gave no definite results.

Professor O. W. Oestlund gave a review of recent entomological literature, speaking especially upon some papers by Marie V. Linden on pigments of Lepidoptera.

267th Meeting, April 11, 1904.

Geology Lecture room, University of Minnesota.

Thirty persons present; President Hall in the chair.

Pursuant to notice at last meeting the yearly dues of resident members were reduced from $3.00 to $1.00, the same as of non-resident members. The President explained that this does not affect the customary election fee of $5.00. Program: "The Gypsum Deposits of New York," by Mr. A. L. Parsons, being a preliminary report of his original studies under the Director of the N. Y. State Museum, illustrated with lantern slides and closing with an historical sketch of the process of manufacturing gypsum.

Wm. A. Bryan of the Bishop Museum, Honolulu, described this museum with the help of lantern slides. He then described his present work here in Pillsbury Hall, where he has been for some weeks examining the unmounted Menage collection of Philippine Islands birds, as part of his plan of working up the birds of Polynesia as he has already done those of the Hawaiian Islands. At the close of his talk he showed many of the birds in his workroom.

268th Meeting, May 11, 1904.

Geology Lecture room, University of Minnesota.

Eighteen persons present; President Hall in the chair.

Program: Preliminary report on Campodia Staphylinus, a primitive wingless insect, found for the first time in the West, by Prof. O. W. Oestlund. This insect was discovered by one of Prof. Oestlund's pupils, Kenneth Taylor, and was shown under the microscope. A few specimens of Scolpendrella Alanthia were found associated with it at the same time. Its bearings on Evolution were discussed by Dr. Sardeson, Prof. Washburn, and others.

Rise of Geographical Societies in America, by Pres. C. W. Hall. Copies of the geographical magazines were shown in illustration. The lately-formed Geographical Society of Minnesota, its objects and work, were then outlined.

269th Meeting, November 9, 1904.

President Hall's study, University of Minnesota, 4 P. M.

Five persons present.

President Hall read a letter from Miss Countryman, Librarian of the Public Library, about storing the museum cases until the room intended for the Academy on the second floor is finished. The former room of the museum has been assigned during the past year by the Library Board to the library. Miss Countryman also suggested a lease of the museum to the Library Board.

It was announced that a bulletin on the Menage Expedition was ready for printing.

Program: Dr. Sardeson reported the discovery in this vicinity of a coral Tetradium, and later he had found many of them in a quarry. They occur in the Galena Series.

H. Gale described Herbert Spencer's scientific method of work as described in his lately published autobiography.

270th Meeting, December 7, 1904.

Directors' room, Public Library.

President Hall presiding.

Program: "The Great Fault Line of Eastern Minnesota," by President C. W. Hall. The paper was illustrated by maps and profiles. Discussion by Prof. Winchell, Drs. Sardeson and Elftman.

"A Remarkable Glacial Plowing in Minneapolis," by Dr. F. W. Sardeson. This was followed by discussion.

271st Meeting, January 3, 1905.

ANNUAL MEETING.

Fifteen members and visitors present.

President Hall in the chair.

H. B. Norton was elected to membership.

Report of the Treasurer, E. C. Gale, showed he had handled $1,060.55 and had a balance on hand of $345.11; it was referred to the Trustees for auditing.

Corresponding Secretary Oestlund reported 381 accessions to the library during the year, and that a bulletin of the Academy would appear in about a month.

Accessions to the Library for the year 1904:

Adelaide, South Australia.—Royal Geograhical Society: Proceedings, Vols. VI and VII.

Agram, Hungary.—Jugoslavenska Akademija: Ljetopis, Vol. XVIII; Rad, Nos. 154, 155.

Agricultural College, Mich.—Michigan Agricultural College: Bulletin, Nos. 211-220; Special Bulletin, Nos. 24, 25, 27-29.

Albany, N. Y.—State Library: Annual Report, 1903; Bulletin, Nos. 84-86, 88.

State Museum: Annual Report, 1901; Bulletin, Nos. 63, 68-76.

University of N. Y.: Regents' report, 1903.

Baltimore, Md.—Johns Hopkins University: Circular, Nos. 2, 3, 5, 7, 8.

Barcelona, Spain.—Real Academia di Ciencias y Artes: Memoirs, Vols. IV, 37-40; V, 1. Nomina Personal, 1903.

Basel, Switzerland.—Naturforschende Gesellschaft: Verhandlungen, Vol. XV: 2.

Belfast, Ireland.—Natural History and Philosophical Society: Proceedings, 1902-1903.

Bergen, Norway.—Bergens Museum: Aarberetning, 1903; Aarbog, 1903, 2; 1904, 1.

Berkeley, Cal.—University of California: Publication, Vol. I, Nos. 2-4, 6, 7.

Berlin, Germany.—R. Friedländer & Sohn: Naturæ novitates, 1904, 1-18.

Béziers, France.—Société d' Etdue des Sciences Naturelles: Bulletin, Vols. XXIII-XXV.

Bologna, Italy.—Accademia delle Scienze dell' Instituto di Bologna: Memoirs, Vol. IX; Rendiconto, Vols. V, VI.

Bombay, India.—Royal Asiatic Society: Journal, Vol. XXI, No. 58.

Bône, Algeria.—Academie d' Hippone: Comptes Rendus, 1901; Bulletin, No. 30.

Boston, Mass.—American Academy of Arts and Sciences: Proceedings, Vols. XXXIX, 13-24; XL, 1-10.

Boston, Mass.—Boston Society of Natural History: Proceedings, Vols. XXXI, 6-10; XXXII, 1, 2.

Boston, Mass.—Horticultural Society: Transactions, 1904; 1.

Boulder, Col.—University of Colorado: Dept. of Psychol. II, 1; Studies, I, 4; II, 1, 2.

Braunschweig, Germany.—Verein für Naturwissenschaft: Jahresbericht, Vols. IX, XIII.

Bremen, Germany.—Naturwissenschaftlicher Verein: Abhandlungen, Vol. XVII, 3.

Brisbane, Queensland.—Geological Survey of Queensland: Publications, Nos. 184-195.

Brisbane, Queensland.—Royal Society of Queensland: Proceedings, Vol. XVIII.

Brooklyn, N. Y.—Institute of Arts and Science: Memoirs, Vol. I, 1.

Brünn, Austria.—Naturforschender Verein: Bericht, Vol. XXI; Verhandlungen, Vol. XLI.

Bruxelles, Belgium.—Société Royale de Botanique: Bulletin, Vol XL.

Budapest, Hungary.—Hungarian Central Bureau of Ornithology: Aquila, Vol. X.

Buenos Aires, Argentine.—Instituto Geographico Argentino: Bulletin, Vols. XXI, XXII, 1-6.

Buenos Aires, Argentine.—Museo Nacional: Anales, Vols. II, III.

Buenos Aires, Argentine.—Sociedad Cientifica Argentina: Anales, Vols. LVI, 4-6; LVII; LVIII, 1-3.

Calcutta, India.—Geological Survey of India: Report, 1902-'03; Memoirs, Vols. XXXIV, 3; XXXV, 2; XXXVI, 1; Paleontol, Vols, III, 2; IV, XIV, 5; Records, Vol. XXXI, 1, 2.

Cambridge, Mass.—Harvard College Observatory: Annual Report, 1902; Annals, Vols. XLVI, 1; XLVIII, 3-8; LI; Circular, Nos. 51-73.

Cambridge, Mass.—Museum of Comparative Zoology: Bulletin, Vols. XLI, 2; XLII, 1-4.

Cape Town, South Africa.—South African Philosophical Society: Transactions, Vols. XIII, pp. 1-293; XIV, 3-5; XV, 1, 2.

Catania, Italy.—Accadémia Gioenia di Scienze Naturali: Bulletin, Nos. 79-82.

Chapel Hill, N. C.—Elisha Mitchell Scientific Society: Journal, Vol. xx.

Chemnitz, Germany.—Naturwissenschaftlicher Gesellschaft: Bericht, Vol. xv.

Chicago, Ill.—Botanical Gazette: Vol. XXXVII, 1-4.

Chicago, Ill.—Field Columbian Museum: Publications, Nos. 75, 77, 78, 81-93.

Chicago, Ill.—John Crerar Library: Annual Report, Vol. IX; List of Books on Industrial Arts.

Chicago, Ill.—Journal of Geology, Vol. XII, 1, 2.

Christiania, Norway.—Videnskabs Selskab: Förhandlingar, 1902; 1903, 1-8; Skrifter, 1902, 1903.

Chur, Switzerland.—Naturforschende Gesellschaft Graubündens: Jahresbericht, Vol. XLVI.

Cincinnati, Ohio.—Cincinnati Society of Natural History: Journal, Vol xx, 4.

College Hill, Mass.—Tufts College: College Studies, No. 8.

Colorado Springs, Col.—Colorado College: College Studies, Vols. XI, XII.

Columbia, Mo.—University of Missouri: Studies, Vol. II, 3-5; Bulletin, Vol. v, 5; Negroes of Columbia, Elwin.

Columbus, Ohio.—Geological Survey of Ohio: Bulletin No. 1.

Denver, Col.—Colorado Scientific Society: Proceedings, Vol. VII, pp. 267-340.

Des Moines, Iowa.—Geological Survey of Iowa: Annual Report, Vols. XIII, XIV.

Dorpat, Russia.—Naturforscher Gesellschaft bei der Universität: Schrifter, No. 12; Sitzungsberichte, Vol. XIII, 2.

Emden, Germany.—Naturforschende Gesellschaft: Jahresbericht, Vol. LXXXVII.

Firenze, Italy.—Biblioteca Nazionale Centrale: Bulletin, Nos. 36-47.

Frankfurt a' d Oder, Germany.—Naturwissenschaftlicher Verein: Helios, Vol. XXI.

Fribourg, Switzerland.—Société Fribourgeoise des Sciences Naturelles: Bulletin, No. 11; Memoirs, Vols. Chem. II, 1; Geol. III, 1; Math. I, 1.

Genève, Switzerland.—Société de Géographie: Le Globe, Vol. XLIII.

Granville, Ohio.—Denison University: Bulletin, Vol. XII, 8-11. Index to Vols. I-X.

Graz, Austria.—Naturwissenschaftlicher Verein: Mitteilungen, Vol. XL.

Greifswald, Germany.—Naturwissenschaftlicher Verein: Mitteilungen, Vol. XXXV.

Guéret, France.—Société des Sciences Naturelles: Memoirs, Vol. IX, 1.

Habana, Cuba.—Academia di Ciencias: Anales, Vols. XXXVIII, XLI, LI.

Hamburg, Germany.—Verein für Naturwissenschaftliche Unterhaltung: Verhandlungen, Vol. XII.

Harlem, Netherlands.—Musée Teyler: Archives, Vol. VIII, 5.

Hermannstadt, Austria.—Siebenbürgischer Verein für Naturwissenschaften: Verhandlungen, Vol. LII.

Innsbruck, Austria.—Naturwissenschaftlich-Medizinischer Verein: Berichte, Vol. XXVIII.

Iowa City, Iowa.—Iowa Historical Society: Journal, Vol. II.

Iowa City, Iowa.—State University of Iowa: Bulletin, Nos. 57, 62, 74, 88.

Kassel, Germany.—Verein für Naturkunde: Abhandlungen, Vol. XLVIII.

Kjöbenhavn, Denmark.—Naturhistoriske Förening: Meddelelser, 1904.

Landshut, Germany.—Naturwissenschaftlicher Verein: Bericht, Vol. XVII.

Lausanne, Switzerland.—Société Vandoise des Sciences Naturelles: Bulletin, Vol. XXXIX, Nos. 147, 148.

Lawrence, Kans.—Kansas State University: Bulletin, Vol. II, 10-15.

Le Havre, France.—Société de Géologique de Normandie: Bulletin, Vols. XXII, XXIII.

Liège, Belgium.—Société Géologique de Belgique: Bulletin, Vol. XXX.

Lincoln, Nebr.—University of Nebraska: Studies, Vol. IV, 1-3.

Llinas, Spain.—Obsérvatorio Belloch: Meteorological Charts, 1903.

Lüneberg, Germany.—Naturwissenschaftlicher Verein: Jahreshefte, Vol. XVI.

Madison, Wis.—Wisconsin Academy of Sciences: Transactions, Vols. XIII, XIV, 1.

Manchester, England.—Manchester Literary and Philosophical Society: Memoirs, Vol. XLVIII, 1-3.

Manila, Philippine Ids.—Museum of Natural History: Bull., Nos. 3, 4.

Metz, Germany.—Sociétè d' Histoire Naturelle: Bulletin, Vol. XI.

Mexico, Mexico.—Instituto Geologico Nacional: Paregones, Vol. I, 1-5.

Milwaukee, Wis.—Public Museum: Annual Reports, Vols. XXI, XXII.

Montevideo, Uruguay.—Museo Nacional Anales: Vol. I.

Montgomery, Ala.—Geological Survey of Alabama: Bulletin, No. 8; Index to Mineral Resources.

Montreal, Canada.—Natural History Society: Record, Vol. IX, 2.

Moskva, Russia.—Imp. Moscow Society of Naturalist's: Bulletin, 1903, 2, 3; 1904, 1.

Neuchâtel, Switzerland.—Société des Sciences Naturelles: Bulletin, Vol. XXVIII.

New York, N. Y.—American Geographical Society: Bulletin, Vol. XXXVI.

Oberlin, Ohio.—Oberlin College: Wilson Bulletin, Vols. X, XI, 1.

Ottawa, Canada.—Geological and Natural History Survey of Canada: Annual Report, Vol. XIII; Altitudes of Canada; Dictionary of Altitudes; Catalogue of Birds; Pt. 3.

Padova, Italy.—Societâ Vento-Trentina di Scienze Naturali: Atti, Vol. I, 1.

Paris, France.—Museum d' Histoire Naturelle: Bulletin, 1903; 3-8; 1904, 1-6.

Paris, France.—Société d' Ethnographie: Bulletin, Vol. XLII, 120- 122; Memoirs, Vol. IV, 13.

Penzance, England.—Royal Geological Society of Cornwall: Transactions, Vol. IX.

Philadelphia, Pa.—Academy of Natural Sciences: Proceedings, Vols. LV, 3; LVI, 1, 2.

Philadelphia, Pa.—Zoological Society of Philadelphia: Annual Report, Vol. XXXII.

Pisa, Italy.—Società Toscana di Scienze Naturali: Atti, Vol. XIV, 1-5.

Pittsburg, Pa.—Carnegie Museum: Annals, Vol. II, 2-4; Memoirs, Vol. I, 4; Publ. Vol. XXVIII.

Port Louis, Mauritius.—Royal Alfred Observatory: Meteorological Observations, 1900, 1901.

Regensburg, Germany.—Naturwissenschaftlicher Verein: Berichte, Vol. IX.

Rochester, N. Y.—Rochester Academy of Natural Sciences: Proceedings, Vol. IV, pp. 137-148.

Rovereto, Austria.—Accademia degli Agiati in Rovereto: Atti, Vols. IX, 3, 4; X, 1, 2.

St. Gall, Switzerland.—Naturwissenschaftliche Gesellschaft: Bericht, 1902.

St. Johns, New Brunswick.—Natural History Society: Bulletin, Vols. XXI, XXII.

Saint-lô, France.—Société d' Agriculture et d' Histoire Naturelle de la Manche: Memoirs, Vols. XX, XXI.

St. Louis, Mo.—Missouri Botanical Garden: Annual Report, Vol. XV.

St. Louis, Mo.—St. Louis Academy of Science: Transactions, Vols. XIII, 5-9; XIV, 6.

Sankt Peterburg, Russia.—Geological Committee: Bulletin, Vols. XXI, 5-10; XXII, 1-4; Memoirs, Vols. XIII, 4; XV, 1; XVI, 2; XVII, 3; XIX, 2; XX, 1; N. Ser. 1, 2, 4-9, 12.

Sankt Peterburg, Russia.—Imp. Minerological Society: Materialien, Vol. XXI, 2; Verhandlungen, Vols. XL, 2; XLI, 1.

San Francisco, Cal.—California Academy of Sciences: Proceedings, Vols. Geol. I, 10; Zool. III, 7-13.

Santiago, Chile.—Société Scientifique du Chile: Actes, Vols. XII, XIII, 1-3.

Semur-en-Auxois, France.—Société des Sciences Historiques et Naturelles: Bulletin, 1903.

Stavanger, Norway.—Stavanger Museum: Aarshefte, Vol. XIV, 1903.

Stockholm, Sweden.—Kongl. Svenska Vetenskaps-Akademien: Archiv. Bot. Vols, II, III, 1-3; Kemi, Vol. I, 2; Zool. Vol. I, 3, 4; Arsbok, 1904.

Stockholm, Sweden.—Entomologiska Föreningen: Tidskrift, Vol. XXIV.

Sydney, New South Wales.—Australian Museum: Report, 1902.

Sydney, New South Wales.—Geological Survey of New South Wales: Annual Report, 1902, 1903; Memoirs, Geol. No. 3.

Sydney, New South Wales.—Royal Society of New South Wales: Vol. XXXVI.

Thorn, Germany.—Copernicus Verein für Wissenschaft und Kunst: Festschrift; Mitteilungen, Vol. XIII.

Torino, Italy.—Museo Zoologico di Torino: Bulletin, Vol. XVIII, pp. 433-458.
Toronto, Canada.—Canadian Institut: Transactions, Vol. VII, 3.
Toulouse, France.—Académie des Sciences: Memoirs, Vol. III.
Trencsin, Hungary.—Naturwissenschaftlicher Verein: Jahresheft, 1902, 1903.
Urbana, Ill.—Illinois State Laboratory: Bulletin, Vol. VII, 1-3; Fish Com. Report, 1900-'02.
Washington, D. C.—Bureau of American Ethnology: Annual Report, Vol. XX.
Washington, D. C.—United States Geological Survey: Annual Report, Vol. XXIV; Bulletin, Nos. 208, 218, 233, 244; Mineral Resources, 1902; Monograph, Vol. XLVI; Professional Papers, 11, 12, 16-28; Water Supply, Nos. 87-96, 101, 102, 104.
Washington, D. C.—National Museum: American Hydroids, Part 2; Proceedings, Vol. XXVII.
Washington, D. C.—Patent Office: Official Gazette, Vols. CVII-CXII, CXIII, 1-8.
Washington, D. C.—Smithsonian Institution: Annual Report, 1902; International Exchange List.
Washington, D. C.—Weather Bureau: Bulletin, L. M.; Monthly Weather Review, Vols. XXXI, 10-13; XXXII, 1-9; Report of Chief, 1902-'03; Weather Folk Lore.
Wien, Austria.—Naturwissenschaftlicher Verein: Mitteilungen, 1903-1-8.
Winnipeg, Manitoba.—Manitoba Historical and Scientific Society: Annual Report, 1903; Transactions, Nos. 64-66.
Zurich, Switzerland.—Naturforschende Gesellschaft: Vierteljahrschrift, Vol. XLVIII, 3-4.
Zurich, Switzerland.—Physikalischen Gesellschaft: Mitteilungen, Nos. 6, 7.

Program: Some Geological Problems of the Black Hills, by Dr. A. H. Elftman.

Many charts and specimens of rocks and ores were exhibited in illustration of the paper.

The following officers were elected:

President, - - - -	C. W. Hall.
Vice President, - - -	Dr. A. H. Elftman.
Recording Secretary, - -	Harlow Gale.
Corresponding Secretary, -	O. W. Oestlund.
Treasurer, - - - - -	Edw. C. Gale.
Trustees, for three years, -	H. T. Eddy. E. C. Gale.

272d Meeting, February 6, 1905.

Thirteen members and visitors present.

President Hall in the chair.

Program: An informal talk on Recent Experiments with Homing Pigeons was given by Mr. Fred M. May, Secretary of the Minnesota section of the National Federation of Homing Pigeon Fanciers. Mr. May showed two of his homing pigeons, describing their training, races, records of speed, manner of starting and landing.

Deep wells as a source of water for Minneapolis, by Professor N. H. Winchell.

[ABSTRACT]

The author showed an outline map of the city on which were indicated the location and the depth of over sixty of the deep wells of the city, some of them being truly artesian. These included only those which are less than 450 ft. in depth, the deeper wells being excluded from the showing because of the greater mineralization of the water from the deeper strata. He stated that the water from the shallower wells is wholesome, clear, and has about the hardness of the water in the river, and hence is suitable for all domestic uses and for steam making. This source of water for city supply has been discredited because of the fact that numerous (perhaps the majority of) deep wells in the city are so deep that they derive their water from the lower strata, from 600 ft. to 800 ft., or 900 ft. below the surface. These waters incrust the boilers with a very troublesome scale and this scale sometimes has been known to choke the supply pipes. This trouble would be obviated or much reduced, by use of the shallower wells.

He also showed a map of the state on which were roughly expressed the limits of the water basins of the Jordan and the St. Peter sandstones which lie below Minneapolis and supply the shallower wells of the city. If one-tenth of their cubic contents may be assumed to be filled by water, the author stated that the gallons in the St. Peter basin amount to 4,054,110,793,200 and the water in the Jordan sandstone, about 400 ft. below the surface, amounts to 18,919,196,078,-220 gallons. These subterranean basins are kept full by the streams and all surface drainage that cross their outcrop at points distant from the city at higher positions, including the Mississippi and nearly all its northern tributaries. The Mississippi itself is the surplus overflow and is less constant, as a source for the city, than the subterranean reservoirs. Water from these basins rises nearly to the surface throughout the city, and in low places it overflows in artesian style.

The author maintained that this source for city water should be used instead of an expensive plant for filtering the river water.

(This paper is incorporated in a more extended article on the

same subject published in the American Geologist for May, 1905, vol. xxxv, pp. 266-291.)

273d Meeting, March 7, 1905.

Twelve persons present; President Hall in the chair.

Program: An informal account, aided by charts and maps, of the work of the U. S. and Canadian Boundary Survey in the Rocky Mountains, was given by Mr. F. A. Camp, who was in charge of one of the survey parties in 1904.

Pres. Hall then showed a fine collection of photographs to illustrate the Geography and Geology of the Canadian Rockies. Much discussion.

274th Meeting, May 9, 1905.

Twenty present; President Hall presiding.

Program: Explorations of Verendrye and his sons, in connection with the History and Geography of Northern Minnesota, by Warren Upham, Secretary of the Minnesota Historical Society. (See paper K.)

An informal report was made by Harlow Gale of a Case of Multiple Personality by Dr. Albert Wilson in Vol. 18, pp. 352-418, of the Proceedings of the Society for Psychical Research. Some of the wider psychological bearings of the case were presented and discussed.

275th Meeting, October 10, 1905.

The four members present on this stormy night exchanged most pleasantly and profitably their experiences in summer scientific work and reading. Prof. Winchell showed two of his own photographs of the Willamette meteorite at the Lewis & Clark Exposition at Portland. This largest meteorite in the United States is 4 ft. in height through its cone shaps, 10 ft. in diameter in its base, and weighs towards 15 tons. The peculiar drill-like perforations about its base seem to be due to air friction, while the sponge-like structure of its bottom, which was towards the surface and not much covered, Prof. Winchell thought due to the decomposition of some other mineral substances in the iron.

Dr. Sardeson reported having found some specimens of Porocrinus, and in fact he had recognized a zone at various points about Minneapolis identical with that about Toronto and Baffin's Land, so that the same shore line had run through these three places.

Professor Arndt reported on his investigations into original methods of teaching science.

H. Gale reported on the interesting picture of scientific activity, mingled with a broad culture, found in the delightful "Briefe von Dr. Theo. Billroth."

276th Meeting, November, 1905.

Secretary's minutes lacking.

Paper L, Psychology of the Business Man by Harlow Gale.

277th Meeting, December 5, 1905.

Secretary's minutes lacking.

Paper M, Glacial and Modified Drift of the Mississippi Valley from Lake Itasca to Lake Pepin, by Warren Upham.

Paper N, Meteorological Statistics covering the period from 1895 to 1905 inclusive, furnished from the records kept at Minneapolis should have been announced at this meeting for publication.

[*Paper J.*]

A MINERAL RESEMBLING MEERSCHAUM FROM THE SERPENTINE RANGE OF HAMPDEN COUNTY, MASS., WITH DESCRIPTIONS OF INTERESTING INCLUDED CRYSTALS.

By A. D. Roe.

I.—DESCRIPTIVE.

While prospecting for cabinet specimens in the fruitful mineral field of Hampden and Hampshire counties, Mass., I noticed a substance which the chemist of the Hampden Paint company called meerschaum. On interviewing the chemist, I was shown small pieces found in the disintegrating serpentine material they were using in the manufacture of chrome paints.

On my next excursion to Chester in Hampden county, I accompanied Dr. Lucas, the inventor of the chrome paint process and promoter of emery mining in that region, to the exact locality of the paint material. Here I succeeded in unearthing good sized specimens of the so-called meerschaum. From one of these a friend, a meerschaum enthusiast, carved a pipe which polished, colored and was declared to exhibit the mythical properties of sepiolite. Subsequently I secured a lease of the locality and had an excavation made to the depth of a few feet, which satisfied me there was, at that point, no large nor continuous quantity of the substance in question, but I observed indications of the manner of its formation and obtained fine included specimens of rare and interesting minerals to be hereafter described.

This pseudo-meerschaum has a specific gravity of 2.5, is usually of a compact slaty structure, under a strong glass somewhat fibrous, cleaving in two directions, giving smooth, impalpable surfaces, creamy white in color, with a glimmering, waxy luster. It adheres slightly to the tongue, yields readily to the knife, at a hardness of 2.5; it could be easily turned in a lathe but for its slaty structure which causes it to split. (See plate vii, fig. vii) It breaks with difficulty across its planes of cleavage with a very hackly fracture, but when polished gives the glimmering waxy luster of its cleavage faces. For this mineral I suggest the name hampdenite for reasons to be stated in another paragraph further on.

In composition the hampdenite and hampshirite are almost identical and closely approach some serpentines as is shown in the following table of analyses:

TABLE OF ANALYSES.

	1	2	3	4	5	6	7
SiO_2	45.78	42.09	42.83	39.38	42.54	38.60	44.1
Al_2O_3	.65	.74	.61	1.56	3.78	0.10	
Fe_2O_3					4.75		
						11.55	
FeO	8.14	11.05	15.043	13.87	5.57		
MgO	32.17	33.08	31.76	32.25	30.48	33.62	43.0
Na_2O	.27	.31	.286				
K_2O	.081	.021	.053				
MnO	1.21	1.78	1.08				
H_2O	11.44	10.01	7.16	11.90	13.13	12.82	12.9
Alkalies				.17		3.31	
	99.741	99.036	98.822	99.13	100.25	100.	100

1. Hampdenite, analyzed by E. E. Nicholson, the University of Minnesota.
2. Hampshirite, fibrous coating, E. E. Nicholson, the University of Minnesota.
3. Hampshirite, inside of crystal, E. E. Nicholson, the University of Minnesota.
4. Gray Serpentine, Brewsters, N. Y. Burt, Am. Jour. Sci., 1873, Vol. 6, p. 210.
5. Serpentine, chrysotile, Amelose, R. Brauns, Jahrbuch für Mineralogie, 1887; Beil., Bd. v, 299.
6. Serpentine, grass green, Porthalla, Collins, Quart. Jour. Geol. Soc. London, 1884, vol. 40, p. 467.
7. Serpentine, calculated, Dana, System of Mineralogy, 6th ed. p. 691, 1892.

Analyses 4 and 6 are quoted from Dana's System of Mineralogy, 6th edition, p. 672, and have not been further verified.

Noting the variation in silica and iron in the first three analyses Prof. Nicholson made a second and third determination of the iron with the result that the inside of the hampdenite which was less exposed to alteration yielded 10.24 percent of FeO which closely approaches No. 2, and the outer portion which was somewhat stained and leached yielded 8.07 percent of FeO. A second determination of the silica using the white material from the inside of the mass gave 42.78 per cent $Si\ O_2$ showing that the larger percentage of silica in No. 1 is probably due to alteration and loss of iron and magnesia. From these results it is evident that from the chemical analyses there would be no reason to make two separate varieties of these two substances, but the texture is so different that the author feels warranted in giving the name hampdenite to the massive splintery material as a distinct variety of serpentine while retaining the name hampshirite to indicate the serpentine pseudomorphs after humite.

The interior of the pseudomorphs is distinct from any serpentine that has come to the author's notice, being compact and massive, with an earthy feel and luster. The composition as determined by Prof. Nicholson is decidedly different from that obtained by Dewey* who obtained $Si\ O_2$ 50.60, Mg O 28.83, $Al_2\ O_3$ 0.15, FeO 2.59, MnO 1.10, H_2O 15.00 = 98.27, which would approximate more nearly the composition of sepiolite than of serpentine.

If the alumina and manganese be considered isomorphous with the iron and the potash and soda isomorphous with magnesia the composition for both hampdenite and hampshirite may be considered as $H_3\ Fe_4\ Mg_{21}\ Si_{18}\ O_{76}$ or 4 FeO, 21 MgO, 18 $Si\ O_2$, 15 $H_2\ O$, which would give a theoretic composition of approximately Fe O, 12; Mg O, 34; $Si\ O_2$, 43; H_2O, 11, which if we consider iron and magnesia to be isomorphous is not far from the theoretic composition of serpentine.

*Am. Jour. Sci., 1822-1823, vol. 4, 275; vol. 5, 249, vol. 6, 334.

The mineral occurs at the foot of a steep, serpentine declivity in shaly, disintegrating rock, frequently in small masses or nests whose upper surface is convex with shallow smooth corrugations, so that its slaty cleavages sometimes show decided curvature.

In opening up the nests of pseudo-meerschaum or hampdenite, I brought to light a crystal of magnetite two inches across; it was a dodecahedron with striated faces modified by the truncation of half of its solid angles; it was symmetrical in form, having a small twinned attachment on one side. This specimen was transferred to Prof. Chas. U. Shepherd of Amherst College, and it was doubtless destroyed in the burning of his collection. Other similar crystals were obtained, measuring from three-fourths of an inch to over two inches—all modified dodecahedrons, (see plate vii, figs i and ii), but none so perfect as the first one found, most of them being attached to or imbedded in the coarse steatite or serpentine debris on which the nests of pseudo-meerschaum rested.

But a more interesting find than the magnetite was in the crystals believed to be pseudomorphic after humite from one to one and one-half inches in breadth, color brownish-yellow, texture loosely steatitic, hardness 1.5, specific gravity 2.23. They showed but one termination, the lower end being attached to the coarse mass below, as were the magnetite crystals.

These crystals recalled the brief notice of Dana regarding hampshirite as analyzed by Dewey and described in vols. iv, v, and vi, American Journal of Science (first series). This mineral was discovered by Dr. E. Emmons in the town of Middlefield, Hampshire county, Mass., and was named after the county in which it occurred. Professor Dewey visited the Emmons locality, described the crystals and the manner of their occurrence in an unnamed matrix, between heavy masses of serpentine. He declared they could not be pseudomorphs but were true crystals of steatite, and thought it would be difficult to get any more crystals from that locality. He found a few crystals of magnetite in the matrix with the hampshirite. Hermann later declared the crystals Dewey analyzed to be a distinct mineral.

Professor Dewey supposes the material between the masses of serpentine was deposited in a semi-fluid condition and that afterwards the crystals of iron oxide and hampshirite developed from elements distributed through the soft mass.

The same theory could be applied to the formation of the associated minerals I have described. Iron and chromium, in various combinations, are distributed through the magnesian rocks of the region. Disintegrating and decomposing agencies, constantly operating, cause the elements to mingle and develop new combinations.

The locality of these minerals is exactly on the line of Middlefield, Hampshire county, and Chester, Hampden county, beside the highway near where it crosses the Boston and Albany railroad. From this justaposition the name hampdenite seems appropriate to the pseudo-meerschaum which I have described as the matrix of hampshirite and magnetite, and the name hampshirite, the same as has been used by Emmons, Dewey and Herman, to the orthorhombic crystals described and figured in this paper, imbedded with large crystals of magnetite in the mineral, pseudo-meerschaum, herein named hampdenite.

The specimens of hampshirite have been examined by Mr. A. L. Parsons, instructor of mineralogy in the University of Minnesota, and their crystallographic characters are reported in paragraph II below.

II.—MORPHOLOGICAL, by A. L. Parsons.

The material is well adapted for securing measurements, though most of the faces are curved and pitted, particularly the pyramidal. It seems likely that the pseudomorph was formed by the loss of a part of the original material and hydration of that remaining. A list of the probable minerals from which it could be derived comprises enstatite, olivine, and the humite group.

Enstatite is dropped from consideration on account of the non-correspondence of angles. In the case of olivine, it is possible to get forms corresponding to the prismatic faces but the pyramidal faces would not correspond. The humite group exhibits a remarkable similarity of habit and its ordinary association with other minerals is so similar that there seems but little reason to doubt the original mineral was humite or possibly chondrodite. Aside from crystallographic grounds there is strong reason to expect pseudomorphous humite or chondrodite to occur in this locality and in such association, and equally good reasons why olivine should not yield such pseudomorphs. In the first place in the deposits of magnetite of southeastern New York at Brewster's and in Orange county, chondrodite, humite, and clinohumite are all found and at the Tilly Foster mine in particular all three occur with magnetite and an earthy serpentine or talcose material in addition to other constituents. In Massachusetts, chondrodite is found at Lee, and Tyringham.* It is also found "in the pre-Cambrian limestone at the mouth of Cole's Brook, at the railroad cutting west edge of large bed, in reddish and grayish grains changing into serpentine"† and from the description of this locality it is not more than a mile from the locality from which the material under discussion was obtained, and probably in the same formation. The determination of the Massachusetts mineral has however depended upon other than crystallographic means and as the mineral is granular in all the localities mentioned it is possible that in the western part of the state at least it is to be referred to humite. So far as can be learned, crystallized olivine in good-sized crystals has not been noted in Massachusetts, Connecticut, Vermont, or New York, but it has been found in New Hampshire though not in good crystals.

The angles on Mr. Roe's hampshirite are compared below with those of humite. (See pl. vii.)

TABLE OF CRYSTAL MEASUREMENTS

Angles	Hampshirite	Humite
o_2o_2 (210)	49°—50°	49° 40½′
ce_2 (001 014)	46° 30′—47°	45° 32½′
ce_5 (001 011)	74°	76° 13′
ci_2 (001 103)	55°‡	55° 44′
cr_3 (001 216)	58°	58° 16′

From these measurements it is seen that the crystal approaches one of the types found at Wermland in Sweden*

*Dana, J. D., System of Mineralogy, 6th edition, 1892, p. 1059.
†Emerson, B. K., U. S. Geol. Sur. Bull. 126, 1895, p. 54.
‡Face not shown in figure.
*Sjogren, H., Zeits, fur Kryst. and Min., vii p. 344 et seq. and pl. vii. Also Hintze, C., Handbuch der Mineralogie, vii., p. 379, Fig. 147, 1897. Also Dana, System of Mineralogy, 6th edition, p. 535, 1892.

with the exception that the base (001) is lacking and the brachypinacoid e_2 (014) replaces the form e_4 (012) and the macropinacoid i_3 (101) is replaced by the form i_2 (103). (See plate vii, figs. iii, iv, v, and vi.)

Through the courtesy of Prof. B. K. Emerson, the material described and figured by him† has been at hand for comparison. (See plate vii, fig. vi.) In his description of the material it is to be noted that he orients his crystal in the same way as the present author, and although he mentions five forms he only gives two measurements, one of which appears to be correct and the other incorrect, on account of an imperfection in the crystal which would readily be overlooked without other material at hand for comparison. From a careful examination of Prof. Emerson's specimen, it appears almost impossible to secure measurements that will do more than give an approximation for any faces except the prism which he gives as ∞P (110) and the brachydome which he gives as $2P\infty$ (021). In the case of prism my measurements agree with those of Prof. Emerson, but in the case of the brachydome, my measurements range from 92° to 95° while he gives the angle as ranging from 79° to 81° 30′. This discrepancy is due in all probability to the presence of a pseudo-cleavage in the fibrous coating of one of the crystals, as by measuring along this cleavage I secured approximately the same angle as Prof. Emerson.

By orienting the crystal so that 010 becomes 100 it is possible to get all the prismatic and normal faces to correspond to possible olivine forms but with two exceptions they have not yet been found on olivine crystals and it seems unreasonable to refer the source of this material to olivine when most of the faces do not correspond to known forms of olivine. These faces, do, however, closely approximate the forms of humite, the association is like that of humite, and if any other ground were necessary for discarding olivine as the source and substituting humite, it would be found in the size of the crystals which vary from about ¾″ to 2″ in length, the largest under investigation being the latter size, and the average about 1½″. Inasmuch as an olivine crystal two inches long is looked upon as of extraordinary magnitude, the presence of

†Emerson, B. K., U. S. Geol. Sur. Bull. 126, 1895, p. 92, pl. 1, fig. 4.

a large number of crystals of such great size in this locality, where no trace of olivine has been found, even by microscopic means, would at least seem to indicate some other source than olivine.

III.—HISTORICAL NOTES.

The best specimen of hampshirite found in my explorations consisted of a group of crystals disclosed by cutting away the embedding hampdenite. When I came to Minnesota, this specimen was supposed to be packed for removal with a large collection previously on exhibition in a mineral store in New York City. On reaching my destination in Minnesota and unpacking my specimens, I missed the fine hampshirite and concluded the box containing it had been lost enroute. While revising this paper for publication my attention was called to the Mineralogical Lexicon of Franklin, Hampshire and Hampden counties, Massachusetts,* published by Prof. B. K. Emerson, of Amherst College. This lexicon contains notes on hampshirite which aroused my interest to that degree that I solicited of Professor Emerson the loan of the somewhat unique specimen belonging to the Clarke collection in Smith College. Through his courtesy that specimen was sent me for examination. (See plate vii, fig. vi.) Inspection proves that it is the identical specimen lost by me during my removal to Minnesota. The figure in Bulletin 126† gives a rough idea of the general appearance of this specimen, but fails to bring out fairly the unique appearance of the grouped hampshirite crystals. I took this specimen myself from an excavation in the locality above described; chipped away the embedding hampdenite from the rough block and exposed the crystals as they now appear upon the specimen. The labor devoted to this preparation as well as its peculiar formation gave an impression which leaves me no room to doubt the identity of this individual piece. I take great pleasure in inspecting this specimen and feel indebted to Professor Emerson for his courtesy in loaning it, thereby enabling me to identify beyond doubt my long lost crystal group, and thereby also enabling Professor Emerson to revise

*Bulletin 126, U. S. Geol. Survey, Washington, 1895.
†Ibid, plate 1, Fig. D.

the unique label which appears in the Smith College collection.*

The hampshirite items appearing in Professor Emerson's lexicon† lead to the presumption that but few specimens of this mineral are extant, scarcely more in number than the distinct opinions as to its nature. In reviewing the literature, it seems that Professor Dewey declared the specimen true crystals of steatite, not a pseudomorph; President Hitchcock believed them to be steatite after quartz; Herman called them a distinct species; Professor Emerson speaks of them as serpentine crystals after olivine.‡ To the foregoing opinions that of Mr. Parsons may be added declaring these crystals to be pseudomorphs after humite, an opinion which he supports by careful crystal measurements.

There is abundant opportunity in the great serpentine formations of Hampshire and Hampden counties to unearth more of the rare and interesting hampshirite. Since I have now pointed out the exact locality which was covered, not for the purpose of concealment, but because the excavation extended into the middle of a traveled highway, it is to be hoped that enthusiastic mineralogists will bring more of these rare crystals to light and Smith College may not be alone in the possession of this unique and interesting mineral.

January 3, 1899.

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* Hampshirite; steatitic pseudomorphs after quartz; Chester, Mass., on the road to Middlefield. Locality exhausted and filled up with rocks to prevent anything more being taken from it. Bailey thinks that this specimen could not be duplicated. From Row's collection; he procured it at the locality for $10.00.

†Ibid, pp. 91, 92, 152.

‡Bul. G. S. A., vol. vi. p. 473.

[*Paper K.*]

EXPLORATIONS OF VERENDRYE AND HIS SONS, FROM LAKE SUPERIOR TO THE ROCKY MOUNTAINS, 1728 TO 1749.

By Warren Upham.

My first interest in the life and work of Verendrye, the heroic first explorer of the northern border of Minnesota, came from my search for the origin, meaning, and earliest use of our Minnesota geographic names. In the year 1728, when Pierre Gautier Varennes, more commonly known by his title as the Sieur de la Verendrye, was stationed as an agent of the fur trade at lake Nipigon, north of lake Superior, a rudely sketched map was drawn for him by an intelligent Assiniboine Indian, named Ochagach, with aid by other Indians, tracing the canoe route of streams, lakes, and portages, from lake Superior along the north boundary of the present state of Minnesota to the Lake of the Woods, and thence northwestward to lake Winnipeg and the Saskatchewan river. This aboriginal delineation of geographic features northwest of lake Superior, with some names inserted by the French as derived from the Indians, was shown by Verendrye to Beauharnois, the governor of Canada, and about the year 1730 it was sent to France. The noted French geographer, Bellin, writing at Paris twenty-five years later, mentioned this sketch drawn by Ochagach for Verendrye as the earliest map of the country beyond lake Superior in the archives of the French Department of the Colonies. It remained unpublished, however, more than a hundred and fifty years, until a tracing of it was printed by Dr. Edward D. Neill, in 1882, in the fourth edition of his History of Minnesota. Two years afterward it was reprinted by Prof. N. H. Winchell in the first volume of his final report on the Geological and Natural History Survey of this state.

The series of many small lakes on our northern boundary is conspicuous on this map, and the thirteenth lake outlined, larger than any of the twelve others preceding it on the route going westward, is named Lac Sesakinaga, evidently the same as our present lake Saganaga. Rainy lake is called Lac Tecamamisuen; but the lake of the Woods and lake Winnipeg, though clearly identifiable by their delineation, the former having many islands, and the latter being narrowed at the middle, are unnamed. The Saskatchewan river, of which only the lower part is shown, not extending to the junction of its south and north branches, is called Fleuve de l' Ouest (River of the West.)

Not far south of the Saskatchewan, in the place of the Porcupine and Pasquia hills, the sketch of Ochagach bears the name Montagnes de pierres brillantes (Mountains of shining stones), which probably suggested later the names Shining mountains and Rocky mountains, applied to our great western Cordilleran belt. As known by Ochagach, however, and described by him to the French, the mountains of his sketch were doubtless the Cretaceous escarpment, generally from 500 to 1,000 feet in height of mostly steep ascent from its base to its top, south of the lower Saskatchewan and west of lakes Winnipegosis and Manitoba and the Red river. This escarpment is now known, in its successive parts from north to south, as the Pasquia and Porcupine hills, Duck mountain, and Pembina mountain, and the Coteau des Prairies, which reach from the Saskatchewan valley southward into North Dakota and to the southwest part of Minnesota.

The "shining stones" were probably selenite crystals from the Cretaceous shales, the same as those which Groseilliers and Radisson had seen, or of which they had heard some description, during their visit nearly seventy years before, in 1660, among the Prairie Sioux, in whose country, as Radisson wrote, "There are mountains covered with a kind of Stone that is transparent and tender, and like to that of Venice." The Sioux or Dakota people knew of the selenite crystals in the shales, and in the comparatively thin overlying glacial drift, which together form the Coteau des Prairies; and the Assiniboines knew of the same "shining stones" of the same formations in the Pembina, Riding, and Duck mountains, and in the Porcupine and Pasquia hills.

In 1731, Verendrye, commissioned and equipped by the Canadian government, with his sons and his nephew, Jemeraye, began their explorations far west of lake Superior, which they left by the route of Pigeon river and the series of lakes and streams continuing west along the present northern boundary of Minnesota. Fort St. Pierre, a trading post, was built at the mouth of Rainy lake; Fort St. Charles on the west side of the Lake of the Woods near its "Northwest Angle," and other forts or trading posts on lake Winnipeg and the Assiniboine and Saskatchewan rivers. Verendrye had more zeal for crossing the continent and reaching the Pacific than for the wealth to be gained by the fur trade. His expeditions did not financially meet expenses, and rivals sought to displace him from the patronage of the governor and the king; but shortly before his death, in 1749, when he had expected soon to set out again on new expeditions, the king honored him by the cross of St. Louis. The name of the St. Louis river, the largest tributary of lake Superior, probably came from this honor conferred on Verendrye. He was the founder of the fur trade in the northern part of Minnesota, in Manitoba, and the Saskatchewan region, where it greatly flourished during the next hundred years; and two of his sons were the first white men to see the Rocky mountains, or at least some eastern range of our great Cordilleran mountain belt.

The chief original sources of our knowledge of the explorations by Verendrye and his sons are the early French Colonial documents, of which a large number relating to their numerous exploring expeditions have been collected and published by Pierre Margry in the sixth volume of his "Discoveries and Settlements of the French in the West and in the South parts of North America, 1614-1754, Memoirs and Original Documents." In his last volume of the series, printed in French at Paris in 1886, pages 583-632 narrate the Verendrye explorations. The document which most interests us, as containing the narration of the journey in 1742-43 by two of Verendrye's sons to the Rocky mountains, is in pages 598-611, and is entitled "Journal of an Expedition made by the Chevalier de la Verendrye with one of his Brothers, for discovery of a passage to the Pacific Ocean; addressed to the Marquis de Beauharnois."

A very satisfactory manuscript discussion of the route of this expedition crossing the Plains from the Missouri river to the Rocky mountains, with platting of the courses as narrated, has been supplied to the Minnesota Historical Society from a corresponding member, Captain Edward L. Berthoud, of Golden, Colorado. This manuscript was received through the kindness of another member, Mr. Olin D. Wheeler, of St.

Paul, well known as the editor, for the Northern Pacific railway, of the yearly publication entitled "Wonderland," and author last year of an important historical work in two volumes, "The Trail of Lewis and Clark."

Captain Berthoud, following the narrative in the Margry Papers, shows that quite surely the Verendrye sons came, by southwest and south-southwest marching from the Mandans on the Missouri river to the Big Horn mountains. They first got a distant view of the mountains, as the Journal given by Margry tells us, on New Year's day of 1743. On January 21, in a great war party of the Indians of the Plains for attacking their hereditary enemies, the Shoshone or Snake Indians, at one of their great winter encampments, the Verendryes reached the foot of the mountains, which, as the Journal says, "are for the most part well wooded, and seem very high."

If they went, in this war raid, around or alongside the north end of the Big Horn range, they may have passed beyond the Big Horn river, coming to the Shoshone camp near the stream now known as the Shoshone river, tributary to the Big Horn river from the west, so that the mountains near whose base was the camp of the Snake Indians would be the Shoshone mountains, close southeast of the Yellowstone Park. Probably their extreme advance, to the Snake Indian camp, was somewhere in the foot-hills of the lofty and extended Big Horn range; and if they went beyond that range, I think that it was only to the Shoshone mountains.

The general route of the return was eastward to the Missouri river, as narrated in the Journal, and thence northward up the west side of the Missouri, to the Mandan villages, from which the expedition had started. This part of the journey is not considered in Captain Berthoud's manuscript. Both the outward march and the route of the return are well discussed by Parkman in his work of two volumes, "A Half Century of Conflict," published in 1892. Volume II, in pages 29-58, with a sketch map of the routes going to the Rocky mountains and returning east to the Missouri, as recorded in the Journal printed by Margry, gives a very vivid account of this whole expedition.

When the Verendryes reached the Missouri on the return, a cairn monument was erected by them on some hill or point of the bluffs overlooking that great stream, and a leaden plate, commemorating the expedition, was buried. This locality was somewhere near the present south boundary of South Dakota, about a months' travel below the Mandan villages. It would be a most interesting discovery, if this plate of lead, "bearing the arms and inscription of the king," could be found. Its burial was unknown to the Indians, who were merely told that the cairn was built as a memorial of the coming of these Frenchmen to their country.

It may well be hoped that some county yet to be formed on the northern border of Minnesota will receive the name Verendrye, in historic commemoration of the explorations, hardships, and sacrifices of the patriotic and truly noble Sieur de la Verendrye and his sons.

May 9, 1905.

[*Paper L.*]

THE PSYCHOLOGY OF THE BUSINESS MAN.

By Harlow Gale.

Having lived largely among business men for the past two years, after having been studying and teaching Psychology for eighteen years, it has been interesting to me to observe the mental life of the typical business man as he is specially different from the working man and professional man.

His eyes and ears, as the avenues of his connection with the world about him, are unusually acute and alert for everything connected with his business. He can size up the topography of a saleable piece of land, spy out new houses for insurance, hear an indistinct telephone order, or catch up customers' foreign names in a surprising way. The touch sense of the cloth and paper dealer is very sensitive; even the sense of taste and smell in the druggist and tea merchant is unusually acute. The special sense, then, which is of particular use in the life of each business specialist has been developed somewhat more than in the average man, just as the only remaining sense, that of touch, has been so remarkably developed in Helen Keller, Laura Bridgeman, and even in the merely blind.

Watch a business man rapidly going through a huge pile of correspondence, dictating letters in the midst of a noisy store or crowded office, reading his trade journal in the street car, or talking "business" on the street corner, and one sees a strong concentration of attention. The life insurance agent looks you straight in the eye and is not troubled with mind-wandering. The trader seizes the kernel of your proposition without being distracted by the blinding chaff. The drug buyer can turn from sulphur to patent medicines, from Christmas fancy goods to figuring complicated rebates, all with the greatest rapidity and no sign of confusion. Even in the midst of fatigue and sickness from overwork, it is often pathetic to see the business man's bulldog tenacity of attention.

Yet this astounding concentration of attention applies again, like the sense of acuteness, to each man's own business. The grain man's eyes wander and he yawns when he is talked to about violins or bricks; but mention chicken feed by chance and he wakes up. While I once enthused over the wonderful fall foliage of a grove of oaks on a vacant residence block of land, my companion, a real estate man, could only see and remark the burden of taxes as compared with the rising value of the unearned increment of the land and on passing his flat building which was being renovated and so much improved architecturally, that I could not help but compliment him on it, he could only reply by a long tale of his tribulations with his Union workmen. And, on my trying to suggest whether there were not some compensating advantages for co-operation in Trades Unions to offset his Union plumbers deserting him in the midst of a torn-up bathroom because they spied his janitor doing a little floor varnishing, he could not be brought to give these "theoretical" things any attention.

In remembering his own business matters, a man is also remarkable. Never can I forget the fun we used to have as young people with an apprenticed hardware clerk as we often called on him at social gatherings to reel off the long price lists of nails and glass, with their complicated discounts. He had of course never sat down and studied these lists; they had "just come to him in the store" by frequent use and by a pride he felt as a "promising young business man." The veteran old book store man can carry about more old editions and magazines in his head than the professional librarian. The life insurance solicitor hardly needs to refer not merely to his own book of rates but also to those of his competing companies and fraternal orders, nor does he forget the horde of solicited men who "don't need any insurance just now but may a little later." An old sewer foreman can give a new brick inspector a history of all the sewers he had built for the city during twenty-five years. The bank cashier carries in his responsible head a summary of business lives which far excels in detail the card catalogs of the mercantile agencies.

Thus what is useful to the business man he has precious little trouble in remembering. He needs no more coaching by patent memory systems to recall his necessary business details than to recognize his own stenographer or keep an appointment to sell a lot. The clan of Loisette trainers of "Memory" (as though it were a special muscle or rubber compartment instead of a complicated brain function attendant on all our sense perceptions and thought associations) have waxed strong by the despairing credulity of teachers, preachers, lawyers, and candidates for examinations who are forced to learn rules of mere words or gradgrind facts which fill no longing in their own or others' lives.

When it comes to doing things, the business man is a wonderful study in ideo-motor reaction or "Will," as such motor life was personified by the older psychologists. The idea of sluicing off a city mountain of dirt to tide flats for a great railway terminal no sooner comes into a vigorous Pacific coast man's head than he begins to do it, though it requires a long series of attempts at persuading the railway officials that the terminal can be made, the city officials that they should rent him the reserve water pumps, and the bank officials that they can risk him money for the venture. The idea of unusual profits in Kansas oil stimulated thousands of men to scrape together some money to put into the speculation. The idea comes to an insurance clerk to break away from his business master and set up for himself; he finds a little agency buys it with hardly money enough to pay his first month's rent, but he hustles about among his friends and makes a go of it. His friends are astonished at this sudden exhibition of "will power"; but this was his first really own idea. hitherto his ideas had been made by his family for him. The idea of putting his house rent into buying his own home occurs to a wholesale clerk with a growing family: he has to twist and turn by all kinds of plans to make some cash payment and see his way through the extra-sized rent payments, but he does it. This epochal family event gives him stimulus toward his idea of making himself so useful to his firm that they will give him some share in their stock,—all of which he in time accomplishes.

Because most plans of business men are quite complicated, involving many preliminary and side activities before the final compound end can be reached, a strong tenacity to the ultimate end is developed. Such a far-reaching persistence has also developed a complicated self-control. The business man is master of his muscles and expressions under sudden and new conditions. How far is this developed above the child with its primitive motor reaction of immediately grasping or wanting everything that attracts its attention!

When we observe how the business man gets the ideas and plans which he acts out, the first evident principle is imitation. Just as all follow the tailor's fashion plates and the changes in collars, hats and shoes, so the lowering and enlarging of show windows spreads up and down the retail streets. Just as the first bicycle or automobile is immediately lengthened out into a universal procession by all the live business men, so the advertising by one house furnishing firm of "Your credit is good at the Chip of the Old Block" is followed by all the other furnishing houses offering "Good Credit," "Your Own Terms," "We take care of our customers," &c., &c. The first cheap grade department store is followed by the enlarging of the old dry goods and carpet stores into selling everything from potatoes to pans, flowers and drugs. The magic spread of the typewriter, cash register and computing scales cannot be accounted for by their usefulness alone; many a small office or store is forced to go in prematurely for these machines "because the others do." The smoking, drinking, club and lodge habits, the winter flying trip to California or the South, the summer exodus to the mountains or the lakes, the shooting or trout fishing trip of the fall and spring and the occasional flight abroad are largely on the sheep-psychology principle of "follow the leader."

Some amusing examples of the conservatism of imitation,—for the one is largely founded on the other,—occurred to me with foreign tradesmen. Having evolved a pattern for a four-in-hand tie which was of certain unusual aesthetic proportions (for I was engaged, among other psychological experiments, in some on the mean-proportional relation in aesthetics) and was to be made so that, both ends and both sides could be used, I took this pattern and description to the best furnishing firm in Leipzig to get a dozen ties made up. After much consideration and perplexity the proprietor confessed that this was too new for his shop and that he would have to send the pattern over to England, from whence the ties finally came. Similarly at the shirt makers my plan for a small bosom shirt, that would be more comfortable and serviceable than a full sized bosom-board the whole length under one's vest, was met with the reply—"We never make them so." On my finally coaxing them to try and offering to pay extra for their trouble, the shirts were produced; but to my sample had been added a triangular piece over the opening between the shoulders. When I objected that I saw no utility in this addition to my design they only said—"We always make them so," and they could not think of removing the appendage until I insisted that I could remove it in a moment with their scissors. Likewise my English tailor insisted, tho to his loss and against my suggestion, in sewing by hand, as was his custom, rather than by machine the many yards of periphery around my long ulster and cape overcoat. Tho our American business men are by no means such blind followers of imitation, and tho there probably remains a relatively small circle of possible improvements in business methods as compared with the wonderful progress already made, yet imitation seems to be the overwhelming acting principle in each man's own business, just as it is the almost exclusive principle of his personal conduct.

The minority method of getting new ideas to put into practice is by reasoning. This is of course not always easy or sure to separate from imitation and there is probably a mingled zone of their mutual action between each's preponderating or exclusive field. But when a rental agent, e. g., who takes charge of an old house which has long sought in vain a tenant by simply exposing an imitation "For Rent" sign, freshens up the decrepit house front with a trifle of paint and a few shingles, he is not disappointed in his reasoning that this slight improvement will lead some house-seeker to the reasoned illusion that the whole house has been renovated or cared for. The fashionable city grocer reasons that he can hold the summer trade of his exodus host of customers to the neighboring summer resort by starting a branch store within their telephone and delivery limits. Of course his reasoned success is followed by many imitators, just as the success of the reasoned idea of attracting an enlarged public thru the mazes of a big department store by perching a dainty restaurant up across the furniture and china floor was followed by less original competitors. Is it possible now, among the hoard of imitators, to find the original reasoner who originated the brilliant advertising imposition of odd-figure prices, by which advantage is taken of the almost irresistible illusion that 99 cents is quite a ways off from a whole dollar and the inference that 32 cents must mean close figuring on profits, when the fact is that the 32 cent article could be bought at the old reliable store for an even quarter? The idea occurs to an old brick-teamster of making iron tongs which will pick up a good arm load of nine bricks, saving back, muscles, and time, in unloading bricks from a car to a wagon; reasoning out thus an artificial, large and sure hand as a betterment on the customary laborious and wasteful carrying or pitching of bricks from hands to hands. The imitator brick man, on seeing this "good scheme," and finding it not patented, naturally asks, in his reasoning, where the discoverer got them made and how much they cost. But if, on getting the tongs thus duplicated, the imitator reasons that tongs which seem to work effectively in unloading cars will be also effective in unloading from the wagon or loading from the kiln, such expectations will be disappointed.

The fresh college graduate, whose wealthy father has just died, is immediately approached with all sorts of business propositions on the reasoned expectation that he will be more easily influenced in favor of new schemes than the experienced paternal accumulator of his inherited money. The arguments for the visible typewriters and the distributed life insurance surplus are met by the counter arguments that an experienced typewriter or buyer of life insurance does not need or want to see his writing or the whereabouts of his surplus. The advantages of the exclusive wire telephone service is sought to be overcome by the cheaper cost of the community wire system. A veteran book seller surprises his street-gazing public by giving up his costly display window and moving his books to the unused sides of the much-traveled corridor of the latest big department store, because he reasons that his decreased sales to the mere passers-by will be more than compensated by his greatly decreased rent.

More entangled cases of business reasoning deal with estimates of character. A street railway manager described to me how he learned to "size up" applicants for positions by standing them up in a row, comparing the physiognomy of their heads, eyes, nose, and mouth; their standing posture and gait; their muscular vigor by a hand shake; and, if uncertainty yet remained, their voices, words and expressions in conversation. By scaling up and adding together these elementary signs of character in a way he could not further analyze or describe, he became quite expert in choosing men within the company's required variations of character. Yet he added that some remaining uncertainty and disappointment by this method of choosing employees was later helped by looking up the past working or business history of each applicant; for often more far-reaching inferences can be drawn from past actions to future actions than from the physiognomy signs of character. Likewise the bank cashier not merely becomes unconsciously a skilled reader of human character, but he wants to know the details of the borrower's plans and resources in order that he too may reason as to the promised repayment of the bank's money. And, if any doubt remains, the cashier's caution of their combined reasonings requires the name of an indorser whose financial reasoning and resources are willing to share the risk of the applied-for loan. In a similar way every petty tradesman or large wholesaler has to judge of the promised payments of his customers, leading to the caution against charging to strangers or too friendly friends, or entailing an expensive and most important department of "Credits." Thus the great mercantile agencies have developed out of the individual business man's reasoning as an organized and wide-reaching method of foretelling the probable means and expectations of the almost universal army of debtors. Think what an insignificant amount of business could be conducted if our credit civilization suddenly returned to the primitive cash or barter basis of exchange by eliminating the enormous and complicated business machinery built up on the reasoned-out expectations of future human actions from their past actions and character!

As to the two kinds of reasoning, induction and deduction, my observation and conviction is that the overwhelming part of the business man's, as well as all persons, serious, honest and useful reasoning is the carrying over from a more or less experienced association the belief that, when one member of the association again occurs, the other or a similar member has preceded or will follow. With the more or less conscious testing of this casual relation by the four casual tests of the methods of agreement, difference, concomitant variations and residues this makes up reasoning by induction, or from particular cases to a new case.

The little use that is made of deduction, or the referring a new case to a universal rule for its casual explanation, seems to me chiefly in cases of illusion or imposition. Thus, the house-seeker in one of the above examples, was misled by his expectation that if some of the house was cared for all the house would be. The short-cut way of disposing of a foe or competitor by referring him to the Jews, Catholics or Democrats, as though they formed a universal sure premise of bad people, is, alas, very common. The implied reasoning in "It must be good if it comes from Brown's" is the suspicious major premise that "All Brown's things are good." The promising cheapness because of a "Fire Sale" or a "Remnant Sale;" reliable quality because of staid associations with the name Plymouth, New England, or Quaker, or style because from the Palace, Regal, or Imperial is the same sort of specious deductive reasoning with which a facetious passenger accosted the seated motorman of a powerless car,—"Why don't you go on? You're my friend, aren't you?"

On turning from the intellectual life of the business man to observe his emotional life or his pleasures and pains in the wide sense,—tho of course this is an artificial separation of what are actually intermingled,—the most striking characteristic is his pleasure in activity. While we all inherit, evolutionally, an instinctive pleasure in mere bodily activity (in common with the lower animals) from this feeling's being an advantageous incentive for us to be doing something, yet the business man has developed this instinct into an executive ability far more than the working or professional man. The laboring man has the natural pleasure in activity too much exercised and worn down by fatigue; the professional man has stunted his natural activity or developed it into more indirect and artificial forms; but the business man is a business man primarily because of his vigorous pleasure in doing things. The elastic step, cheery voice, and alert face of the hurrying business man on the street are contagious signs of his joyous pleasure in work. Even now a veteran business man occasionally still clings to the early farm hours of his youth, and is down at his winter or summer office before any of his clerks and takes a worthy pride in this early activity of the day.

Such a business hustler is restless and unhappy when still. A wealthy manufacturer was finally inveigled abroad with his whole family as a precaution for his health; but he no sooner got ashore at Alexandria, Athens, and Constantinople than he instantly got into cable communication with the price of wheat and sales of his flour. The trip did him no appreciable good; he was beamingly happy on getting back again to his haunted Chamber of Commerce, and died in the prime of life at full gallop in the business harness. Another wealthy man, who had built up a great firm, laughed at the idea of his lying still in a hospital bed a couple of weeks after an appendicitis operation; and, after reasoning and entreaties had been tried on him in vain, his angry threats of getting up from bed himself and going home in his own carriage were only met by the absolute commands of the doctor to his attendants.

On the other hand, even men with less than the average instinctive pleasure in activity can become entirely devoted to business thru the operation of custom or habit, which will develop pleasure in any kind of long-continued activity that is not positively killing in its operation. Thus many a restless wealthy merchant's son, whose pleasurable activity seems for some youthful years to be confined to sporting and society novelties, grows finally to be a concentrated business machine; for, as business habits engross him more and more, his family and friends are relieved at his settling down from a roaming life of search for excitement to the customary enslavement to office hours and desks, accomplished gradually by business habits. An instructive example of an extremely exclusive and artificial business criterion of happiness, tho highly idealized by Dicken's genial humor, has been given in Nicholas Nickleby's old clerk friend, Tim Linkinwater, who judges even the reported climate, flowers, and landscapes of the whole outside world, unknown to him, by the happy habit standards of his contented London office with its dark and barren prospect.

It sometimes happens, too, that a young lawyer, preacher or professor of college philosophy, whom chance or necessity has diverted from his original youthful ideals into some unexpected business scheme, becomes, through habit, so contracted in his business activity as to quite forget his "trailing clouds of glory." If he has time at all to look back from his pursuing and pursued real estate deals, it is to smile at his boyish illusions of helping the world,—"That was all very pretty; but I've had to get down to the business of pot-boiling, and that's now good enough for me."

Not seldom a pure example of mere business activity can be seen on the streets; as a whole-souled contractor who seems always hustling about on his wheel and yet is still the petty contractor of thirty years ago; or a business property owner, who has worn out a whole stable of horses and carriages in his enormous share of building up a western city, but has only a little country homestead left in which to end his worn-out days. Yet this fearfully strenuous business worker for everybody but himself is satisfied with his life's work, while his optimistic cheer thru all his business sunshine and shadows has been an untold blessing to his community.

Allied to genius is the activity of the big-scheme man whose sole existence is the generation and execution of the original real estate auction, the first public park, a city market, glass works, a cemetery, or a fancy stock farm, a co-operation colony, etc., etc. His absorbing interest is in the discovery and initiation of the idea; while its execution he leaves, together with its business profits, if it finally has any, to smaller but more practical business parasites. Such business originality, with its disregard or neglect of its pecuniary advantages, is quite the opposite of the professional promoter of schemes whose executive energy and often unprincipled persuasive ability is solely bent on the gain. While the inventor's absorption in his ideas and their execution leads over from the business world into the art region of the creative architect, writer, poet and composer.

Along with the business man's pleasure in activity is usually associated, however, its companion pleasure of success; for it is not merely the doing, but also the succeeding, which is the aim and satisfaction of the business man. This pleasure in success is also an inherited mental instinct showing itself among the earliest mental signs of the child, having proved its serviceability in the long struggle for existence. For beyond the spontaneous activity of play there lies some goal which must be gained or the action is not successful. Imagine what a paralysis of the business world would happen if its workers suddenly lost the satisfaction of succeeding in their enterprises and merely did "busy work" like primary scholars in order to be kept occupied! A petty German harness dealer in an obscure street resisted a concert subscription with the reason that, having gained one business goal in the purchase of his own home and its adjacent lot, he was now aiming to take the special opportunity of buying his store building and lot. A veteran book-keeper, on the other hand, justified his taking a subscription by his satisfaction that his years of faithful service had at last succeeded in giving him the enjoyment of his highest needs. The son of an Irish school janitor shows a most commendable pride as he tips back in his present broker's chair and loves to recount how he has striven to be decent and respectable all thru his advancing stages of flour packer, proprietor of "241 Main St." (which he never calls a saloon), chattel mortgage loaner, flat owner, and timber land dealer. A hard working young corporation manager apologizes for his apparent luxury of a motor launch by the modest explanation that, having successively gained his business rewards of an unmortgaged home and country place, a safe life insurance provision for his large family, and one of the finest private libraries in his city, he can now reasonably begin to go in for some outward luxuries. When a reputed millionaire could not borrow a bank dollar in 1893, he proved himself a high Stoic philosopher in those straightened times by his satisfaction that at least he had accomplished something worth doing in his business evolution from a frontier store keeper thru a hardware merchant, lumberman, miller, governor, to a highly honored public benefactor. While in the uncertainties of life and billion dollar deals an irrepressible railway maker, who used to eat his tin pail dinner in the shadow of levee warehouses, pointed to his railway crossing half the map of America and said of this life's success,—"There, anyway, I've left a life mark that will stand."

Almost pure cases of the mental element of pleasure in success are seen, on the one hand, in the pitiful disappointment and shame, and in the premature ageing of an active business life, which finally encounters failure or bankruptcy. It is not the cessation of activity or the loss of the accumulated property, or the fear for the remaining necessities of life, which break the man; it is the pain of failure. On the other hand, there are the cases where the stress of business competition has so concentrated the worker's aim on success as to blind him to the living uses of the money he succeeds in getting. While the old fashioned miser, who secretly gains, hoards, and loves his gold for its own sake, is almost gone, his place has been taken a thousand fold by the modern competition—developed extreme business man who lives to win. He has developed the trust combinations and monopolies as means of beating by crushing out competition. The spirit of the modern extreme of business success is anything to beat, i. e., anything this side of a damaging public notoriety or the certainty of state's prison. The rational and normal business element of success, when it is so overwhelmingly present in the business mind, thus becomes irrational and pathological. Not that the beating-addicted hustler is always or largely planning and plotting to do up his competitors with deliberate and conscious malice. The rather does a vast deal of his mental perceptions and reasonings go on below the clear level of consciousness, down in the more or less dark regions of his subconsciousness. These considerable mental workings in so blind and mysterious a way,—which are being found to constitute a far larger part of all mental life than has ever been supposed,—all this extreme beatin-bind to the ways of genius again. Thus the "great captains of industry" are not usually by any means the frightful gorgons that they are often pictured, and ought even to be acquitted of much of the moral responsibility which is justly charged up against deliberate and conscious ill-doing to our fellow creatures. They are simply the extreme products of their strong heredity of activity and success, as developed in the beating environment of business competition.

Two more emotional traits are specially characteristic of the business man. One trait is his buoyant optimism. His belief that "it'll turn out all right" is almost unlimited. Even when his bank account is overdrawn and he does not know where the next dollar is coming from, he will give every street-greeter the confident assurance that his business is a "fine proposition." The pressure of the rent and collection agent cannot phase the shop keeper's confidence that he is all right any more than the lowering stock pointer or the losing gambling run can cool the better's confidence in his luck. And what is often so pathetic to observe is that, as a result of the business man's being rarely honestly content with his present stage of business, he exists largely by discounting his future "Great Expectations." A mighty business chorus never tires of stoutly singing—"There's a good time coming." While this optimism is sometimes merely a deceptive keeping up of appearances for the sake of credit or advertisement, it seems more often a genuine self-confidence and unconquerable belief in one's own city and country. The high bodily tension and vigorous health of the business man,—even if he does thereby run down and wear out a score of years earlier than he should, —is of course the physical basis of this undaunted optimism which is so powerfully infectious. What a picture of this American trait Dickens again has given in his jolly Mark Tapley during his business experience in the wilderness Utopia of Eden.

Along with this optimism is seen the other emotional trait of good nature. Just as the discouraged business man is quickly relegated to the care of his relations, so the recluse, unfriendly, or sour business man cannot exist under competition. Formerly, when the isolated shoemaker, tailor, or country store keeper had a monopoly of his district's trade, he could maintain some unpleasant personal idiosyncracies. But now the competition man of business has to fulfill the apostolic injunction,—"Be all things unto all men." Without the obsequiousness of the Europeans the American business man has a friendly face, cheerful greeting, and accommodating ways to all men. The book seller, insurance solicitor, or floor walker could no more be outwardly suspicious, critical, or even reserved than the cigar stand girl can afford to dress slovenly or not shake conversational dice with every customer.

This business advantage or even necessity for friendly good nature seems to have acted evolutionally towards the elimination from the business world of unpleasant dispositions; for, in spite of some artificial assumption of friendliness, the tendency is towards genuineness. The typical business man is a wholesome, gentlemanly, friendly, and cheery creature, who sheds a deal of courage, hope and sunshine thru the world. Much of this, too, he carries to the wife and children at home, except as it is counteracted by over-fatigue at the end of the day or by absorption of his interest and time in his business.

When we turn now to the lacking or harmful traits in the business mental life, the first striking characteristic is the monotony, uniformity and lack of individuality. The business forces and advantages, which conduce to a friendly good nature also tend to make all business men on the same pattern or mould. In having to be agreeable to everyone, the business man cannot seriously disagree or dispute, but the tendency is to accede and conform to others. Thus the Methodist or republican store keeper keeps these professions quiet when talking with his Catholic or democratic customer; the book seller and music teacher, who really like good books and music, have to talk and give trashy books and music to their society patrons. Even the bank cashier has to become almost an accomplished village barber in the catholicity of his conversational subjects. Just as the clothes and automobiles of the club men are hardly distinguishable from one another, so their conversation at the club lunch shows pitifully the lack of any mental individuality. In fact, to show any very decided or conspicuous mental characteristic, like an enthusiasm for chamber music, a devotion to Ibsen in the original, an aversion for club and society life, and critical distrust of religious revivals, is to make one's self peculiar, disliked, in bad form, and may perhaps harm one's credit. This uniformity is apparently not nearly so much a hiding of one's true traits as the lack of any strong feelings, convictions and interests outside his business, which go to make up a tame and unindividual personality.

And yet this illustrative case of business timidity happened to me. Wanting to have a brochure printed I warned my usual printer that some reflections in this paper on his great patron might harm him in the patron's eyes. But he assured me of his business independence and his belief in my paper until, on reading it for the first time in proof, he telephoned me with much shamefaced hesitation in his voice that he really did not know what he could do about that. Of course I relieved him from its embarrassment; he melted up the score of pages he had set up, and I took the copy, with the same warning, to another printer who had also had business relations with the same patron. Though this second printer was a fraternity brother with the first printer and both were college men, he was his business competitor and enemy, and said: "Why, of course, I can't touch this copy, though I believe it's all true; because if that damned C. got wind of it he would use it as a club against me with the N.' But I tell you what, you take it down to the little Scandinavian job printer in the basement; he'll print the job in his name, but we'll do all the composition for him, you see?" I saw and did.

Then the natural childish instinct to deception for its advantage is (strongly cultivated by competition in the business man) up to the point of its being to his disadvantage. While the results in business methods of misrepresentation and adulteration are bad enough on the whole (although some valuable material progress is made against the conservatism of buyers by the surreptitious introduction of cheaper and harmless substitutes) yet the most pernicious form of business deception is in its tendency to superficiality of workmanship and of living. Just as our ready made clothes, shoes, and building are chiefly gotten up for cheapness and looks rather than for comfort and service, so the tendency of their designers and makers is towards inflating the appearance of their persons and business. Aided by his strong optimism and discounting of the future, by which he is always living on credit, this veneering of surfaces leads the business man to all the extravagant forms of living which make up the "grand game of bluff."

The show must be kept up at any cost. His "credit," that chaste maiden for whose honor he is so punctiliously chivalrous, must be guarded from every breath of suspicion. Each business man lives in the sight of his fellows and not for himself. Those who would naturally lead a simpler life are forced by their watered-stock business position, as an advertising proposition, or by the morbid social ambition of their wives and daughters, to set and keep up a scale of wasteful living that is often a nightmare to the whole family's souls. Think what a scaling down of stores, offices, houses, and turnouts, what a plucking of feathers and silks, what a breaking of plate glass and china there would be if every business man lived with his business and family on the safe side of his legitimate income!

Another unfortunate tendency of the competition business life is to dry up rather than cultivate the instinctive emotion of sympathy which otherwise naturally grows strong in the breezily optimistic western business man especially. But where his business forces him to look out, not for exchanging fair equivalents of labor, but to get the better of his customer as one means of beating his competitor in business,—under such conditions he naturally schools himself in the selfish principle—"let each look out for himself." So, tho he cannot afford to deny or dispute openly, he will quietly or indirectly let you drop or find a roundabout way to beat you. Even the many philanthropic and public enterprises, for which are long printed lists of business supporters, are forced to almost every kind of motive and argument except a pure sympathy for a good cause. The best argument for getting business guarantors and patron subscribers for a newly founded symphony orchestra was found to be that such a musical attraction had been demonstrated to bring to the city families of means who made good business for lot-sellers, house-renters, and trade in general. Even the good Y. M. C. A. is disgustingly habituated to appeal to its business public as a "paying proposition." Thus, while the occasional business man with some freedom from perpetual competition can use his leisure and natural altruistic sentiments in working disinterestedly for public benefactions, the typical trader's purse is only touched for public affairs by some motive for private gain.

Under such conditions, too, it is no wonder that the business man, who is hounded to death with an endless round of public and private appeals, develops a weary suspicion. While it is axiomatic with him that his business deals are for business and not for philanthropy, he naturaly becomes suspicious of the ingenious variety of philanthropical causes which masquerade about the streets under the pretense of business advantage, while of course against every legitimate business proposition he has to maintain, behind all the social forms of good nature, a guarded suspicion, until he can assuredly see his own advantage in the deal.

Finally, from a bird's eye position as a psychological observer, one comes to find that the combination of all the mental and bodily traits make together a splendid example of the law of mental causation, as against the old metaphysical doctrine of free will. For, the more one gets into view the mental components of the business man, the more one can see how his past conduct has been caused and how his future action will work out. Not but that he feels himself a free man; no one questions that. But that, in spite of this freedom from outward compulsion and his consciousness of doing "just as he wants to," his hereditary tendencies and acquired habits of feeling, thinking and acting give us a more complete casual analysis of his past life and a provision into his future. So that our residuum of uncertainty as to what he will want and "will" to do, which residum further lessons with our more intimate knowledge of each man, is far more reasonably charged up to our remaining ignorance of some of his mental components than to a separate and different kernel of metaphysical "Free Will." To be sure, even the business man's restricted round of life is the resultant of a conflicting lot of hereditary and environment components focusing into one body and head. But he must nevertheless be classed at the top of other complicated products of nature and art, as a human machine, and as a machine that has been developed evolutionally into wonderful efficiency for the environment in which he exists. May the future changes in his business environment give less necessity for his fighting nature and better play for his nobler self!

Summary:

1. The business man's intellectual life thru his sense perceptions, attention, memory, imitation, and reasoning, is unusually keen and efficient as far as concerns his business; much more than the over-worked and slower working man and probably more efficient than the pro-

fessional man with his over-developed and largely distorted intellectual development. His intellectual originality seems chiefly confined to methods of his own business, as they are improved thru largely subconscious inductive reasoning, what little deductive reasoning is used being largely for deception and imposition; while the greater part of his own business and most of his ideas outside his own business are gotten thru imitation.

2. His executive ability in carrying out his ideas places him away above all other men in the strength of his ideo-motor life of action. The working man's activity is more exclusively muscular, stimulated by bodily necessities or by example, i. e., is more sensory-motor activity; while the professional man's ideo-motor activity is largely stunted or works itself out more indirectly thru words. But the business man forms the middle class between these two extremes, primarily because of his strong and absorbing activity in doing things.

3. His emotional life chiefly centers in the pleasures of activity and success, which tend to be developed in his business to a morbidly absorbing passion of beating in a fight. His pleasure in established habit and custom makes him fundamentally conservative, which conflicts with the opposite pleasure of novelty only in the venturesome reasoned-out innovations or speculations of his business and in the restless chasing after any new excitement outside of business hours; for, as he has little permanent interest or pleasure in anything outside his business, his extra-business life is the childish or dissipating pleasures in the distractions of novelty. His living in the eyes of others and on credit make him a slave to a wearing tension of fashion and extravagance. As he lacks in sympathy and trust in others, so he decidedly excels all other men in an almost unconquerable optimism and a cheery good nature.

In all his emotional life, then, the business man differs from the working man chiefly in a stronger intensity rather than a larger range of emotions, just as, on the other hand, he is inferior to the professional man in his wider variety of intellectual and aesthetic pleasures.

4. He is a splendid example of mental causation, as against metaphysical Free Will, and, for his business functions, a marvelously efficient bodily and mental human machine.
5. His better mental traits of activity, success, some sympathy, and a deal of optimistic good cheer are his more natural characteristics by instinct, except that the optimism and good nature are increased by business life; while his lower traits of an exhausting high-pressure activity, absorption in beating, selfishness, suspicion, and a narrowness of intellectual and aesthetic interests, are chiefly developed by the competition struggle of business life.

November, 1905.

[*Paper M.*]

GLACIAL AND MODIFIED DRIFT OF THE MISSISSIPPI VALLEY FROM LAKE ITASCA TO LAKE PEPIN.

By Warren Upham.

From its source in lake Itasca to Minneapolis and St. Paul, the Mississippi river traverses a large area of the late glacial drift, with many marginal moraines, belonging to the Wisconsin stage of the Ice age. In the outermost moraine belt, intersected by this river within a few miles south of St. Paul, several moraines are merged together, namely, the Altamont, Gary, Antelope, Kiester, and Elysian moraines, or the first to the fifth in the series of twelve which are traced in well defined separate courses across the west half of Minnesota. Continuing eastward through the central and eastern parts of this state, these twelve moraines have an equally conspicuous development, in belts of irregularly knolly and hilly drift, partly till and partly modified drift, rising usually to heights of 50 to 150 feet above the smoother intervening drift tracts; but two or more consecutive moraines are in many places pushed together in the vicinity of the Mississippi river and farther east, or are interlocked as a network, so that the series mapped there can only be provisionally identified with the twelve distinct and successive moraines mapped west and north of this part of the Mississippi.

Above the junction of the Minnesota river, the upper Mississippi passes through six moraines formed later than those noted as confluent close south and east of St. Paul, these of later dates being the Waconia, Dovre, Fergus Falls, Leaf Hills, Itasca, and Mesabi moraines, which in this order are the sixth to the eleventh of the Minnesota series. Only one, the last and most northern recognized in the state, named the Vermilion or twelfth moraine, runs through northern Minnesota beyond the Mississippi watershed.

Details of the course, topographic features, material and structure, and the chronologic sequence, of these most prominent drift deposits of our region, have been published throughout the many chapters describing our counties in the final reports of the Minnesota geological survey. Little attention was given there, however, to the very interesting question of the probable length of time, in years and centuries or in thousands of years, occupied by the accumulation of this numerous series of frontal moraines, marking short or long pauses, or sometimes re-advances, of the ice border during its general wane and departure from the state area.

But in another work, for the United States Geological Survey, on the Glacial Lake Agassiz, I have shown reasons for ascribing to the entire history of that vast ice-dammed lake, stretching gradually about seven hundred miles from south to north in the valley of the Red river and the basin of lake Winnipeg, no longer time than one thousand years. This is a proportional estimate, in connection with the evidence set forth by N. H. Winchell, G. F. Wright, and other glacialists,[*] both in America and Europe, including the present writer, that the Postglacial period, since the recession of the ice-sheets from the northern United States and Canada and from northwestern Europe, measures about 10,000 to 5,000 years, being approximately alike on opposite sides of the Atlantic.

In comparison with these estimates, the time required for the formation of any one of our great marginal moraines could be no more than a few decades. All the retreat of the ice-sheet on the moraine-bearing region of Minnesota, from the compound belt of marginal drift hills adjoining St. Paul to the Itasca, Mesabi and Vermilion moraines, at and beyond the most northern sources of the Mississippi, did not probably occupy more than ten or fifteen centuries. If the recession of a Mississippi cataract from the site of Fort Snelling northward, now called the Falls of St. Anthony, began only about 8,000 years ago, as shown by Winchell, the latest melting of the icefields on our northern boundary took place within some one thousand or fifteen hundred years afterward, that is, between 7,000 and 6,000 years ago.

Far greater age, however, must be attributed to the glacial drift of a tract 40 to 50 miles wide in southeastern Minnesota, lying next east of the outer moraines, which run southerly from St. Paul through the west part of Dakota county, and through Rice, Steele, and Freeborn counties, into Iowa. The tract of more ancient drift comprises much or all of Dakota, Goodhue, Wabasha, Dodge, Olmsted, Mower, and Fillmore counties, lying between the Altamont or first moraine and a large driftless area, which includes a width of 20 to 40 miles in the southeast edge of this state from lake Pepin southward, between the attenuated margin of the glacial drift and the Mississippi river. The same remarkable driftless area reaches thence nearly 100 miles east in Wisconsin, but has its greatest extent of about 150 miles from north to south, continuing, mainly east of the Mississippi, to the northwest corner of Illinois.

In the series of stages or epochs of the glacial period, characterized by alternating growth and wane of the continental ice-sheet, with advance, retreat and re-advance of its borders, ascertained by Chamberlin, Salisbury, Leverett, Calvin, and others, our tract of the old drift outside the moraines in the southeast part of Minnesota belongs probably to the Kansan stage of glaciation, when the ice-sheet attained its greatest extension in the center of the continent, probably fifteen or twenty times as long ago as the final departure of the ice from this state.

The great age of this drift is indicated in Dakota and Goodhue counties, bordering the Mississippi from St. Paul to lake Pepin, by occasional columnar or towerlike remnants of the St. Peter sandstone, of which the most noteworthy are Castle rock, about a mile east of the railway station of that name and Chimney rock, in the east edge of the northeast quarter of section 31, Marshan, about eight miles south of

Hastings. Castle rock originally had a height of 70 feet above the lowest ground at its base, and its upper 20 feet was a slender rock column, which, by the effect of subaerial erosion of its lower part, fell down several years ago. The Chimney rock here mentioned, one of several in Dakota county bearing this name, is the most picturesque and perfect example of columnar rock weathering in Minnesota, or indeed, as I believe, in our entire country. It is a vertical pillar, measuring 34 feet in height and about 6 and twelve feet in its less and greater diameters, being no thicker near the base than in its upper part. Plate VIII gives a view of this sandstone column, of which no former description or illustration has been published.

Such spires of easily crumbling sandstone could not endure the envelopment of this area by the slowly moving ice-sheet, which is known to have once existed there by the continuation of the very old drift many miles beyond these rock pillars. During the deposition of that glacial drift, knolls or small plateaus of the sandstone, capped by an exceptionally hard layer or by the next higher Trenton limestone, and having sufficient area to withstand the pressure of the ice current, doubtless occupied the sites of the Castle and Chimney rocks; and by subsequent erosion of weathering, through the agencies of rain and wind, cold and heat, the sandstone slowly crumbled away, leaving only these columnar masses. How long a time would be required for this result, we can only vaguely conjecture; but it seems probable that the 50,000 or 100,000 years which have been variously computed to have passed since the culmination of North American glaciation, in the Kansas stage, would suffice. It is evident that the relatively short time since the Illinoian and Iowan stages of glaciation would be inadequate.

The Ice age thus was very long in comparison with the Postglacial period. Indeed, the whole Quaternary era may have measured 150,000 years, or more, in which time were comprised the gradual oncoming of the ice-sheet, its repeated fluctuations, and at last its most energetic accumulation of marginal morainic hills, whenever its final melting and retreat were temporarily interrupted.

With the departure of the ice-sheet, while it was being melted back from one marginal moraine to another, yielding its ground in general by a recession from south to north, the

Mississippi valley was partly filled with modified drift, or the stratified gravel, sand, and fine silt, which form terraces or plains on either side of the river. An abundant supply of water from the dissolving ice and from rains caused the river to be in a continual flood stage during the summers; and much of the drift was then carried into the valleys of the great river and its tributaries, filling them from side to side up to the levels of their highest gravel and sand terraces. In proportion as the ice-sheet withdrew from this area, the tribute of drift borne into the valleys was greatly diminished, while yet the Minnesota and St. Croix rivers, and the Mississippi below their mouths, were flooded through every summer by the outflow of lake Agassiz and of the Western Superior glacial lake, both held by the barrier of the retreating ice-sheet farther north. Then the valley floodplains so lately formed were deeply channeled until the Mississippi flowed at levels 50 to 100 feet lower than now along some parts of its course in and adjoining Minnesota.

After the great discharge of the glacial lakes ceased, the ability of these rivers to erode their valleys was less, and in consequence the alluvium of tributaries has in some cases partly refilled the main valley. Thus the silt brought to the Mississippi by the Chippewa river during the Postglacial period has been spread as a barrier at its mouth and southward, forming lake Pepin, 25 miles long and 1 to 3 miles wide, which has a maximum depth of 56 feet in its southern part. The Mississippi valley for many miles below the lake has been refilled with the Chippewa alluvium nearly to that depth. In the same way lake St. Croix, 25 feet deep, has been formed in the St. Croix valley just above its mouth, by the barrier of the Mississippi alluvium; and likewise the shallower Lac qui Parle, on the Minnesota river, owes its existence to refilling of the Minnesota valley by the silt of the Lac qui Parle river.

In the city of St. Paul a very coarse valley deposit, allied with the modified drift, but consisting mainly of small and large fragments and blocks of the underlying Trenton limestone, is spread here and there on the level Trenton terrace plain, about 90 to 120 feet above the Mississippi and also about 100 feet below the tops of the valley bluffs. The coarse limestone debris, occasionally holding blocks of all sizes up to 20 or 30 feet in length or diameter, is seen in many places, but not continuously, along the distance of seven miles from the vicinity of Fort Snelling to the east part of the city, varying from a few feet to about 30 feet in thickness. With its commonly more or less waterworn masses derived from the Trenton limestone, which makes up nine-tenths or often nineteen-twentieths of the deposit, are everywhere scanty drift pebbles and less frequent boulders, brought from great distances at the north, which show for this unusual deposit an intimate relationship with the glacial and modified drift. It is nowhere overlain by till, nor by valley drift of the usual type. No description of this singular formation, illustrated in Plate IX, has been previously published.

Guided by helpful suggestions of Prof. C. W. Hall and Dr. F. W. Sardeson, I am led to ascribe this very coarse valley debris to erosion by the river at some time during the final recession of the ice-sheet, when the ordinary modified drift, continues with the wide floodplains of the Mississippi at Minneapolis, Fort Snelling, South St. Paul, Newport, and Langdon, had filled the valley just to the height of this limestone terrace. It is needful, however, to go back to a much earlier part of the Glacial period and thence bring forward a very important part of this explanation.

During some long interglacial stage, probably the Buchanan time of glacial recession next after the Kansas glaciation, southern Minnesota had been uncovered from the ice and the Mississippi here had sculptured its valley to nearly its present form, allowing prolonged erosion by rivulets and by weathering on this limestone tract, which reaches seven miles along the valley from southwest to northeast. This part of the valley, it should be noted, lies transverse to its general course both above and below; and it is also transverse to the directions of the glacial currents during both the earlier and later advances of the ice-sheet. Parts of the limestone surface became very irregularly channeled and decayed during this interglacial exposure of perhaps 15,000 years, as its duration is computed by Prof. N. H. Winchell from an interglacial drift-filled gorge of the Mississippi in the west part of Minneapolis. Afterward the valley here and nearly all of southern Minnesota were again covered by the readvancing ice-sheet during the Illinoian and Iowan glaciation, and were next uncovered, as I think, during the Wisconsin stage of the final departure of the ice. Then the river built up its floodplain of modified drift to a height that coincided closely with that of the limestone terrace, causing the mighty stream to flow there in rapids, carrying the limestone masses and finer debris short distances from their original beds, and in some places undermining and toppling down the very large limestone blocks.

This peculiar formation is well seen near the north end of the High Bridge, for a third of a mile thence westward, at numerous other places on that northeast side of the river through this city, and on the opposite side near the Edison school in West St. Paul. It is of very unusual and surprising character and aspect, quite unlike any other formation which I have ever found in much exploration of glacial and valley drift. Therefore the probable conditions of its origin have been sought, with the results here presented, and with the hope that other Minnesota students of glacial geology will more fully investigate the many interesting questions connected with the history of this valley during the Ice age.

December 5, 1905.

[*Paper N.*]

METEOROLOGICAL STATISTICS.

By William Cheney and T. S. Outram.

These statistics are a continuation of the personal Meteorological Observations began in 1864 by William Cheney, for many years a member of this Academy. The first table published by the Academy is in Bulletins vol. I, 1873-1879 pp. 174-186; the second in Bulletins vol. II, 1880-1882, pp. 422-435; the third, this volume, ante, pp. 123-130.

	Mean Height of Barometer	THERMOMETER Monthly Mean	Maximum	Minimum	Monthly range	90° or above	32° or below	PRECIPITATION IN INCHES Monthly	Total Snowfall	Percentage of Cloudiness	Relative Humidity	Prevailing Winds.
1895												
January	......	4.7	32	—25	57	0	31	1.08	10.80	....	....	N. W.
February	30.186	9.8	49	—30	79	0	26	.45	4.30	....	....	N. W.
March	30.039	28.	58	— 9	67	0	28	.51	.70	....	....	N. W.
April	29.968	52.1	80	25	55	0	4	1.59	0.	....	....	S. & S. E.
May	29.892	59.2	94	28	56	1	3	2.67	0.	....	....	S. & N. W.
June	29.928	67.4	87	41	46	0	0	3.40	0.	....	....	S. E.
July	29.922	70.	100	44	56	4	0	4.15	0.	....	....	W.
August	29.870	69.	93	46	47	4	0	2.27	0.	....	....	N. W.
September ...	29.850	65.1	94	30	64	7	1	4.69	0.	....	....	S.
October	30.025	43.1	71	14	57	0	16	.09	.50	....	....	N. W.
November ...	30.073	30.1	67	— 7	74	0	26	.94	3.70	....	....	S.
December ...	29.990	20.3	40	— 6	46	0	31	.23	1.00	....	....	S.
Total for Year	......	.....	100	—30	130	16	166	22.07	21.00	....	....	
Mean for Year	29.977	43.23	...	....	...	..	...	.....	.....	....	....	N. W.
1896												
January	30.176	15.	43	—21	64	0	31	.85	6.55	....	....	N. W.
February	......	20.4	61	—15	76	0	29	.26	2.60	....	....	N. W.
March	30.077	24.5	59	—11	70	0	30	3.02	11.80	....	....	N. W.
April	29.929	47.1	81	11	70	0	10	5.22	7.60	....	....	S. E.
May	29.825	63.3	90	39	51	2	0	3.92	0.	....	....	W. & S. E.
June	29.916	68.1	90	44	46	2	0	3.76	0.	....	....	S. E.
July	29.951	71.1	94	47	47	6	0	1.73	0.	....	....	S.
August	29.937	68.9	96	42	54	5	0	4.15	0.	....	....	N. W.
September ...	29.991	56.3	84	31	53	0	2	2.42	0.	....	....	N. W.
October	30.007	44.5	73	16	57	0	11	3.94	0.20	....	....	N. W.
November ...	30.110	21.1	50	—11	61	0	30	4.17	9.90	....	....	N. W.
December ...	30.128	22.3	44	—12	56	0	31	.83	4.70	....	....	N. W.
Total for Year	......	.....	96	—21	117	15	174	34.27	43.35	....	....	
Mean for Year	30.004	43.5	...	....	...	..	...	.....	.....	....	....	N. W.
1897												
January	30.15	8.6	46	—29	75	0	30	1.66	16.6	....	....	N. W.
February	30.06	19.2	38	—24	62	0	28	1.05	10.5	....	....	N. W.
March	30.08	23.5	60	—12	72	0	25	3.23	14.1	....	....	N. W.
April	30.02	45.2	78	20	58	0	11	1.61	.9	....	....	N.
May	30.02	56.6	90	30	60	1	3	1.92	.0	....	....	N. W.
June	29.92	64.7	100	31	69	1	2	9.40	.0	....	....	S. E.
July	......	73.8	97	53	44	6	0	4.93	.0	....	....	S. E.
August	......	66.8	86	47	39	0	0	1.84	.0	....	....	N.
September ...	30.10	66.3	91	33	58	3	0	1.97	.0	....	....	S. E.
October	30.05	51.8	84	24	60	0	5	1.67	.0	....	....	N. W.
November ...	30.15	28.5	69	—10	79	0	27	.97	4.9	....	....	N. W.
December ...	30.17	15.2	46	—15	61	0	31	.18	1.8	....	....	N. W.
Total for Year	......	.....	100	—29	129	11	162	30.43	48.8	....	....	....
Mean for Year	30.072	43.4	...	....	...	..	...	.....	.....	....	....	N. W.

		THERMOMETER						PRECIPITATION IN INCHES				
	Mean Height of Barometer	Monthly Mean	Maximum	Minimum	Monthly range	90° or above	32° or below	Monthly	Total Snowfall	Percentage of Cloudiness	Relative Humidity	Prevailing Winds.
1898												
January	30.10	21.5	42	—5	47	0	31	.08	.8	....	....	N. W.
February	30.16	19.2	44	—15	59	0	28	1.79	9.9	....	....	N. W.
March	30.06	33.6	60	7	53	0	28	1.65	13.1	....	....	N. W.
April	30.11	44.2	76	16	60	0	13	1.49	1.0	....	....	N. W.
May	29.94	57.2	83	35	48	0	0	5.53	.0	....	....	N. E.
June	29.92	68.2	93	46	47	1	0	4.82	.0	....	....	N. W.
July	29.96	71.5	92	48	44	3	0	.51	.0	....	....	S. E.
August	29.94	68.3	95	44	51	3	0	3.01	.0	....	....	S.
September ...	29.94	62.1	92	36	56	2	0	.81	.0	....	....	N. W.
October	30.00	45.	81	24	57	0	9	6.22	T	....	....	N. W.
November ...	30.00	28.7	58	—15	73	0	27	1.56	13.	....	....	N. W.
December	30.11	10.4	37	—25	62	0	31	.07	.7	....	....	N. W.
Total for Year	......	.....	95	—25	120	9	167	27.54	38.5	....	....	....
Mean for Year	30.05	44.2	...	....	...	..	...	.....	.....	....	....	N. W.
1899												
January	30.09	10.6	40	—31	71	0	31	.81	7.5	....	....	N. W.
February	30.12	5.8	47	—36	83	0	25	1.21	11.9	....	....	W.
March	30.08	16.6	34	—14	48	0	31	2.39	22.2	....	....	N. W.
April	29.96	46.7	85	11	74	0	8	1.15	T	....	....	N. W.
May	29.95	58.0	86	33	53	0	0	3.52	.0	....	....	S.
June	29.93	67.9	88	46	42	0	0	6.55	.0	....	....	S.
July	29.93	72.3	95	45	50	5	0	2.13	.0	....	....	S. W.
August	29.91	71.4	96	52	44	4	0	3.45	.0	....	....	S.
September ...	30.05	57.4	89	23	66	0	4	1.35	T	....	....	S.
October	30.04	49.8	80	27	53	0	3	3.54	T	....	....	S.
November ...	30.08	39.0	60	18	42	0	18	.38	.5	....	....	W.
December ...	30.12	18.5	49	—12	61	0	31	1.44	1.3	....	....	N. W.
Total for Year	......	.....	96	—36	132	9	151	27.92	43.4	....	....	....
Mean for Year	30.02	42.8	...	....	...	..	...	.....	.....	....	....	S.
1900												
January	30.11	18.9	47	—20	67	0	31	.55	5.1	....	....	N. W.
February	30.16	6.2	35	—21	56	0	28	1.00	10.	....	....	N. W.
March	30.11	24.1	53	—11	64	0	31	1.53	15.3	....	....	N. W.
April	30.06	50.7	82	22	60	0	11	2.06	1.2	....	....	S. E.
May	29.94	62.	92	29	63	4	3	.35	.0	....	....	S. W.
June	29.92	69.4	98	43	55	7	0	2.41	.0	....	....	N. W.
July	29.89	71.6	96	51	45	5	0	9.10	.0	....	....	N. E.
August	......	76.3	95	54	41	12	0	7.07	.0	....	....	S. W.
September ...	......	60.	92	33	59	1	0	7.53	.0	....	....	S. E.
October	29.98	56.1	79	31	48	0	1	4.81	.0	....	....	S.
November ...	30.15	27.4	61	7	54	0	24	.73	7.	....	....	N. W.
December ...	30.04	19.9	42	—13	55	0	30	.42	4.2	....	....	N. W.
Total for Year	......	.....	98	—21	119	29	159	37.56	42.8	....	....	....
Mean for Year	30.036	45.2	...	....	...	..	...	.....	.....	....	....	N. W.

	Mean Height of Barometer	THERMOMETER Monthly Mean	Maximum	Minimum	Monthly range	90° or above	32° or below	PRECIPITATION IN INCHES Monthly	Total Snowfall	Percentage of Cloudiness	Relative Humidity	Prevailing Winds.
1901												
January	......	12.5	41	—15	56	0	31	.40	4.	....	....	N. W.
February	30.10	9.5	37	—15	52	0	28	.36	3.6	....	....	N. W.
March	29.93	26.8	53	— 8	61	0	30	1.93	13.7	....	....	N. E.
April	30.11	48.4	88	22	66	0	14	1.82	.0	....	....	N. E.
May	29.94	59.7	91	31	60	1	1	1.89	.0	....	....	N. E.
June	29.85	69.2	96	36	60	5	0	6.67	.0	....	....	S. E.
July	......	77.4	102	53	49	13	0	1.64	.0	....	....	N. E.
August	......	72.2	93	48	45	6	0	2.65	.0	....	....	S.
September ...	......	60.	90	36	54	1	0	3.80	.0	....	....	W.
October	......	51.6	82	30	52	0	4	.94	.0	....	....	S. E.
November ...	......	31.	58	12	46	0	27	1.00	3.2	....	....	N. W.
December	......	15.9	44	—27	71	0	31	.46	7.2	....	....	N. W.
Total for Year	......	.....	102	—27	129	26	166	23.56	31.7	....	....	N. W.
Mean for Year	29.986	44.5	...	....	...	..	...	....	....	....	....	....
1902												
January	......	18.7	46	—17	63	0	31	.44	5.3	....	....	N. W.
February	......	18.2	52	—15	67	0	26	.47	4.4	....	....	N. W.
March	......	36.2	63	— 7	70	0	17	.30	1.5	....	....	S. E.
April	......	44.6	84	16	68	0	14	2.70	.8	....	....	S. E.
May	......	60.2	86	34	52	0	0	4.33	.0	....	....	S. E.
June	......	64.1	86	44	42	0	0	2.00	.0	....	....	W.
July	......	71.1	88	54	34	0	0	6.05	.0	....	....	S.
August	......	66.5	86	48	38	0	0	5.94	.0	....	....	S.
September ...	......	57.2	82	36	46	0	0	4.03	.0	....	....	S.
October	......	49.6	74	30	44	0	1	1.40	T	....	....	S. E.
November ...	......	36.	62	17	45	0	17	1.74	2.4	....	....	N. W.
December ...	......	15.6	39	—20	59	0	30	2.61	24.	....	....	N. W.
Total for Year	......	.....	88	—20	108	0	136	32.01	38.4	....	....	....
Mean for Year	......	44.9	...	....	...	..	...	....	....	....	....	N. W.
1903												
January	......	14.6	40	—14	54	0	31	.22	4.2	....	....	N. W.
February	......	14.8	42	—24	66	0	27	.50	2.5	....	....	W.
March	......	33.6	60	8	52	0	26	2.05	4.1	....	....	N. W.
April	......	45.1	73	24	49	0	12	3.02	1.5	....	....	N.
May	......	59.1	83	32	51	0	1	4.40	T	....	....	N.
June	......	65.4	85	40	45	0	0	1.02	.0	....	....	N. E.
July	......	69.4	92	51	41	1	0	7.29	.0	....	....	N.
August	......	65.1	88	48	40	0	0	4.61	.0	....	....	N. W.
September ...	......	58.2	82	37	45	0	0	7.77	.0	....	....	S.
October	......	50.	73	30	43	0	1	4.36	.0	....	....	S. E.
November ...	......	29.8	66	0	66	0	24	.37	2.5	....	....	N. W.
December	......	12.6	35	—19	54	0	31	.64	8.3	....	....	N. W.
Total for Year	......	.....	92	—24	116	1	153	36.19	23.2	....	....	....
Mean for Year	......	43.1	...	....	...	..	...	....	....	....	....	N. W.

	Mean Height of Barometer	THERMOMETER						PRECIPITATION IN INCHES		Percentage of Cloudiness	Relative Humidity	Prevailing Winds.
		Monthly mean	Maximum	Minimum	Monthly range	90° or above	32° or below	Monthly	Total Snowfall			
1904				*								
January	......	7.3	38	—33	71	0	31	.43	8.5	....	....	N. W.
February	......	5.2	36	—19	55	0	29	.75	13.2	....	....	N. W.
March	......	27.7	53	— 4	57	0	29	1.64	5.8	....	....	N. W.
April	......	41.0	73	21	52	0	17	1.83	7.8	....	....	N.
May	......	57.6	84	35	49	0	0	3.54	.0	....	....	W.
June	......	65.6	83	48	35	0	0	3.81	.0	....	....	S.
July	......	68.4	† 92	53	39	1	0	4.78	.0	....	....	W.
August	......	66.2	88	46	42	0	0	5.61	.0	....	....	S.
September ...	......	59.7	83	38	45	0	0	3.19	.0	....	....	S. E.
October	......	48.8	76	29	47	0	4	4.94	T	....	....	S. E.
November ...	......	38.6	69	12	57	0	15	.10	.3	....	....	N. W.
December ...	......	19.9	50	—11	61	0	30	.61	7.4	....	....	S.
Total for Year	......	.....	...	....	...	1	155	31.23	43.0	....	....	....
Mean for Year	......	42.2	...	....	51	..	...	.....	.....	....	....	N. W.

* Minimum temperature —33° Jan. 24th.
† Maximum temperature 92° July 16th.

	Mean Height of Barometer	Monthly mean	Maximum	Minimum	Monthly range	90° or above	32° or below	Monthly	Total Snowfall	Percentage of Cloudiness	Relative Humidity	Prevailing Winds.
1905												
January	......	7.4	36	—18	54	0	31	.71	13.1	....	....	W.
February	......	11.9	56	—26	82	0	28	.59	9.3	....	....	N. W.
March	......	35.1	67	3	64	0	21	.73	1.0	....	....	S. E.
April	......	44.0	72	21	51	0	13	.74	T	....	....	N. W.
May	......	54.2	77	36	41	0	0	4.47	T	....	....	N. E.
June	......	64.9	85	45	40	0	0	7.11	.....	....	....	S. E.
July	......	69.8	93	54	39	3	0	3.02	.....	....	....	N.
August	......	70.8	95	50	45	2	0	4.32	.....	....	....	S. E.
September ...	......	63.7	84	43	41	0	0	6.50	.....	....	....	S.
October	......	45.6	82	17	65	0	8	2.17	5.5	....	....	S.
November ...	......	35.2	61	— 8	69	0	22	3.07	11.5	....	....	W.
December ...	......	23.9	45	— 1	46	0	31	.06	1.9	....	....	W.
Total for Year	......	.....	...	....	...	5	154	33.49	42.3	....	....	W-S. E.
Mean for Year	......	43.9	...	....	53	..	...	.....	.....	....	....	....

* Minimum temperature —26° Feb. 2nd.
† Maximum temperature 95° Aug. 10th.

Seasonal Temperature and Total Precipitation for the Years 1895 to 1905

Year	Jan.	Feb.	March	April	May	June	July	August
	TEMPERATURE							
	Winter {Dec. Jan. Feb.}	Spring	Summer	Autumn	Mean	Maximum	Minimum	Precipitation
1895	15.7	47.5	69.5	47.6	44.6	96 Sept. 17	26 Feb. 5	21.44
1896	20.5	46.1	70.6	42 2	45.0	99 Aug. 4	18 Jan. 3	30.65
1897	18.3	42.6	68.2	50.6	44 1	96 June 13	26 Jan. 25-26	28.37
1898	19.6	46 0	70.5	46.5	45.6	97 Aug. 22	20 Dec 31	25.92
1899	11.9	41.2	71.1	51.1	44.4	96 Aug. 10	33 Feb. 9	24.93
1900	17 0	46.8	72 1	49.3	46.3	95 July 30	19 Jan. 31	34.89
1901	16.1	45.9	72.9	47.5	45 2	102 July 20	27 Dec. 14	22.30
1902	17.6	47.0	67.4	47.6	44.9	88 July 29	20 Dec. 26	32 01
1903	15.0	45.9	66.6	46.3	43.1	92 July 7	24 Feb. 16	36.19
1904	8.4	42 1	66.7	49 0	42.2	92 July 16	33 Jan. 24	31.23
1905	13.1	44.4	68 5	48.2	43.9	95 Aug. 10	26 Feb. 2	33.49

PLATE VII

Fig. I. Magnetite crystals nearly parallel in growth in a matrix of hampdenite. The dodecahedron and cube are prominent but the surface is rough, and on two sides a great number of minute octahedral facets are shown which suggests that the entire crystal is built up of octahedra.

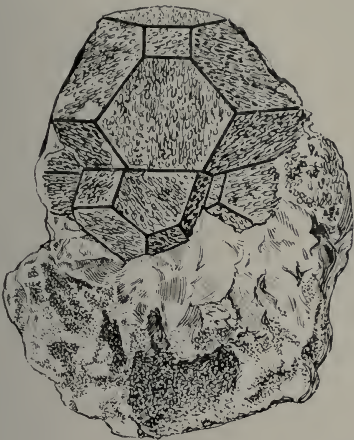
Fig. II. Magnetite and hampshirite in hampdenite. The magnetite shows a similar development of faces to Fig. I., but the octahedron is more prominently developed than in the preceding case and gives a striated appearance to the crystal and at one place gives a nearly smooth octahedral face beveling the solid angle of the dodecahedron. In both figures I and II the typical appearance of hampdenite is well shown.

Fig. III. Cast of a hampshirite pseudomorph after humite.

Figs. IV and V. Hampshirite pseudomorphs after humite showing typical development. Fig. V shows the best detached crystal known to the author.

Fig. VI. Group of Hampshirite pseudomorphs after humite in hampdenite loaned by Prof. B. K. Emerson from the Smith College collection. This is the specimen referred to on page 274.

Fig. VII. Hampdenite showing smooth fibrous fracture.
Reduced one-half.

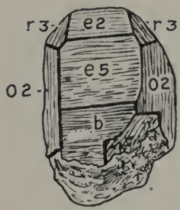


I

II

III

IV



V

VI

VII

PLATE VIII

Chimney Rock, Section 31, T. 114 R. 17 W., Marshan, Dakota County, Minn., looking southeast.

A spire of St. Peter Sandstone capped by a thin layer of more enduring Trenton limestone.

Photographed by Howard W. Crosby, Hastings, Minn.

PLATE IX

Coarse limestone debris, northwest bluff of the Mississippi river gorge near the High Bridge, St. Paul, Minn., showing beneath it the unevenly eroded top of the St. Peter sandstone.

Photographed by Prof. C. W. Hall.

PROCEEDINGS

OF THE MINNESOTA ACADEMY OF SCIENCE

MINNEAPOLIS, MINNESOTA

VOL. IV. BULLETIN III.

FOR THE YEARS 1906-1910

PLATES X AND XI

(EDITED BY A COMMITTEE OF THE BOARD OF TRUSTEES)

PROCEEDINGS OF THE MINNESOTA ACADEMY OF SCIENCE

(Abstracted from the records by Secretary Harlow Gale.)

278th Meeting, Jan. 6th, 1906, *Annual Meeting in the Art Gallery of Mr. T. B. Walker,* 807 *Hennepin Av.*

Present: President C. W. Hall, Winchell, Upham, Walker, Roe, Oestlund, Sardeson, Meeds, Arndt, R. J. Mendenhall, Benner, Nathan Butler, Dr. Chas. Simpson, Mrs. G. W. Tinsley, and Gale, with five lady and six men guests.

Historical program. Retiring President Hall reviewed, from 7:45 to 8:15 the growth of our city during the 33 years of the Academy, of Carlton, Hamline, and the State Universities, of similar Academies of Science in Philadelphia, Boston, New York, and Chicago, and then suggested the possibilities for the growth of our Academy in this large and wealthy state. He hoped our Academy would be the center for scientific research throughout the state and that thus it would grow out into the life of the State.

Moved and carried that the President appoint a nominating committee for the officers: Sardeson, Meeds, and Winchell being thus appointed.

A Historical Sketch of the Minnesota Academy of Science, compiled from the books of the Secretary and the trustees and from personal interviews, was read by the Secretary, Harlow Gale.
Personal Recollections were given:

On Geology, by N. H. Winchell.

On the Menage Philippine Expedition, by Pres. Hall.

On Dr. A. E. Johnson's work in Mycology, by Dr. Chas. Simpson, the first secretary of the Academy.

On the Museum, by Curator A. D. Roe.

Report of the Treasurer, Edw. C. Gale, read by Pres. Hall, showed balance of $233.41.

Report of Corresponding Secretary Oestlund showed accessions by exchanges during 1905 to be 712, total entries to date, 12,526. The revised exchange list, representing 127 Academies, Societies, Libraries, Museums, Universities, and Surveys, are distributed as follows:—European 93, American 79, South American 9, Australian 7, Asiatic 4, African 3; total 195. The great value of the Academy's exchanges, many being in no other library in this part of this country, and the wholly inaccessible condition of the books, were explained and emphasized.

In his address "On the Function and Future of the Academy", Mr. T. B. Walker referred to his first interest in the Academy in getting it moved from the East Side in the Kelly block in 1882, to his interest being mainly that of a business man, although he had formerly studied geology much and had read a paper in connection with the Academy meeting on Sanitary Science, which also touched his long-studied sociological subjects. As an active director in the old Athenæum he had been largely instrumental in forming the new Library, the president of whose board he had been since its organization. He recalled how the original plan of the organization of the Public Library was for a co-organization of the Athenæum, Academy and the Art Society. He had been instrumental in providing new cases needed by the Museum in the Library Building, and had presented minerals and other specimens to the collections. The great value of the museum as a means of public education was emphasized and the Library officers had realized of late what a persistent public demand there was to see the museum.

Thus, the Library Board, at its meeting yesterday, had decided to finish off the third floor in the new wing for the Academy's Museum, along with the fourth floor for the Art School. Thus the present building and quarters will last for some years, although we may look forward to a separate building sometime. For such a building some friend of his had spoken of offering $50,000 and others would doubtless help; for such an enterprise must be done by private means given for public purposes. Such a purpose is ,however, far more important to the State than most people realize.

The speaker's ambition for Minneapolis was to make it the educational center of this Northwest,—"We can make it the highest grade city in proportion to its size, in the world." The Academy of Science helps largely to make the city attractive to families and children. Thus he desires to see in our city one of the foremost libraries and museums in the country, so that it shall be the center of half the United States.

The Librarian, Miss Gratia Countryman, asked the privilege of telling the Academy that it was Mr. Walker's personal generosity which had made possible the immediate finishing of its museum room. She realizes more than ever the great educative value of the museum. She is decidedly not in favor of paid admissions, however, and she suggests a lease of the museum and library to the Library Board, similar t othe Athenæum arrangement, by which the Board will probably care for the Academy's property.

Mr. Walker suggested to first get the museum set up in good shape, then let the Library Board see how valuable it is, and it would then probably be glad to take charge.

Prof. Sardeson referred to the inducements to move the museum to St. Paul.

Additional words of reminiscence were given by Nathan Butler, who had been present at the early meetings in Dr. Johnson's office, by R. J. Mendenhall, who was almost an original member, by Franklin Benner, who desired to renew his active membership and hoped that many others would, by A. D. Meeds, a former secretary, by Mrs. F. L. Tinsley, the first woman member, and who was proud to be here again.

Moved by Winchell "That a vote of thanks be given Mr. Walker for the very pleasant surroundings amid which our meeting tonight has occurred." Unanimously carried. On Mr. Walker's assuring the Academy of its being very welcome, President Hall added one more item of our host's generosity; when he maintained a taxidermist for some months at $75 a month, setting up the Philippine collection, until the Omaha Exposition providentially came in.

The nominating committee reported as follows:—

President—T. B. Walker.

Vice President—N. H. Winchell.

Recording Secretary—H. Gale.

Corresponding Secretary—O. W. Oestlund.

Treasurer—Edw. C. Gale.

Trustees—C. W. Hall, A. D. Roe.

Moved and carried that the Secretary cast the ballot of the Academy for the above list. Done.

On being congratulated by President Hall, Mr. Walker accepted it with appreciation under the present conditions,—though he has refused many positions,—on the ground, that, as a business man, who has long been a trustee of the Academy, he can be more helpful to it in this official position.

On finding that the constitution makes a Vice President a trustee ex-officio, it was moved and carried that the secretary cast the vote of the Academy for O. W. Oestlund for trustee for the unexpired term of Winchell, i. e., for one year. Done.

The names of O. O. Whited and Dr. Frank Corbett were proposed by Winchell and Roe and were both unanimously elected. Adjournment at 11:00 p. m.

HARLOW GALE, *Secretary*.

Special Meeting, Jan 11*th*, 1906, *in President Walker's Study*.

Present: Walker, Winchell, Norton, Roe, and H. Gale.

President Walker spoke of the plans for finishing the new Academy museum room, its heating by hot water and of its ventilation; of ultimately getting a large lecture room built in the court. Mr. Roe urged getting some women members and setting them doing something in the Academy's activity.

Mr. Winchell urged the providing of public scientific lectures, and then told of the possibilities of our giving Dr. Otto Nordenskjöld a reception. A committee of Winchell, Oestlund, and H. Gale was appointed to arrange for the reception. It was suggested to ask Professor Hall, as President of the Minnesota Geographical Society, to join the reception committee, also Miss Countryman, Mrs. Tinsley, and a representative of the Commercial Club. Adjourned.

H. GALE, *Secretary*.

Jan. 22d, 1906 a Public Reception was given to Dr. Otto Nordenskjöld and his bride by the Academy in President Walker's Art Gallery from 3 to 5 P. M.

The reception committee was composed of President and Mrs. Walker, Miss Gratia Countryman, Mrs. L. F. Tinsley, Prof. C. W. Hall, President of the Geographical Society of Minnesota, B. F. Nelson, for the Commercial Club, and Winchell, Oestlund, and H. Gale, as the Committee of Arrangements for the Academy.

Between 200 and 300 guests were present during the afternoon and everyone found it a most delightful occasion. Dr. Nordenskjöld spoke a few words in English, telling somewhat of his Antarctic experiences, as his public lecture on Jan. 23rd will be mostly in Swedish.

279 *th Meeting, Feb. 6th,* 1906, *Directors' Room, Public Library.*

Vice President Winchell in the chair. 18 persons present.

The following resolution on the death of the founder of the Academy, Dr. A. E. Johnson, was offered by the secretary, and it was moved and carried that it be adopted, recorded, and a copy sent to Dr. Johnson's relatives.

In Memory of Dr. A. E. Johnson.

Born Mar. 16, 1825. Died Jan. 27, 1906.

The Minnesota Academy of Science hereby records its profound appreciation of the rare ideal of a student of nature which was shown by "the Father of the Academy", Dr. Asa E. Johnson. His scientific knowledge, energy, and enthusiasm, as displayed by his generous devotion to the study of nature at our own doors, was the foundation spirit of the Academy. In his own field of original investigation, the Mycology of Minnesota, he has left a monumental record in the Academy's publications; while, among his eighteen other scientific papers, there is an astonishing accumulation of evidence for his broad scientific culture. Thus, besides being one of St. Anthony's foremost pioneer physicians, his intellectual life was tireless until health and strength failed.

To his guidance in this ideal scientific spirit, during the six years of his presidency and the ten years of his active membership, the Academy also records its deepest gratitude. He gathered an apostle group of similar lovers of nature about him in his own office, gave his own collections as the foundation nucleus of the museum; as a trustee and business man he gave generously of his time and means, while his quiet modesty in all this generous enthusiasm was only equalled by his fidelity to every detail of the Academy's life, both great and small.

May his genuine love of nature, his disinterested search for her minute secrets and great laws, and the application of this sincere knowledge to man's position in nature continue to be the motive spirit in this second generation of the Academy's life and be transmitted as a growing heritage to the perpetual intellectual life of our beloved State!"

Personal recollections of Dr. Johnson were then given by Messrs. Roe and Upham, while Professor Winchell, as one of the charter members, gave quite a sketch, though informal, of Dr. Johnson's founding of the Academy, of the character and method of his work in the study of Fungi, and an enumeration and estimation of his published papers.

The names of S. R. Child and Prof. F. J. Wulling were proposed for membership by the Secretary and Mr. Roe and that of Edgar Reed by Mr. Roe and the Secretary; for all these the Secretary was directed to cast the Academy's ballot for membership. Done.

The following amendment to the constitution was offered by Mr. Roe, action to be taken at the next meeting: "To amend Art. 1 so that its name shall read 'Minnesota Academy of Science', and leaving out the word 'Natural.' Also that Art. 5, relating to the Board of Trustees, be amended so as to make 'the Vice President of the Academy an ex-officio member of the Board, and that four members shall constitute a quorum.'

At 8:45 Mr. H. B. Norton gave his report on "Some recent Studies of the Drift, bearing on the 'Great Geological Puzzle', illustrated by photographs and erratics from this vicinity." Mr. Norton described three kinds of glaciers: (1) stream, as in Switzerland; (2) mixed, as in Alaska; (3) the Piedmont, spreading out by its own weight. The speaker did not believe that the "Piedmont" form existed, and so did not bring drift. Only sharp rocks are reported on glaciers and there are no such sharp rocks in our moraines. The speaker's main point was that our drift was the result of water action and not glacial action. He cited the sand water deposit of some 50 feet in the Cedar Lake hill, the gravel cones in the Cannon river valley near Red Wing, his finding polished rock under the cones and circular striations around them, such as is done by water and not by ice. He described the gravel ring about Minneapolis, with sand toward the center and black earth in the center, such as would be made by a swirl of water. How could the soft rocks with mica, such as cannot withstand a single Minnesota winter, have been brought by the glacier? How could the field of some 500,000 rocks, from one half to about three quarters of a ton, polished all over, which were found around Franklin Av. and the river, have been made by ice? Then those rocks, which are too large to be rolled over and over, are not polished. Rocks, too, are found on the hills and alone in valleys: glaciers do not melt fast enough to do this work. The cross-hatched striation on the bed rocks appears to be the work of sea-ice rather than glaciers. The "terminal moraines" were regarded by the speaker as the shore beaches of this inland sea.

It was the sense of Mr. Norton's greatly interested hearers that he should continue his evidence at the next meeting and that there should be a chance for a discussion of the question. Adjournment at 10:20.

HARLOW GALE, *Secretary.*

280*th Meeting, March 6th*, 1906, *in the Directors' room, Public Library Building.*

Vice President Winchell in the chair: 24 members and guests present.

Moved by Roe that the amendment to the constitution changing the name to the "Minnesota Academy of Science", according to the notice given at the last meeting, be adopted. Seconded. After some discussion it was carried. Similarly, the other proposed amendment, adding the Vice President ex-officio as a member of the trustees, was adopted.

Mr. Roe again spoke of the desirability of getting women members and moved the membership dues of women be rebated from \$5. to \$2. for one year from date. Seconded and carried in the amended form "That membership dues required from lady members for one year from date be \$5, but that \$3 be remitted."

At 8:30 Mr. H. B. Norton resumed his presentation of the drift as due to water rather than glacial action. He quoted from Dawson and Alex. Winchell in support of this theory discussed the "Driftless Area" in Wis. as due to water alone, for it was not a plateau, as all the large rivers now ran through it, and he did not consider that the glacier came nearer it than the north shore of lake Superior, i. e., about 400 miles.

Animated discussion at 9 o'clock; Sardeson speaking of the personal equation in scientific work and described the Greenland glacier and what it probably could do here and the fact of large stones dropped in Iowa on fine clay.

Mr. Upham appreciated the speaker's observations, but reminded him that the glacial theory was not the work of any one man, but of many men, and any single observer's results must be compared with many others. He added that J. W. Spencer, the geologist of Missouri and Georgia, also held to the floating ice theory of Dawson, by whom he was educated. Yet the great majority of geologists held to the glacial theory.

Mr. Norton replied for ten minutes.

At 9:25 Professor H. L. Osborn of Hamline University, presented some "Remarks on Clinostomum Marginatum."

Adjournment at 10:10.

HARLOW GALE, *Secretary.*

281*st Meeting, April 3d*, 1906, *Directors' Room, Public Library.*

Vice President Winchell in the chair: about 25 members and guests present. An offer of a copy of Eaton's Ferns of America was received from Dr. W. H. Leonard. The offer of Henry W. Eustis' collection of butterflies and moths by means of a public subscription was explained by Winchell and Oestlund.

Professor O. W. Oestlund showed and explained an interesting specimen of a "Walking Stick", sent from Java. The names of Miss Gratia Countryman, Daisy S. Hone, Clara K. Leavitt and Elizabeth Foss were proposed by Mr. Roe for membership, duly seconded, and carried.

Individual letters were suggested to be written to our congressmen in favor or not in favor, according to our individual judgements, of the government's adoption of the metric system.

Owing to the absence of Prof. F. W. Sardeson, his announced paper "On the Primitive Discoid Crinoidal Root and Camarocrinus" was read by title.

At 8:30 Dr. H. L. Lyon, of the Botanical Dept. at the University of Minnesota, gave a review of the botanical experiments of Luther Burbank of Calif., as contained in Haywood's late book on Burbank, "New Creations in Plant Life", and compared with other sources. Discussion of the drift by Winchell and Norton. Adjournment late.

HARLOW GALE, *Secretary.*

282*d Meeting, Tuesday, May 8th*, 1906, *Directors' Room, Public Library.*

President Walker in the chair: 12 members and guests present.

The paper of the evening was "The Sewer System of Minneapolis: its Development, Topography, Geology, and Engineering Problems," by City Engineer Andrew Rinker. (Printed in this Bulletin:)

An animated discussion followed by Sardeson and Mr. Rinker on the proposed plan of diverting Bassett's creek through the chain of park lakes into Minnehaha creek.

President Walker then gave an informal tribute to Mr. Rinker's work for the city, praising his honesty, integrity, and judgement. Though on the other side in politics Mr. Rinker had been kept for 30 years in this office which is more important than that of mayor. The money has been expended in our Engineering Department as well as in any city in the country.

Moved by the President, seconded and carried, that Mr. Rinker be given a vote of thanks for his very interesting and intelligent address.

At 10:15 Vice President Winchell spoke on an endowment for the Academy, as he had suggested some years ago, by means of a donation from several lumbermen of cut-over land. He said some preparation ought to be made to present this to the next legislature. Moved by him, and seconded by Roe, that a committee of three be appointed by the President, of which the President should be the chairman, for the purpose of getting an endowment for the Academy. Carried. Discussion as to getting subscriptions. Adjournment at 10:30.

Immediately called to order again by President Walker. Moved, seconded and carried that the Secretary cast the ballot of the Academy for the following persons present for membership:—Dr. C. N. Spratt, Dr. P. A. Aurness, Professor Dr. T. G. Lee, Dr. E. J. Brown, and Mr. S. Lemere. Done. Adjournment at 10:45.

HARLOW GALE, *Secretary.*

283*d Meeting, June* 5*th*, 1906, *Directors' Room, Public Library.*

President Walker in the chair: about 15 members and guests present.

Mr. Henry W. Eustis exhibited his collection of some 3000 butterflies and moths, described his own interest and methods in collecting them, gave a considerable description of the specimens, and showed some of their evolutionary bearings.

Moved by Arndt that Mr. Eustis be given the Academy's thanks for his very interesting lecture and the exhibition of his collection, and urged him to publish a list of the Lepidoptera of Minnesota. Seconded by Winchell and carried. Adjourned at 9:40.

HARLOW GALE, *Secretary.*

284*th Meeting, Tuesday, Oct.* 2*d*, 1906, *in the Academy's new Museum Room.*

(In the second floor of the newly finished south wing of the Public Library Building.)

Vice President Winchell in the chair: 17 members and guests present.

After reading the minutes, as usual, the Secretary reported on the acquisition, during the past summer, of the collection of butterflies and moths, collected by Henry W. Eustis, by the raising of nearly $500.00 in subscriptions from friends of the Academy and of Mr. Eustis. The Secretary was asked to make arrangements for the formal presentation of the Eustis collection, which is now on exhibition near the door of the museum, in the name of the subscribers.

Mr. Roe, curator of the museum, then described the rehabilitation of the museum during the summer, after its being moved out of the way in the halls and the directors' room, from its former place in the corresponding room in the old wing (now used for the Art Book room), for the last two years. The expense of finishing this second floor of the new wing, as well as of the Art Gallery on the floor above, had been advanced to the Library Board by President T. B. Walker. Nearly $500.00 had been spent in cleaning and reinstalling the collections, $265 being for the renovation of the cases, nearly every one of which was somewhat broken, and putting new and heavy castors under them, $200.00 being for the services of Mr. Roe and his assistants in cleaning and arranging the collections in the cases. Little serious damage had, fortunately, taken place, although some specimens had disappeared.

Thus, after five weeks' work, the museum had been opened to visitors during the G. A. R. week in August and for State Fair week in September. Since then Curator Roe has been directed by the trustees to charge the former admission fee of ten cents for adults and five cents for children.

Mr. Roe then spoke of the necessity for a permanent curator to answer questions and give information, besides being a care-taker of the collections, and a mere watchman.

Prof. Sardeson spoke at length on the functions of the Academy, its museum, its young men, and its publications.

Miss Countryman, librarian of the Public Library, explained the relations of the Athenæum to the Library Board, and suggested, as she had before, a similar lease and conjunction between the Academy and the Library Board so that the Library would have more official connection with the museum for the purpose of caring for it.

A guest, Mr. David Boyle, of Toronto, Canada, was called upon and gave a most interesting talk, from his own experience as curator and his wide travel, on the needs and opportunities of a curator.

Informal reports were given by several members on their summer's scientific work or reading, especially by Sardeson, who gave a very interesting sketch of his accompaning a member of the U. S. Geological Survey on a trip through southern Minnesota for evidence on glacial work. Adjourned at 10 P. M.

HARLOW GALE, *Secretary.*

285*th Meeting, Wednesday, Nov. 2d,* 1906, *in the New Museum Room.*

Vice President Winchell in the chair: 13 members and guests present.

A paper "On some Modern Conceptions of Science" was read by Miss Julia B. Clifford, of the East High School. Discussion followed from 9:05 to 9:30 by Winchell, Random, Child and Gale. A vote of thanks and appreciation was moved by Roe and voted to Miss Clifford for her very learned, interesting, and stimulating paper.

As the hour was then so advanced Mr. Norton did not desire to begin his paper "On the Causes of Earthquakes", so it was agreed to postpone that subject until the next meeting. Adjournment at 9:45.

HARLOW GALE, *Secretary.*

286*th Meeting, Wednesday, Dec. 5th,* 1906, *in the New Museum Room.*

Vice President Winchell in the chair: about 20 members and guests present.

A paper "On the Causes of Earthquakes" was read by Mr. H. B. Norton, giving an extensive review of the causes (1) by volcanoc action, and (2) by faults of the earth's crust.

Mr. Upham then gave a detailed account of the late California earthquake, based on an article he had lately written for the Victoria Institute of London.

Discussion followed by Arndt, who asked Winchell about the fault at Hastings; by Random on the physics of wave propagation in rock and soil; by Norton, who objected to classing faults with smaller veins and joints; while Winchell regarded them as only different degrees of motion of the earth's crust .Thus, after a most interesting meeting, the Academy adjourned at 10:10.

HARLOW GALE, *Secretary.*

287*th and Annual Meeting, Tuesday, Jan.* 8*th*, 1907, *in the New Museum Room.*

Vice President Winchell presiding: 25 members and guests present.

The treasury balance, reported by the Treasurer, Edw. C. Gale, had increased during the year from $223.41 to 242.98, due to a participation in the admission receipts to the museum.

The Corresponding Secretary reported: Acquisitions during 1906, making a total of.... numbers in the Academy's library.

The Recording Secretary offered the following memorial:—

"The Minnesota Academy of Science wishes to make a slight record in memory of our life member, Mr. R. J. Mendenhall, who died Oct. 25th, 1906, aged .. years. Mr. Mendenhall was elected a member of the Academy on Mar. 4th, 1873, at its first regular meeting after its organization. He kept up his active membership until 1890, when he became one of our two life members (the other being Bishop McGolrick). His scientific interest is evidenced by his faithful attendance at the meetings for many years and by his three papers, read before the Academy, on his entomological and botanical subjects which he loved and lived with during his long and beautiful life. The silent beauty of the flowers, which he cultivated and studied, was a most fitting environment and reflection of his own serene, peaceful, and lovely life."

Moved by Child, and voted, that this memorial be adopted.

At 8:30 Mr. A. Jackson, Resident Engineer of the Great Northern Railway, described "The Filling-in of the Bryn Mawr marsh Bog" for the new freight yard. Abstract as follows:

In 1895 it was decided that more room was necessary for the Clearwater freight yard and the only available ground was across the Bryn Mawr swamp. Consequently we determined to fill the same with material from the high cliff at Cedar lake. The steam shovel started work at Cedar lake pit on Aug. 29, 1905.

The Bryn Mawr bog extends from a point about 400 feet west of Laurel Ave., measured along the tracks as they originally existed, to within a couple of hundred feet of Superior Av, a total distance of from 1,200 to 1,500 feet. The bog consists of a peat bed on top, from 1½ to 7 ft. thick, lying on a stratum of shell formation from 6 to 12 ft. thick, and below this a deep stratum of greasy clay.

Shortly after the filling-in began soundings were taken with a ⅝-inch sounding rod, such tests being taken about 50 ft. apart, and the work was done by hand. With such power we were only able to get down to a maximum of 30 ft. As it was very hard to get the rods down to this depth we supposed we had gotten into a good solid foundation to support the filling. But soon the track began to settle 2 to 3 ft. in a night, and great cracks would appear, showing where the underlying foundation had settled or slipped out. This happened repeatedly and some said that the Bryn Mawr bog could never be filled, but there was foundation somewhere between Minnesota and China, and so we kept filling in.

During March, 1906, four holes were sunk with a well-drilling machine. Hole No. 1, as shown on the diagram, was just outside the limits of the new fill and opposite the point of greatest settlement. The drill was put down to a depth of 92 ft. and was still in greasy clay. At this depth the drill buckled on account of the lateral pressure from the entire ground moving toward the north. Hole No. 2 was sunk outside the fill in the same manner, and at a depth of 62 ft. we ran into a gravel stratum underlying the clay, and in this gravel we struck a flowing well. Hole No. 3 was sunk to a depth of 58 ft., when we encountered gravel and a flowing well. Hole No. 4 was sunk through the new fill at about the point of greatest settlement. At a depth of 71 ft. the drill was still in our new gravel filling. As the grade of the new fill was only 12 ft. above the natural surface of the ground this showed that the settlement at that point was 58 ft., or, in other words, that the original material had been shoved out ahead of the filling to the depth of 58 ft. The settlement, however, did not stop at this point, for it was necessary several times afterwards to raise the fill to keep the embankment up to the established grade. Thus I estimate that the total settlement was from 80 to 90 ft. At this depth a firm bottom was evidently found, for, although there has been a little settlement since, I think this is more from the material packing, as is experienced in all new fills during the fall and winter.

Thus the filling stopped July 20, 1906, nearly 11 months after it was begun, and, instead of the estimated material of 211,000 cubic yards, it required about 500,000 cubic yards. The greasy clay in the bog, which slid or was pushed out ahead of the gravel filling, raised up a crescent-shaped tract of several acres to the north of the tracks, towards Laurel Avenue, to about 20 ft. higher than its natural bog level, seaming it with great cracks several feet wide and deep.

After many questions and much examination of Mr. Jackson's plan and fine series of photographs Mr. Winchell followed at 8:50 with "A Review of the Geology of the Bassett's Creek Valley," of which the following are the notes: This Bryn Mawr marsh or bog is only part of the large region like the Mississippi gorge below the falls. The speaker was first attracted to the subject in 1876, as State Geologist. The gorge between here and Fort Snelling was different from that above and below the city. He found the Bassett's gorge went through the chain of lakes (Isles, Cedar, Calhoun, and Harriet) and thence, in some unknown way, into the Minnesota river. Bassett's creek flows over the morainic drift and strikes the surface materials of the old gorge about Inglewood springs. The Glenwood-

Inglewood springs are not really springs, but artesian wells through the same strata as found in Mr. Jackson's test holes.

Another gorge the speaker found from the mouth of Rice creek, 15 miles up the river, off east through the chain of lakes north of St. Paul to the mouth of Trout creek at the foot of Dayton's bluff in St. Paul. Although not so definite a valley, this was a more direct route than either of the two later right-angled courses. As the Mississippi river or its ancestor always existed somewhere here between the archaen areas in Wisconsin and in Minnesota, this Rice and Trout creek valley was undoubtedly an ancient course of the Mississippi river. This course was interrupted by the first glacier, that which came from the northeast, until its deposited till filled the old straight gorge and turned the river into the forge of the Bassett's creek valley.

After a long interglacial period came another glacial disturbance from the northwest which cut off the Bassett's creek course and turned the river into its present channel between here and Fort Snelling. The speaker measured the recession of the falls since Hennepin's time and calculated therefrom that from 7,000 to 8,000 years had been occupied in cutting this third and last gorge from Fort Snelling to the Falls of St. Anthony. Applying this datum to the Bassett's creek route it makes some 15,000 years for the excavation of the Bassett's creek gorge.

There is no possibility of measuring in years the first Mississippi route by way of Rice creek to Dayton's bluff in St. Paul.

In the discussion following Mr. Upham spoke of the great value and importance of Professor Winchell's early estimate of the river's cutting, along with that of Niagara. Professor Winchell's calculation of the date of the last Glacial epoch having preceded that based on the recession of Niagara falls by Gilbert. Prof. Sardeson spoke of the bog at Eden Prairie on Purgatory creek, where the M. & St. L. Ry. had put in a large cement culvert which was cracking and going apart with the continued settling of the filling; also of a bog in England which was covered with a layer of cotton waste and then evenly with dirt so as to permit no bulging in any one part; also of a small bog by lake Phelan near St. Paul.

The nominating committee, Norton, Oestlund, and Spratt, reported in favor of the re-election of the present officers. Moved by Child, seconded, and carried that the Secretary cast the ballot of the Academy for the re-eelction of the present officers. Thus the following were elected for 1907:

President: T. B. Walker.

Vice-President: N. H. Winchell.

Recording Secretary: Harlow Gale.

Corresponding Secretary: O. W. Oestlund.

Treasurer: Edw. C. Gale.

Trustees: Dr. T. S. Roberts, O. W. Oestlund.

Prof. Oestlund spoke again of the necessity of moving the Academy's books from his laboratory, or he himself would have to move out; also that the risk of fire there was too great for the valuable accumulation of from $3,000 to $4,000 worth of books received by the Corresponding Secretary yearly. He moved that a committee be appointed to collect and remove to this new museum room all the books and pamphlets of the Academy.

Secretary Oestlund was appointed to effect this removal. Adjournment at 10:15.

H. GALE, *Secretary.*

288*th Meeting, Tuesday, Feb.* 5*th*, 1907, *in the Academy's Museum Room.*

President Walker presiding; nearly 30 members and guests present.

Mr. Gilbert Random, of the North High School read a thorough "Review of the Various Theories of Gravitation" from 8:10 to 9.

The discussion was opened by President Walker, who had had much interest and thought on this subject since his study of Newton's Principia in his young manhood.

Vice-President Winchell expressed his admiration for the learning showed in the paper, but confessed that the present conflicting and highly developed theories were too complicated for him to understand without special study. After further discussion Mr. Random added some closing explanations.

At 9:30 the Secretary gave some informal "Notes on the history of Mind Cures, especially of 'Christian Science' in Minneapolis." These notes were begun 20 years ago, when the first general interest in mental healing was evident in Minneapolis and before the special form of "Christian Science" was heard of here. All the various forms of mind cures were reduced by the speaker to the simple practice of suggestion, even though its physiological connection of mental expectation and accession of bodily vigor was not as yet known. Considerable discussion followed.

The removal of the Academy's library from various places at the University to the Museum room was announced. Adjournment at 10:05.

H. GAIE, *Secretary.*

289*th Meeting, Tuesday, March* 5*th*, 1907, *Directors' Room, Public Library.*

President Walker presiding; about 100 members and guests present.

Dr. Thomas S. Roberts gave a most valuable and interesting description of "Bird Life in Minnesota," illustrated by about 100 from his own original collection of some 800 lantern slides photographs of birds of Minnesota and their habits.

At the conclusion of this memorable occasion a vote of thanks to Dr. Roberts was proposed by President Walker, and was carried enthusiastically and gratefully by a unanimous rising vote. Adjournment at 10:10.

H. Gale, *Secretary.*

290th Meeting, Tuesday, April 2d, 1907, Directors' Room, Public Library.

Professor C. W. Hall was called to the chair at 8:10 in the absence of President Walker. About 100 members and guests present.

A paper on "The Prehistoric Aborigines of Minnesota and their Migrations" was read by Professor N. H. Winchell and is already printed in the "Popular Science Monthly," September, 1908. (Abstract in this bulletin).

After some discussion of this scholarly and interesting paper the Academy adjourned at 10 P. M.

H. Gale, *Secretary.*

291st Meeting, Tuesday, May 7th, 1907, Directors' Room, Public Library.

President T. B. Walker presiding; 25 members and guests present.

The Secretary offered the following memorial, which was then ordered to be inserted in the minutes of the Academy:

"The Minnesota Academy of Science wishes to record its loving remembrance and scientific appreciation of its charter member, Dr. W. H. Leonard, who died April 29th, 1907, aged 82 years. As one of the charter members of the Academy Dr. Leonard was electetd a trustee at its organization on Jan. 6th, 1873. He was for some years chairman of the sections on the Archeology and Botany of the state and made several reports, specially his report on 'Ferns' in 1876. His well known interest in the hygiene of the city was shown in the Academy by his getting a committee to examine the water of the chalybeate Springs opposite lower Hennepin Island, at about the foot of 5th Avenue S. E.

"He was one of the dozen faithful attendants at the Academy's meetings during its early years; he kept up his active membership for over 20 years, and maintained his intellectual interest in the Academy to the last.

"His gentle, kindly heart and his alert scientific intellect, in the midst of a busy physician's life, will always be held in affectionate remembrance and civic honor."

At 8:15 the paper of the evening, "The Weather and Weather Forecasting," was given by Mr. H. E. Osborn, of the Central High School. The speaker described the great variety of popular weather signs and the kinds of professional individual forecasters. He then described and showed some of the apparatus and methods of the U. S. Weather Bureau.

Our new section director of the Government Bureau, Mr. U. G. Purcell, then expressed his appreciation of Mr. Osborn's interesting and instructive paper, said the Government was anxious to spread the knowledge of its methods (this in contrast to the secrecy of the professional individual forecaster) and added some details from his 22 years experience in the Weather Department. More discussion followed,—President Walker speaking of the U. S. Bureau's method having left philosophizing and practiced instead Bacon's inductive method based on a large collection of facts.

President Walker reported informally that the committee for the re-incorporation of the Academy as a state institution had met with such legal obstruction for such proposed legislative enactment that the project had to be abandoned. He also said that, although nothing definite had been done towards a permanent endowment, he still hoped that the Academy would some day be in its own building with an endowment.

After a suggestion by Winchell and some discussion it was moved, seconded, and carried that the Academy, through its president, vice-president, and secretary, should offer an invitation to the American Association for the Advancement of Science to hold in Minneapolis its meeting after the next, i. e., in 1908-9. Adjournment at 10 P. M.

H. GALE, *Secretary.*

292*d Meeting, June* 4*th*, 1907, *Directors' Room, Public Library.*

President Walker presiding; 16 members and guests present.

Professor N. H. Winchell read a paper on "The Mammoth in Minnesota," illustrated by a newly found tooth, the property of our member, Mr. O. O. Whited. At the conclusion President Walker recalled the presence in our Museum of a large mammoth tooth, which he had given the museum some years ago.

At 8:45 Professor O. W. Oestlund spoke on "Celebrations of the Linné Anniversary," calling special attention to Linné as a zoologist, or indeed, as a biologist, which broad scientific characters of the great man are too often lost sight of in his fame as a botanist. The speaker also described his extraordinary power as a teacher and as a writer of some 100 books in Latin.

President Walker announced that, through the action of the Library Board, the curator of the museum, Mr. A. D. Roe, had been provided with sufficient income and an assistant, so that the museum could be now kept open all day and every day, and with free admission.

Mr. Whited asked as to the age of the Esquimaux compared with the Mound Builders, and was answered by Prof. Winchell that the Esquimaux was here before, during, and since the Mound Builder, living on the edge of the ice field. On further questions Mr. Upham caller attention to Prof. Winchell's articles 30 years ago on the identity of the Mound Builder and the worker of the ancient copper mines of lake Superior, also to his present series of articles on "The Antiquity of Man," now running in "Records of the Past."

The President reported having written the proper officers of the

A. A. A. S., inviting the Association to hold its 1908-9 meeting in Minneapolis. Adjournment at 9:45.

H. GALE, *Secretary.*

293d Meeting, Tuesday, October 8th, 1907, *in the Academy's Museum Room.*

President Walker presiding; 12 present.

A report from Curator Roe was read, describing the increased attendance at the museum since it was opened free through the Library Board's paying the curator a salary, and suggesting that the library of the Academy be put in shape for use.

The program of the evening being "Informal Reports of our Summer's Scientific Work or Reading" Professor Winchell reported a curious accidental deception. On examining a supposed meteoric stone by thin sections he found it a fine-grained fragmental rock, with metallic substances on the outside. As he could not account for this external metallic substance it finally occurred to him that it might be aluminum which had rubbed off from his pocket magnifying glass, as he had carried them together in his pocket. Such proved to be the case, and he found similar aluminum specks on other stones of his collection. He also called attention to some apparent Indian Mounds on the Pacific coast in Oregon, which were now believed, as described by Mr. Upham earlier, to be of drift or terminal moraine origin. The nature and origin of the iron ore in the Mesabi Range, which he had visited again this summer, were discussed by Professor Winchell.

President Walker described his first buying of iron lands in the Mesabi Range about 25 years ago, and his tracing the veins of iron by the hills, water courses and the magnetic needle.

Professor Oestlund reported a six weeks visit to Vancouver, Id., and his special studies in plant lice, some three-quarters of his 30 species collected there being new to science.

Dr. Sardeson reported having been engaged all summer in a search for pottery clay near New Ulm and the discovery of it where other searchers had not found it.

Professor Lange, of St. Paul, reported having studied on the north short of lake Superior the influence of wild mammalian life on trees and animal life. Moose and deer, of which he had seen 36 and 35 respectively in five days, had killed the willows and kept down the mountain ash, birch, poplar, and June-berry; they had not touched the spruce, fir, and black alder, but water lilies had been eaten, leaves and stalk.

The Secretary reported having found a delightful and instructive picture of German student life 60 years ago, and of a country physician's work in Dr. Kussmaul's "Jugenderrinerungen." Adjourned at 10 P. M.

H. GALE, *Secretary.*

294th Meeting, Monday, November 4th, 1907, Academy's Museum Room.

Vice-President Winchell presiding; 13 present.

Mr. E. E. Woodworth, St. Paul, was proposed for membership and elected.

At 8:20 Professor C. W. Hall gave a very interesting paper on "North American Waterways," beginning with an outline of the river systems of both North and South America, then giving details of the proposed improvements of our Mississippi Valley system .

Discussion followed until adjournment at 10:10.

H. Gale, *Secretary.*

295th Meeting, Monday, December 2d, 1907, Academy's Museum Room.

President Walker presiding; 12 present.

The President reported informally that the Academy's invitation to the A. A. A. S. to hold its 1908-9 meeting here had been sent to some 20 societies and institutions of the state to join the Academy in this invitation. If this invitation is accepted it will be 25 years since the previous meeting of the A. A. A. S. here. The Secretary of the American Economic Association had also been written to by the President, who was authorized to extend the same invitation to this body.

At 8:20 Dr. F. W. Sardeson began a paper in "The Principle of River Erosion," being a criticism of the usual view as described by Salisbury and Chamberlin, and showing its application to the Mississippi river from Fort Snelling to the Falls of St. Anthony.

Discussion by Winchell, Upham, Hall, Norton, and Walker. Adjournment at 9:45.

H. Gale, *Secretary.*

296th and Annual Meeting, Monday, January 6th, 1908, Academy's Museum Room.

President Walker presiding; 15 persons present.

The President reported informally that the invitation of the Academy, seconded by some 20 other state organizations, had been presented last month to the A. A. A. S. at its Chicago meeting and our cause forcibly presented by Professors Winchell, Hall and himself. They found that Baltimore had been already selected by the committee for the next meeting and that Boston had been in the minds of the committee for the following one. But no official action had been taken on this latter, and, after the presentation of the claims of Minneapolis, our committee was assured that Minneapolis had every prospect for this meeting of 1909-1910. This would probably be a summer meeting, but a regular, not a special one.

The paper of the evening was by Mr. Warren Upham on the "Progress of Discovery of the Mississippi River, with special reference to Minnesota and its Geography." Discussion of this very able and interesting paper by Hall and Walker.

The year's report of the Academy's Treasurer, Edw. C. Gale, showed a decrease in the balance from $242.98 to $34.29, being due to the publication of Bulletin Vol. IV, No. 2, costing about $200.

Notice was given of a proposed change in the By-Laws, whereby the meetings should be held on the first Monday of the month instead of the first Tuesday after the first Monday.

Moved and carried that Oestlund and Gale be a committee to arrange for some disposition of the Academy's library to the Public Library Board, similar to the agreement with Athaeneum, and report at the next meeting.

Committee on nominations,—Upham, Hall, and Norton,—reported the following list for 1908 and they were electetd:

President: T. B. Walker.

Vice-President: F. W. Sardeson.

Corresponding Secretary: O. W. Oestlund.

Recording Secretary: H. Gale.

Treasurer: Edw. C. Gale.

Trustees for three years: N. H. Winchell and Edw. C. Gale.

Adjourned at 10:30.

H. Gale, *Secretary.*

297th Meeting, Monday, February 3d, 1908, in the Academy's Museum Room.

President Walker presiding; 25 members and guests present.

The paper of the evening, "Healing Forces in Nature," was read by Mr. H. B. Norton, dealing with the natural forces in the mineral vegetable, and animal kingdom, down to the present form in Christian Science, which was nothing new in essence.

President Walker remarked on the paper, and then spoke of plans for building up the Academy, and of its history and relations to the Library Board. He hoped there would be a hall built in the court of this building for public lectures and meetings. He also hoped that before many years the Academy would have a building of its own, or in conjunction with art, where books would be more incidental; so rather the opposite of the present situation.

The draft for a contract between the Academy and the Library Board, similar to that with the Athenæum, and drawn up by our treasurer, Mr. Edw. C. Gale, was read and discussed. Moved that this contract be received and accepted, subject to such changes as the Library Board may deem necessary, but that the term of the contract be for not more than three years. Carried.

Wm. P. Johnson, 1019 W 28th St., was elected to membership on the motion of Winchell and Walker.

The Amendment to the By-Laws, making the first Monday in the month the day for the regular meetings instead of the first Tuesday after the first Monday, was moved and carried, having been duly presented at the last meeting. Voted that the Secretary get together a list of the Academy's officers and members and make out "Sections" in accordance with the plan of the trustees. Adjournment at 9:50.

H. GALE, *Secretary.*

298*th Meeting, Monday March* 2*d*, 1908, *in the Museum Room.*

Professor Winchell presiding: 25 members and guests present.

Discussion as to the proposed agreement with the Library Board as to the Academy's library. Mr. F. H. Carlton, of the Library Board, spoke of the Board's attitude of assistance and also of the uncertain character of the Academy's books and the uncertain expense of properly binding the books.

A similar proposition to receive, bind, and catalog and use the Academy's books, the Academy to retain the ownership, was received informally through Prof. Oestlund from the University Library. After discussion it was moved by Prof. Wulling, seconded ,and carried, that this proposition of the University Library be also considered at the next meeting.

Considerable discussion followed as to the procuring of an original design for the Academy's stationary and publications through an open competition from art or school students.

Owing to the sudden illness of Mr. Horace V. Winchell, Geologist of the Great Northern Railway, Mrs. Winchell read his paper on "The Origin of Ore Deposits", and showed a rare collection of specimens of ores and ore-bearing rocks. The Academy was greatly indebted to Mrs. Winchell for her clear, interesting and intelligent presentation of this original and highly valuable paper, and for her participation, likewise, in the discussion which followed. Adjournment at 10:10.

H. GALE, *Secretary.*

299*th Meeting, Monday, April* 6*th*, 1908, *in the Museum Room.*

Vice President Sardeson presiding: about 25 members and guests.

The following memorial was offered by the Secretary:

"In Memory, of A. D. Roe, born June 28, 1825; died March 20, 1908.

From his earliest young manhood our late venerable and beloved curator of the Academy's museum has been a lover and student of nature. Amid his varied studies of law, education, and theology Mr. Roe has always studied the earth's history in the plants and rocks. Throughout his active educational life of some thirty years as a teacher, pastor and home missionary, his never failing source of bodily refreshment and mental invigoration has been these tramps for the collection of his plants and minerals, with the subsequent examination and classification of them in his study. Thus his study at home has been gradually filled with a large and valuable collection of rare and beautiful minerals and fossils.

On removing to Minneapolis in 1894 Mr. Roe soon discovered our Academy and its modest museum. He was elected a member on Feb. 9th, 1897, was secretary for the two years of 1898-1900, and a trustee from 1900 continuously until his death. He was the first permanent curator of the museum, being appointed in 1899; and it was to his knowledge, experience, scientific enthusiasm, and business ability in this curatorship that the Academy is chiefly indebted for being guided successfully through a trying period of its existence.

On the reopening of the museum in its present quarters on the third floor of the west wing of the Public Library Building, after being closed from the winter of 1903-04 to the summer of 1906, our then 80-year-old curator worked all summer with the enthusiasm of youth in renovating and rearranging the collections. Undoubtedly his interest in his scientific activity and in the Academy's museum was one of the main factors in prolonging his not naturally robust life to the rare and ripe age of nearly 83 years.

The memory of the life and works of our colleague will be one of the most precious records in the annals of the Academy."

Moved, seconded, and carried that this memorial be recorded in the minutes of the Academy.

The Secretary reported that the deed of sale of the Henry W. Eustis collection of butterflies and moths was now in the hands of the Academy's Treasurer, and that the transaction was closed to the mutual satisfaction of both parties, about $465.00 having been raised by subscription from the friends of the Academy and of Mr. Eustis for this purpose.

At 8:30 the paper of the evening, "The Opsomic Theory and the New Hygiene," was read by Professor Dr. F. J. Wulling, Dean of the College of Pharmacy of the University of Minnesota. The very scolarly and interesting paper was discussed by Dr. H. L. Ulrich and others. It has since been published in the *Northwestern Druggist*. Adjournment at 10:10.

H. Gale, *Secretary*.

300th Meeting, Monday March 2, 1908, *in the Directors' Room.*

Minutes and business were dispensed with in favor of the speaker of the evening, Professor D. Lange, of the Humbolt High School, St. Paul, on "Birds and Wild Animals of Northern Minnesota", illustrated by many original photographs, as lantern slides, of birds and deer in their natural habitat. The large audience was intensely interested in this most original and delightful address and exhibition.

H. Gale, *Secretary*.

301*st Meeting, Monday, June* 1, 1908, *in the Museum Room.*

Vice President Sardeson presiding; about 15 present.

Cor. Sec'y. O. W. Oestlund showed and described a "Goliath Beetle" from Africa.

Professor N. H. Winchell read a very interesting and original paper on the historical inaccuracy of the new historical painting in the State Capitol, illustrating the discovery of the Falls of St. Anthony. Discussion. [Published in this Bulletin.]

H. GALE, *Secretary.*

302*d Meeting, Monday Oct.* 5*th*, 1908, *as the invited guests of the Engineers' Club, at its club room*, 17 *S.* 6*th St.*

To hear a most interesting paper by Professor C. W. Hall on the "Water Supplies of the Twin Cities."

Present from the Academy among the entire audience of some 50 were Hall, Sardeson, Winchell, Rinker, Norton, Spratt, Roberts, and H. Gale.

Discussion joined in by Winchell, Sardeson, and Rinker. Adjournment at 11.

H. GALE, *Secretary.*

303*d Meeting, Monday, Nov.* 2*d*, 1908, *in the Museum Room.*

President Walker presiding: 12 present.

The museum's new curator, Mr. J. W. Franzen, was introduced.

A most interesting and valuable paper on "The Prairie Flora of western Minnesota" was read by Mr. Lycurgus, R. Moyer, of Montevidio. (Printed in this Bulletin).

Discussion from 9:20 to 10 by Leonard, Upham, Hall, Walker and Gale.

H. GALE, *Secretary.*

304*th and Annual Meeting, Monday Jan.* 4*th*, 1909, *in the Directors' Room.*

Vice President Sardeson presiding 10 members and two guests present.

Moved by Winchell that, in consideration of the absence of President Walker from the city, the annual election of officers be postponed until the Feb. meeting. Seconded and carried.

Corresponding Secretary Oestlund reported 652 additions to the Academy's library during 1908.

Treasurer Edw. C. Gale reported a balance of $15.89 as against $34.39 a year ago.

At 8:30 Mr. H. B. Norton began a "Symposium on the Geological Aspect of the City Water Supply Problem of the Twin Cities." He gave evidence to show the slow rate of filtration of water through sand rock. Evidence against this was offered by Winchell, and the discussion was continued by Sardeson and Mr. Walter S. Pardee. Adjournment at 9:50.

H. GALE, *Secretary.*

305*th Meeting, Monday, Feb. 8th*, 1909, *in the Museum Room.*

President Walker presiding: 11 present.

A letter from secretary Howard, of the A. A. A. S., was read by Winchell saying that the meeting for the holiday week of 1910-1911 was fixed for Minneapolis and requested to be advised of the committee of arrangements. After considerable discussion it was moved, seconded, and carried that a committee of five be appointed by the president, of which he should be a member, to select a local committee of some 100 members from Minneapolis and St. Paul, and make all the arrangements for this meeting of the A. A. A. S.

The following record of the death of Mr. Thomas Lowry on Feb. 4, 1909, was offered by the Secretary and was adopted and ordered sent to the press and the family:

"The Minnesota Academy of Science, like so many other organizations of our city and state, wishes to record its great loss in the death of Mr. Thomas Lowry. For, in spite of all his other various and absorbing activities, Mr. Lowry has maintained his membership in the Academy for nearly 36 years from almost its beginning in the spring of 1873. While, by his donations to our museum of the two fine specimens of Egyptian mummies, and by his keen interest in the welfare of the museum even during his late illness, Mr. Lowry has again only shown the bouyant interest and kindly helpfulness which has so remarkably characterized his breadth of mind and largeness of heart."

The paper of the evening, "The Future Timber Supply", was read by President T. B. Walker (printed in this bulletin) and discussed with much interest.

Winchell offered a resolution on Lincoln, suggesting calling the national schools of agriculture "Lincoln Schools of Science." Adopted, and the secretary was instructed to forward a copy to our representatives in congress.

Whereas, this meeting of the Minnesota Academy of Science takes place near the date of the one hundredth anniversary of the birth of Abraham Lincoln, and *whereas* it is suitable and incumbent on the American people, in gratitude for the great service and sacrifice rendered by him to the fundamental elements of American civilization, to perpetuate his name and to honor it by inscribing it in conspicuous places where the youth may frequently be reminded of the excellence of his character, and *whereas* the American Congress has by a commission appointed for this purpose, after long and extended consideration, recommended the construction of a great thoroughfare from Washington City to the battlefield of Gettysburg and, *whereas* still there seems to be room and opportunity to commemorate the name of Lincoln in a line of science in which he was a prominent actor, and:

Whereas it was by his signing and approving of the act of Congress in 1861 establishing the State schools known as Colleges of Agriculture and Mechanic Arts, to the maintenance of which this nation is committed, and which have since been called "National Schools of Science", of the United States, that the science of agriuclture and mechanics have been benefitted and firmly established in the educational curricula of the country, therefore,

Resolved, that it is the opinion of the members of the Minnesota Academy of Science that the name of *Lincoln* ought to be applied by Congress to these schools, and that all the literature and all the researches from such schools that may hereafter be published ought to be labelled and every where known as products of the "Lincoln Schools of Science.

It is the opinion of this Academy that by so designating these schools, while an immaterial and uncostly honor would be conferred on the greatest American citizen, such honor would be likely to be more influential and more durable in the perpetuation of his memory than the expenditure of large sums of money in material monuments of any kind."

Minneapolis, Feb. 8, 1909.

The President nominated Winchell, Oestlund and Butler as a committee on nominations, which reported the renomination of the present officers. The Secretary was instructed by motion to cast the ballot for the following officers:—

President: T. B. Walker.

Vice President: F. W. Sardeson.

Cor. Sec'y.: O. W. Ostlund.

Rec. Sec'y.: H. Gale.

Treasurer: Edw. C. Gale.

Trustees for three years: C. W. Hall, H. Gale.

Curator Franzen reported that something would have to be done to preserve the group of orangs of the Philippine collection from destruction. Referred to the trustees. Moved and carried that the Secretary prepare a copy of the "Proceedings" for publication in a new bulletin and that the Academy publish such a bulletin as soon as possible. Adjourned at 9:40.

H. GALE, *Secretary.*

306*th Meeting, Tuesday, March 2d,* 1909, *in the Museum Room.*

About 12 persons present. In the absence of the President and Vice-President and no quorum of members being present, no formal meeting was held. But the announced subject of the evening, "The Psychology of Music", was given by the Secretary, Harlow Gale, showing in outline, with the aid of brain models, charts and some simple apparatus, the process of hearing through the ear mechanism, nerves, and brain; the perception of tones in pitch, quality, quantity and rhythm. Helmholtz and Dr. Billroth's "Wer ist musikalisch?" were much cited, and many original experiments given by the speaker.

Considerable discussion followed until after 10.

H. GALE, *Secretary.*

307*th Meeting, Monday, April* 5*th*, 1909, *in the Directors' Room of the Public Library.*

President Walker presiding; about 30 members and guests present.

"Personal Impressions of the Panama Canal" were given by Mr. Edw. C. Gale, illustrated by charts, maps, and photographs. The subject was continued by Professor C. W. Hall and gave rise to many interesting questions and much discusssion.

At 9:30 Professor Winchell explained the progress of the preparations for the A. A. A. S. meeting and the method of formation of the large committee of 100. Adjournment.

H. GALE, *Secretary.*

308*th Meeting, Monday May* 10*th*, 1909, *in the Directors' Room of the Public Library Building.*

No business. About 100 persons present to hear Dr. Thomas S. Robert's extremely able and interesting lecture on "Sparrows and Finches of Minnesota", illustrated from his own splendid collection of original photographs as lantern slides.

H. GALE, *Secretary.*

309*th Meeting, Tuesday Oct.* 5*th*, 1909, *in the Academy's Museum Room in the Public Library Building.*

In the absence of the President and Vice President the Rec. Sec'y., was called to the chair: about 20 persons present.

Report by Curator Franzen on the improvements in the Museum during the summer, the large increase in attendance, and the further needs.

Informal inspection of the eight new cases of Greek vases and glassware, Chinese idols, coins, a bison and a musk-ox head, and a mammoth tusk from Alaska,—all deposited in the museum by President Walker. Moved that the thanks of the Academy be given to President Walker for placing these valuable specimens in their handsome cases in the museum. Carried.

Symposium on the Cook-Peary discoveries of the North Pole; joined in by Norton, Child, Winchell, Oestlund, Wulling, Brown, Mackenzie, and Gale. The consensus of opinion was that Cook had gained in public confidence and Peary lost public sympathy by their respective conduct during the newspaper controversy.

H. GALE, *Secretary.*

On Monday afternoon, Oct. 25, 1909, from 3 to 4 o'clock, a Reception was given to Dr. Frederick A. Cook, the discover of the North Pole, in the Art Gallery of President T. B. Walker, 803 Hennepin Av. About 200 of the members and their friends were present.

Committee:

For the City of Minneapolis	*For the Minn. Academy of Science.*
B. F. Nelson	Prof. F. W. Sardeson
Willis Walker	Prof. C. W. Hall
F. M. Prince	Prof. N. H. Winchell
Dr. G. G. Eitel	Andrew Rinker
Dr. C. H. Hunter	Dr. T. S. Roberts
Judge D. F. Simpson	Dean F. J. Wulling
Miss Gratia Countryman	Dr. C. N. Spratt
	S. R. Child
	Edw. C. Gale

310*th Meeting, Tuesday Dec.* 7*th*, 1909, *in the Directors' Room of the Public Library.*

Vice President Sardeson in the chair: about 25 presnt.

Miss Mary C. Judd, 112 State St., was proposed for membership (by Winchell and Gale) and elected.

An extremely valuable and interesting paper was read from 8:15 to 9:15 by Mr. Warren Upham on "Englacial and Superglacial Drift in Minnesota, the Dakotas, and Manitoba." This paper gave the results of additional field work during the past summer and autumn, mostly near Winnipeg. Discussion till 9:45 by Sardeson, Moyer, Mackenzie, and Winchell. (Abstract in this bulletin).

Prof. Winchell spoke on the matter of delegates to the A. A. A. S. and by motion of the Academy was appointed the Academy delegate to the coming Boston meeting. Adjournment.

H. GALE, *Secretary.*

311*th Meeting, Tuesday Jan.* 4*th*, 1910, *in the Directors' Room of the Public Library.*

Annual Meeting. Vice-President Sardeson presiding; present,— Oestlund, Winchell, Norton, Franzen, Decker, Child, Miss Judd, H. Gale and six guests. Amendment of the By-Laws, offered by Wulling at the Nov. meeting, abolishing the membership fee of $5. and raising the yearly dues from $1. to $2., was adopted.

Curator Franzen spoke again of the necessity of sending for the Academy's collection of Philippine bird skins which had been several years with Mr. Bryan in Honolulu. After explanations from Winchell it was voted so to do.

Moved and carried that the chairman appoint a committee, not including any of the present officers, to present nominations for officers. Messrs. Child, Decker, and Norton were appointed. Moved and carried to postpone the election of officers to an adjourned meeting in one week, i. e., on Jan. 11th.

Cor. Sec'y. Oestlund reported 634 separate accessions to the Academy's Library during the past year. He enumerated many of the valuable exchanges and urged that some means be provided for making these valuable publications available for readers. Moved and carried to adopt his report and refer his recommendation to the trustees.

An extremely interesting paper on "Extinct Pleistocene Mammals of Minnesota" was read by Professor N. H. Winchell, and discussed by Sardeson and others. (Printed in this bulletin).

Much discussion of the past and future of the Academy until adjournment at 11.

H. GALE, *Secretary.*

312*th Meeting, Tuesday Jan.* 11*th*, 1910, *in the Museum Room.*

Vice President Sardeson presiding: 10 members present.

The chairman spoke of the condition of the Academy.

Report of the nominating committee from the last meeting was received and read. Moved by Winchell and seconded by Rinker that the Secretary cast the ballot of the Academy for the officers reported by the committee. Carried and done, resulting as follows:

President: T. B. Walker.

Vice President: F. J. Wulling.

Treasurer: Edw. C. Gale.

Cor. Sec'y.: O. W. Oestlund.

Rec. Sec'y.: H. Gale.

Trustees for three years: O. W. Oestlund and F. W. Sardeson.

A letter from Prof. Washburn was read, inviting the Academy to send representatives to a meeting at Pres. Northrop's house to arrange for the meeting of the A. A. A. S., which had accepted the invitation from Minneapolis in the name of President Northrop. Vice President Wulling and Prof. Winchell were appointed delegates from the Academy. Much discussion as to this invitation and the original one a year ago from President Walker and a score of other organizations; whether St. Paul joined in it and should be asked to participate in the reception committee. Finally moved and carried that the secretary be instructed to answer Prof. Washburn's letter and remind him of the list of persons and institutions joining in the original invitation.

Moved that the matter of abolishing the $5 membership fee be reconsidered and a committee of three be appointed to consider and report on it. Carried. Chair appointed Winchell, Oestlund, and H. Gale. Moved to reconsider the question of annual dues and that they be raised from $2 as voted at the last meeting, to $3. Much discussion. Carried. Adjournment about 10.

H. GALE, *Secretary.*

313*th Meeting, Tuesday Feb.* 6*th*, 1910, *In the Museum Room.*

Vice President Wulling presiding: 7 members and 15 guests present.

Informal report by Winchell of the committee meeting at President Northrop's house to prepare for the meeting of the A. A. A. S.; also of the various amendments to the Academy's constitution, as found by him in the office of the Minnesota Secretary of State. Moved and carried that the various amendments to the Academy's constitution be properly collected and recorded with the Secretary of State by Childs and Gale.

Moved and carried that Curator J. W. Franzen be elected a member and that his membership fee and all dues be remitted in consideration of his services.

In "The Continental Ice-Sheet a Myth?" Mr. H. B. Norton made an effective array of the evidence against the Glacial Theory as the sole cause of our drift, illustrated by many geological specimens and photographs. Much discussion followed by Winchell and others. Adjournment at 10.

H. GALE, *Secretary.*

314*th Meeting, Tuesday March* 8, 1910, *in the Directors' Room.*

Vice President Wulling presiding: about 40 persons present.

An extremely able paper "On the Structure of the Universe, being a presentation of Professor Osborne Reynolds' Theory of Gravitation" illustrated by experiments, was given by Mr. John Mackenzie, M. E. E.

This learned paper was followed by much discussion by Profs. John and Anthony Zeleny, and others. (Printed in this bulletin).

H. GALE, *Secretary.*

315*th Meeting, Tuesday April* 5, 1910, *in the Directors' Room of the Public Library.*

Vice President Wulling presiding: about 25 present.

A report on "Teaching Bacteriology in a City High School" was given by Miss Eliz. Foss, of the North High School.

A paper on "The Minneapolis Wild Botanic Garden" was given by Miss Eloise Butler, of the South High School, illustrated by lantern slide photographs of this Glenwood garden, founded by Miss Butler, and of its use in High School education.

H. GALE, *Secretary.*

316*th Meeting, Tuesday, May* 3*rd*, 1910, *in the Directors' Room.*

Vice President Wulling presiding: about 70 persons present.

A paper on "The Prairie Legumes of Western Minnesota" was read by Mr. L. R. Moyer of Montevidio, Minn. (Published in this bulletin.)

A lecture on "Halley's Comet," illustrated by many lantern slide photographs of this and other historic comets, was given by Professor F. P. Leavenworth, of the University of Minnesota.

H. GALE, *Secretary.*

317*th Meeting, Tuesday, June* 7*th*, 1910, *in the Directors' Room.*

Vice President Wulling presiding: about 15 present.

An address on "The Kinds of Reasoning and the Psychological Evidence for and against the Existence of 'Souls' and 'Spirits' " was given by Mr. Harlow Gale.

Much discussion until adjournment at nearly 11 o'clock.

H. GALE, *Secretary.*

CONSERVATION OF THE FUTURE LUMBER SUPPLY.

By President T. B. Walker.

Any practical plan of conservation of existing forests for a continued future supply of lumber and wood products must be based upon a fair, candid understanding of past conditions and policies which have been responsible for the wasting and denuding in the past.

Investigations should not be confined to summarizing present conditions. They should be directed largely to determining the causes which have been responsible for denuding our forests. In this way only can past errors be avoided and a comprehensive plan be worked out to conserve the future supply.

The destruction of our forests is charged to the wasteful propensities of our lumbermen. This is as unjust as it would be to charge the agriculturalists with a responsibility and blame for destroying our hardwood forests.

These forests were two to three times as extensive in area and amount of timber as the pine or coniferous forests. To reach the soil to furnish the food supply the timber was rightfully and naturally cut away, and in large part destroyed by burning—only a fractional part being utilized.

So far as the forestry questions relate to hardwood timberland, which was mostly agricultural, the conveyance of title, largely as a free gift under the Homestead Act was not only justifiable, but a necessary policy to pursue. While it resulted in the destruction and waste of a large proportion of the hardwood timber, it cleared the land and laid the foundation for the great national progress and the prosperous conditions now existing.

The lumbermen, being as legitimately, and next in usefulness to the farmer engaged in furnishing the timber supply, were naturally compelled to cut and manufacture the pine forests in a way which would make a return for the labor, capital and energy devoted to it. The farmers have always had the good will of the people, but for some remote and contingent reasons, a strong prejudice has existed against the lumbermen.

The policy of distributing the pine timberlands as a gift or at a nominal price to the multitude of people or citizens who chose to secure a tract for the advantages of the speculative value, was not a wise or justifiable policy.

But as the present timber and stone act has been preceded by yet more liberal laws, by which distribution of the timberlands was made from the earliest times and applied to all the forests from the eastern states all across to the remaining western states, the western people naturally consider that the same right and privilege should be continued with them, and there is so little left unreserved or not disposed of that it makes but little difference at this late day.

The timber land should not have been sold in this way. The timber should have gone direct in suitably large tracts, to those who intended to hold and use it in supplying the public demand for lumber. This would have been more appropriate and served better purpose for the public. It was the intention that this method of disposing of the timber should be only an indirect way of furnishing the lumberman with timber from which to supply the public with the necessary commodity of lumber.

This roundabout method made higher costs of stumpage and heavier carrying charges of interest and taxes, and also prohibited securing consolidated holdings and cheaper logging and driving.

It originated more from a prejudice against a presumed monopoly which was anticipated if the timber was placed directly in the ownership of lumber manufacturers at a minimum price and in large consolidated holdings. These facts have also been emphasized by the refusal to give to lumber a tariff approximating that given to other products, although, in this case, the foreign competitors had greater advantages in supplying our market at much lower prices than other manufacturers had to contend with.

This to a considerable extent, has come from the policy of the government in its determined efforts to depress and keep down to the lowest possible point the price of the lumber to supply the needs of the public.

One important feature of the government policy accomplished or operated in the opposite direction and tended to increase prices.

It has from the start been made a criminal offense for the lumber manufacturers to seek to secure a large body of pine at a low cost, which made the production of lumber more expensive. This, added to the high rate of wages, the carrying charges of interest on the larger investments and the excessive taxation on standing timber, lumber, mills, etc., has compelled the rapid destruction and the wasteful methods of producing lumber.

It has been one strong feature of the government policy to survey the forest lands rapidly and place them in market in order to keep an over-stock of timber, with a view of cheapening lumber for use of the public. This policy has resulted in the surveying of over nine-tenths of the timber lands, and leaving in the possession of the government less than ten per cent of the original area and quantity of timber, the government owning a considerable amount of land that is surveyed, together with some that is yet unsurved.

This method of disposing of the timber has made the cost of the timber to the lumbermen or timber owners much higher than the price received by the government from the entrymen, and has been one of the prime factors in the denuding of the forests. And the method of disposing of the timber has prevented the lumbermen from securing consolidated holdings by and through which they could, to better advantage, conserve and preserve the forests.

These conditions have prevailed, to a large extent, from the earliest times through the territory of our white pine forests to within the past ten or fifteen years. They do now and will prevail in the future in the remaining quite extensive southern forests, and the great and principal supply of the Pacific or western states. In the old white pine states the problems of conservation are of little concern. The small stock of timber remaining and the reduced amount of the white pine in the eastern Canadian provinces, render it of much less concern as to the remainder of our white pine forests. On the Pacific coast the conditions are as much subject to waste as those formerly prevailing in the old pine regions; and in some respects more waste has been carried on, especially in the great forest of California.

We are now confronted with the conditions and problems transmitted to the remaining timber supply and which have led to the consumption and the wasting of so much of our forests that there is now left only an equal fraction of the original timber supply. The temporary advanced prices of lumber in the central and eastern part of the country, excepting as to the past year when prices have been lower, has not, to any extent, reduced the per capita use of lumber, or the general consumption which has prevailed in earlier years. In fact, for the past several years, the per capita consumption has been increasing because of the disappearance of the hardwood which formerly supplemented largely the pine lumber, but which is, to large extent, now exhausted. The use of lumber within the past several years has reached the actual amount of nearly 600 feet per capita, although counted at only 500, as a large amount is cut that is not reported. The use of substitutes like cement, iron, steel, bricks, stone or paper for purposes where lumber was formerly used, has not apparently reduced the demand materially. The great activity has kept the demand and supply up to the former amount.

The inherited conditions pertaining to the remaining forests bring with them the same difficulties for the continuance of forest destruction that have caused waste in the past.

Unless a more correct and rational understanding of the lumber situation and problems is taken and understood, rightly appreciated, and a practical policy—with public sentiment fairer to the lumbermen—more adaptable to the real best interests of the public, is put into operation, a comparatively few years will see the end of cheap or moderate priced lumber.

This desire to over-stock the market with the timber supply has been carried to that extent that while we have been cutting over and denuding one-half of our coniferous forests, the title to nearly the whole has been parted with by the government. So that at the present time, the condition is that about one-half of our pine timber lands have been denuded. Of the other half over four-fifths of this remainder has been sold under this promiscuous method and passed to private owners.

The conservation of the forests under, and in the manner that the lands have been handled by the government, and other adverse conditions, have made it absolutely impossible for the lumbermen to cut and handle the timber conservatively, or to reforest the areas as they were cut over. In fact, the lumberman has had more adverse conditions to work against than the men engaged in any other industry or occupation whatsoever.

We have now reached that period of our history when it has come to be known that the forests must be conserved or in a comparatively few years, supply will be practically exhausted.

Other substitutes, and economical and more efficient methods of manufacture, can and will be applied when the price of lumber gets to that point that it will make practicable these new methods. But in the meantime the remaining forests, especially those in the Pacific and mountain states where the land is of but litle or no use for agriculture and available for a timber supply, and where the area is sufficient to furnish a reasonable stock for many generations to come—perhaps a perpetual supply—may be sufficient to serve the more urgent needs of the people, and especially when supplemented by the general development of timber culture throughout the countrl.

The question now comes up—what can be done to conserve the forests?

There is quite a demand for the removal of the little tariff protection that is now existing. Agricultural products are protected to an extent three times as great as lumber, which are not in need of protection to as great extent as lumber; and it would not work continued waste by removing tariff on agricultural products as it would on lumber.

The forests will be continually wasted as a matter of necessity if free lumber and continued high local taxes are maintained.

The timber lands are held in such small parcels or tracts as to make conservative methods of lumbering, together with reforesting and the protection of timber from destruction by fire, impracticable. At all events, the timber lands must be consolidated to make conservation a possibility.

So that under existing conditions, I do not see but one practicable plan to conserve the present forests and provide for a future supply.

Economical lumbering can be carried on only on a large scale with sufficient capital and large enough operations to establish large milling plants and provide them with a stock of timber that will, for the first cutting, extend over nearly or quite a century before it is once cut over. Then to apply thoroughly efficient measures for reforesting as the land is cut over, and to protect the whole tract from destruction or damage by fire.

This handling of the forests, the reforesting, the economical cutting and manufacturing in ways that will make a cost for the low grades more than their worth now in the market, must necessarily be provided for, and a tariff sufficient on the low grades of lumber with which we cannot compete and conserve the forests.

In cutting the timber, it will be necessary to leave the smaller size trees up to those of medium size. These will necessarily have to be a continual source of expense in reforesting and protecting and interest on the investment. The cost of logging and manufacturing, and especially if the more conservative methods of producing composition boards of a thinner kind, are entered upon, will make the cost of production higher, but will increase the amount of available lumber to the extent of two or three times what the old methods or even more conservative way of applying the old sawing methods.

Then the question of local taxation must be met and the matter of taxing the one crop of timber every year for a century on the same crop, must be radically changed and the standing crop of timber must not be taxed, but a reasonable tax on stumpage may be placed on the timber when cut for the benefit particularly of the local county in which the timber is located, and which tax should be paid to the county for any amount cut in that county whether manufactured there or elsewhere. All other taxation on the lumber cut and other taxation pertaining to the lumber production should be merged into this stumpage tax, which may be made to perpetually furnish the country a larger revenue than under the old method, but in such way that it can be charged up as part of the cost of the timber. And with this change in taxation a better method of organizing timber and lumber companies should be enforced in such way and under such provisions of organization and management and control, that the government and the public will be satisfied that it is not a trust form organized to plunder the people by means of extravagant prices. It is evident that higher prices for lumber, more especially on the lower brades, but in general on the whole mill run, must be maintained in order to make it practicable, or we might say possible, to conserve the timber, and which for the next perhaps ten or fifteen years would make lumber moderately higher priced than at present, but not excessive compared to other commodities and products. And at the end of 20 or 30 years, this process, if the whole or a large part of the remaining forests could be placed in such aggregations and under the best practicable form, the prices of lumber for the next 30 to 50 years would probably not be one-half of what they will be without a practical process of this kind.

A tract of timber of say 250,000 acres of the heavy timber of the coast would furnish a stock sufficient to furnish a hundred million a year of lumber for a century, or nearly that. By reforesting and protection to the fullest extent, there will, at the end of that time, be timber standing, that when cut over from the same point of beginning as was practiced the previous century, that before it is cut over the second time will produce for this second cutting as much, or more lumber, than was taken off the first cutting, and at the same time leaving a sufficient re-foresting stock to make for the third century perhaps as large a supply.

The lumbermen generally are willing to do their full part in any practical scheme or measure that will enable them to handle the timber in the most conservative method practicable for them to devise if the conditions are made so that they can do it. But if free trade, designed to cheapen lumber, excessive taxation and prejudice against large timber holdings, shall prevail, it cannot be accomplished.

To organize companies to handle the timber in such a conservative method as herein outlined, it would seem to be necessary for Congress to enact laws under which might be organized companies of that nature and kind that would meet the approval of all parties concerned, including capitalists, timber owners, counties, states and the general government and public. Such act of Congress should provide for the method of organizing the companies, the issuance of stocks and bonds and stockholders' liability, and for a sufficient supervision and control by the government through the Commission and Forestry Departments so as to protect from fire, and conservation methods of cutting and manuracturing, and in reforesting, and against excessive prices on lumber which might result from controlling a large part of the supply of lumber, but provide and authorize a sufficient price to make it practicable and reasonably profitable to so handle and conserve the timber.

There may be same other methods of doing it. I do not know what way would be practicable, excepting in this general way. It is certain that small holdings cannot do any more than cut the timber into lumber as rapidly as possible, as they have in the past, and cut and handle the timber in the cheapest way of producing the lumber, and produce only the kind and quality of lumber that will bring a price large enough to make it profitable. In other words, the continuance in large part of that system which has prevailed in the past and has wasted the forests, and will continue to do so without doubt or question if present conditions are continued.

The Conservation Commission has made no suggestions other than a resolution asking the States to take a certain supervision of the methods of cutting timber, but which, when applied to the best that the State can do, will not be sufficient means for conservation to provide for a future supply of lumber.

The time is becoming shorter when any feasible conservation plan can be developed and installed in time to save enough of the forests to make anything of a reasonable supply for the future at reasonable costs or prices. The message of the Governor of Washington to the Legislature just now handed in says that conservation must be entered upon immediately. That in ten years from now it may be too late. And I will say that it is a matter more particularly for the general interests of the Commonwealth than it is for the timber land owners.

But the timberland owners are willing to adjust themselves to a reasonable method of handling the forests on that basis that will bring about the best results for the future welfare of the whole nation along any lines that will not be unjust, unfair and destructive to the interests of the present owners who came into possession through the voluntary established laws and public policy of the nation.

The timber land owners do, or should, recognize the fact that the timber is the heritage of the people; Providence provided it for the benefit and use of the people generally.

The soil was made fertile and to serve the essential purpose of furnishing the food supply of all the people, and not for the exclusive benefit of those engaged in agriculture; but the distribution of the farming lands was made upon the same general policy of so distributing the earth's surface among those who chose to enter upon that occupation that it would, to best advantage, supply the whole Commonwealth with food the same as the distribution of timber would furnish the lumber supply.

There is complaint of the agricultural methods as there is of lumber, and the agricultural lands are brought in as one of the essential measures where conservation is considered necessary to protect the general interests of all, the same as with the timber.

And while the farmers are doubtless equally under obligations to handle the soil conservatively and bring it to the best use of all as well as of themselves, the lumbermen do, or should, recognize that they are equally under obligations; but in both cases, the public can only expect, and put in force, any policy or requirement consistent with the ownership and local control of each tract or portion which has come into the possession of the different individuals or companies—whether of timber or agricultural land.

That the timber should be conserved in the best practical manner, and the soil cultivated in a like conservative way to produce the best results in both cases, is the duty of both the farmer and the lumberman, as far as it is made practicable for them.

But the General Government, the States and timbered Counties and the timberland owners and lumbermen must co-operate and agree upon a conservation policy that will to best advantage for the future and for centuries to come, serve the best interests of the present and coming generations with the best and most satisfactory supply of timber that can be devised to meet the increasing demands of the great populations of the future centuries.

THE PRAIRIE FLORA OF SOUTHWESTERN MINNESOTA.

L. R. Moyer, Montevideo.

In its physical features western Minnesota is an undulating plain lying about 1,000 feet above the ocean level. This plain is of glacial origin, and consists of blue and yellow till, probably underlaid with beds of Cretaceous rock. Entering the state about thirty miles south of Big Stone lake and extending southeasterly toward the southern boundary of the state is a great terminal moraine known to the early voyageurs as hte "Cateau des Prairies." In the western part of Lincoln county the Coteau rises to the hight of about 1,900 feet. The northeasterly slope of the Coteau consists of till containing many boulders—worn and rounded by the glacial waters. Some of these boulders are of granitic rocks similar to the rocks in the northern part of the state, and others are of magnesian limestone—such as are not now found in place nearer than at Winnipeg.

Another terminal moraine known to geologists as the "Dovre moraine" extends from a point in Kandiyohi county north of Willmar, northwesterly through Swift, Pope and Douglas counties, and culminates in the Leaf hills in the southern part of Otter Tail county, where an elevation of 1,750 feet is reached.

Between the Leaf hills on the north and the summit of the Coteau des Prairies on the south lies the Minnesota valley. This valley in western Minnesota has a width of about 120 miles; and through the center of this region the Minnesota river—or more properly the glacial river which preceded it—has eroded a deep channel, cutting through the drift, and through the geologically recent rocks on which the drift is super-imposed, down to the original Archean rocks which appear to cross the state from the northeast to the southwest. These rocks are exposed in great ledges at Beaver Falls, Granite Falls, Montevidio, and Ortonville. This river bed or channel is from 100 to 200 feet in depth and will average about one mile in width. In many places the bluffs are quite abrupt, and in other places they have become much worn down. A great river once occupied this valley extending across from bluff to bluff, and was the outlet of a great lake which covered all the Red River country. This great lake is known to geologists as Lake Agassiz and the ancient river has received the name of the River Warren. The Minnesota river which now occupies this great channel is a typical prairie river. In midsummer when it is dry, and likewise in winter when its affluents are frozen up it is an insignificant stream; but when a heavy snowfall melts in April with unusually heavy spring rains it is still capable of becoming a great stream sweeping everything before it.

From the south the Minnesota river receives such important affluents as the Redwood river, the Yellow Medicine river, the Lac qui Parle river, the Yellow Bank river, and the Whetstone river. All of these streams head in the Choteau des Prairies and in the case of sudden rains send down from their headwaters enormous floods. From the north the Minnesota receives Hawk creek which heads in the hills north of Willmar, and the Chippewa and Pomme de Terre rivers which both head in the Leaf hills.

The soil o fthis region is mostly a deep black loam—formed from the materials brought from the north by the glaciers, containing for the most part decomposed limestone, and is very rich and fertile. There are some sandy areas, apparently formed from the till by the water that flowed away from the melting ice. There are areas—more or less large—of loess, or wind-formed soil.

With the exception of narrow strips along the streams or on the north slopes of protected bluffs, or in ravines, such as the couleés cut by streams in the slopes of the Coteau, the region under consideration is all prairie.

Much of this region was at one time timbered, and it is not uncommon to find well preserved trees deeply buried in the drift. Such a tree was found in digging a well at Montevideo, in the bluff near the south end of Fifth street, some 20 feet below the surface. The tree was probably a pine, carried there by the last extension of the glaciers. It seems likely that the reason for the treeless condition of much of this region is due to diminished rainfail. At Montevideo the average annual rainfall is 21.33 inches. This rainfall is sufficient to produce a thrifty growth of trees in the deep rich alluvial soil of the river valleys, but seems to be insufficient to induce a successful stand of trees on a closely compacted soil of heavy till without cultivation. It has been thought too that the rainfall is too unequally distributed through the year,—sufficient perhaps in the summer, but deficient in the inter. Others have suggested that the hot southwest winds from the plains scorch and wither the trees and make the forest impossible. Many think, and with much show of reason that the treeless condition of the prairies is due to prairie fires set by man. Prof. Shaler has advanced the idea that the American Indians before the advent of the whintes had advanced to such a degree of culture that they had begun to regard the great herds of bison then living on the prairies somewhat in the light of domestic animals, and that they purposely set fire to the prairie and forest openings to make better pasturage for them.

Among the trees native to this region and forming the great body of the native forests are the following:

American elm (Ulmus americana).
Green ash (Fraxinus lanceolata or pennsylvanica).
Bur oak (Quercus macrocarpa).
Box elder (Acer Negundo).
Cottonwood (Populus deltoides).
Basswood (Tilia americana).
Slippery elm (Ulmus fulva).
Silver maple (Acer sacharinum).
Cork elm (Ulmus racemosa).

Hackberry (Celtis occidentalis).
Ironwood (Ostrya virginiana)..
Willow (Salix amygdaloides).
Red) cedar (Juniperus Virginiana).

Along the borders of the forest may be found such shrubs as:
Wild plum (Prunus americana).
Wild red cherry (Prunus pennsylvanica).
Choke cherry (Prunus virginiana).
Sheepberry (Viburnum lentago).
Downy arrow wood (Viburnum pubescens).
Burning bush (Euonymus atropurpureus).
Red osier dogwood (Cornus stolonifera, or more properly perhaps stolonifera riparia of Rydberg).
June berry (Amelanchier oblongifolia).
Smooth rose (Rosa blanda).
Hawthorne (Crataegus Sp.)
Shining willow (Salix lucida).
Heart leaved willow (Salix cordata).
Sandbar willow (Salix longifolia).
Buffalo berry (Shepherdia argentea).
Wolf berry (Symphoricarpos occidentalis and S. orbiculatus).

Nearly all of these shrubs and trees have an eastern range and they appear to be advancing westward. The Buffalo berry is the only one of them that seems to have come from the west, and that seems only to be found at the head of Big tSone lake. Where the woodlands are not heavily pastured the forest seems to be advancing on the prairie. This advance is led by the shrubs, especially by the Wolf berry. In small valleys and wherever the soil is uneven the Wolf berry springs up, forming a dense shade, and destroys the tough prairie sod. Under the shelter of its leaves sunflowers, silphiums and other tall Compositae spring up, to be followed by box elders, green ash, bur oaks and other forest trees. On low bottoms the sand bar willow answers the same ends, forming dense patches on the river bottoms to be followed by box elders, ash and elms. On other and higher prairies the borders of the forest are extended through the growth of shrubs, such as the wild rose, wahoo, choke cherries and wild plums. As soon as the shrubs have taken possession of the ground the seeds of trees spring up amongst them and the forest is extended.

The black walnut is found as far west as Walnut Grove in Cottonwood county. There is a grove of sugar maples in what is known as the Lynn woods on the headwaters of the Redwood river, where it descends from the Coteau southwest of Marshall; and there is another grove of the same tree where lake Whipple lies embosomed in the Dovre moraine at Glenwood in Pope county. There is also said to be a grove of sugar maples in the ravine formed by the Minnesota river, where it cuts through the coteau in South Dakota.

When we turn to the prairie flora of this region, we are beset with many difficulties. In the first place the prairie flora has been destroyed. The breaking plow has been at work in this region for about forty years, extending the wheat fields, and the remaining portions of the prairie have been fenced in by barb wire fences and closely pastured. The showy prairie flowers are gone, and even the grasses have been mostly destroyed. Along the roadsides and on railway rights of way a few individuals of the original flora are still to be found, but they are being rapidly driven out by the introduced blue grass and by European weeds.

No ecological survey of this region conducted according to modern ecological methods, has ever been made, and it does not seem possible to make such a survey now. It may however be best to put on record some notes regarding this flora, based partly on recollection and partly on herbarium material. The writer greatly regrets that he feels incompetent to write accurately about the most important constituents of this flora—the prairie grasses.

For convenience this flora may be considered in different groups or areas characterized somewhat as follows:

1. The upland prairie flora, found on high rich rolling well drained land.
2. The slough or marsh flora on land covered by water, or at least wet for the greater part of the year.
3. The prairie meadow flora usually a zone area around a marsh, or rich low lands between low hills.
4. The alkali flora on low saline level prairies where vegetable growth is much stunted.
5. The valley flora where there is good drainage but plenty of moisture.
6. The bluff flora where the soil is dry, and where xerophytic plants abound.
7. The rock flora on gneiss or granitic rocks and on the surrounding shallow soil where the conditions are still more xerophytic.
8. The bog flora found around prairie springs.

Let us consider these floras, or different plant societies, somewhat in detail.

1. *The High Rolling Prairie Flora.*

The greater part of this region consists of high rolling prairies. These are now all under cultivation, so that the characteristic prairie plants are destroyed. These notes refer to what the observant traveler might have seen thirty years ago. With the opening of spring the first plant to attract the attention of the traveler would doubtless have been the pasque flower, Pulsatilla hirsutissima as we have been in the habit of calling it, or *Anemone potens wolfgangia*, if we are bound by the Vienna agreement. It opens its pale lilac petals early in April on dry ground everywhere, and is almost equally conspicuous later on in its fruiting stage when it flings to the breeze its silvery silken styles. *Ranunculus rhomboideus* is found opening its golden petals low down among the gray grasses of the previous year. At about the same time of the year the diminutive *Carex pennsylvanica* is seen blooming everywhere. It is in May, too, that the holy grass, *Hierochloe odorata*, earliest of grasses, sends up its sweet scented panicle in little depressions of the prairie. The deep purple flowers of the prairie violet, *Viola pedatifida*, now begin to appear on the hills. The yellow flowers of the star grass, *Hyproxis hirsuta*, brighten up the springing grass. The prairie blue-eyed grass, *Sisyrinchium campestre*, blooms with the star grass, and many of the plants show white flowers. In dry places the earliest of the Compositae, *Antennaria plantaginifolia*, forms patches of gray on the prairie. Toward the end of May the early meadow rue, *Thalictrum dioicum*, opens its delicate blossoms on rich ground. *Viola pratincola* opens its modest flowers, but buries its cleistogamous flowers in the ground. The ground plum, *Astragalus caryocarpus*, opens its showy racemes of violet-purple flowers, to be followed by its thick-walled fleshy edible pods, said to be part of the bill of fare of the early voyageur. *Vicia americana* is common in rich places, and *Vicia linearis* could be sometimes found toward the western boundary of the state.

With the beginning of June several grasses become conspicuous, and among these perhaps the most common and beautiful are the pale panicles of *Koeleria cristata*, opening everywhere on bluff side and prairie. A much taller and almost equally beautiful grass is *Phalaris arundinacea* often found in moist places on the prairie. The slender wheat grass, *Agropyron tenerum*, is seen sending up its slender spikes everywhere. This grass has persisted along road sides and on dry bluffs, and has perhaps the most agricultural value of any of the native grasses. On richer and moister prairies the awned wheat grass, *Agropyron caninum*, is found sending up its nodding bearded spikes, while in very dry places the western wheat grass, *Agropyron smithii* is common, and its broad flattened spikes are very conspicuous.

Sometimes, but not very often, *Comandra umbellata* is found forming patches on the prairie early in June, where its long running root stocks seem to connect the plants together..

On high rolling prairies *Psoralea esculenta* sends up its spreading bushy tops villous with whitish hairs, bearing spikes of bluish flowers. This plant has a deep farinaceous root and was called "pomme-de-terre" by the French frontiersmen, and it was from the abundance of this plant along its sandy banks that the Pomme-de-Terre river took its name. By the Sioux Indians, this plant was called the Teepsenee, and it was their principal food plant. One who chose to follow an Indian trail in the early days was sure to find wherever the Indians camped a great pile of these thickened roots from which the edible central part had been extracted. These roots are rich in starch and have a pleasant flavor. I do not know that any attempt has ever been made to cultivate this plant. Perhaps it would take too many years to get a crop. In shallow depressions of the prairie one is sure to find a rich growth of *Lathyrus venosus* with its showy bluish or purple flowers. In early June, too, the prairie rose, *Rosa pratincola*, begins to bloom; and one who has seen it at its best will never be able to forget its beauty. Toward autumn, the corymed flowers are followed by the large showy, glabrous fruits which distinguish it from the smaller fruited smooth stemmed rose, supposed to be *Rosa blanda*, found along the river banks and edges of timber. The proper nomenclature of these two roses would be much easier did we not find many bushes seemingly intermediate between the two. Another prairie shrub, *Amorpha nana*, blooms early in June; and its long slender curving spikes of deep purple flowers are very beautiful. *Amorpha canescens*, almost always called shoe strings for the reason that its roots are so hard to cut with a breaking plow, blooms a little later. Its flowers are not nearly so showy, while its densely canescent foliage serves largely to give the prairies their prevailing gray tint. Two species of *Lepidium* are in bloom by road sides and on waste ground. By the middle of June, the red flowers of *Phlox pilosa* are to be seen everywhere, while the marsh vetchling, *Lathyrus palustris*, is blooming in low rich places. The vetches are especially common about gopher mounds. Towards the close of June, the silvery-white foliage of *Psoralia argophylla* begins to be dotted with its deep purple flowers. Among the rarer June flowers is *Agoseris glauca*, a plant of western range, observed in Big Stone county.

Early in July the grayness of the prairie due to the *Amorphas* and *Psoraleas* is heightened by the whitening glumes of the ripening porcupine grass, *Stipa sparatea*. The loosening seed grains with their long spiral awns work through one's clothing and irritate one's flesh in a way never to be forgotten. The Canada milk vetch, *Astragalus canadensis*, becomes a conspicuous object on the prairie where the soil has been loosened by the pocket gopher. Where the soil is somewhat moist the whitely tomentose showy milk weed, *Asclepias speciosa*, raises its stout stem thickly covered with its large oval leaves, carrying at its top its clustered umbels of large flowers. In dry places the rough ox-eye, *Heliopsis scabra*, begins to bloom,—a forerunner of the great show of Compositae to follow. In rich places the showy tick-trefoil, *Desmodium canadense*, may be seen in bloom, together with two prairie clovers, *Petalostemon purpureum*, the latter being one of our most showy prairie flowers. The tall *Elymus canadensis* with its nodding head is now one of the most notable of prairie grasses and the field thistle, *Cirsium discolor*, is becoming a conspicuous object everywhere. Its flowers are light purple or pink, while its stems and the under sides of its leaves are densely white tomentose. Occasionally one finds a white-flowered plant. *Scutellaria parvula* is a modest and unassuming plant on level ground, while *Chenopodium album* grows up in waste places.

In the early part of August the tall stems and purple spikes of the big blue stem grass, *Andropogon furcatus*, are conspicuous objects on rich moist prairies. Indeed, one who has seen this noble grass in great areas growing on the wild prairie, especially if he has seen it in full bloom in early morning swaying before a gentle south wind, will have impressed on his mind a sight never to be forgotten. This grass was the blue stem of the early settlers, and the hay made from it was more prized than that of any other grass. In these rich upland meadows there is sometimes found the tall meadow rue, *Thalictrum purpurascens*, always a conspicuous object. On rich soil the great rag weed, *Ambrosia trifida*, grew to immense proportions, often forming thickets where horses and rider might be concealed from view; while the common rag weed, *Ambrosia artemisiaefolia* was found on the prairie everywhere. Both of these rag weeds became pernicious weeds, after the cultivation of the prairies began, and grew much larger on cultivated ground. The rough cinque foil, *Potentilla monspeliensis*, is occasionally found on the prairies, but is not so common as in the older parts of our country. *Convolvulus sempium* grows around gopher mounds and climbs over *Symphoricarpos*. Since the cultivation of the country began it has become common in fields. In dry places, *Eragrostis purshii* often forms a considerable portion of the soil cover, spreading like a mat over the ground. *Gerardia tenuifolia*, another August flower, is common on bluffs and frequent on level prairie. The earliest sunflower to bloom is *Helianthus scaberrimus*, common on prairies, and persistent as a weed in wheat fields. It is commonly called rosin-weed. Closely related to the rag weeds but with broad entire leaves is *Ivaxanthifolia* growing to the height of six or seven feet in rich locations, and becoming a pernicious weed after the cultivation of the prairie began. The early smooth golden rod has been called *Solidago Missouriensis*, but it is clearly different from *Solidago Missouriensis*, as it grows on the foot hills of the Rockies, and Dr. Rydberg is of the opinion that it should be referred to *Solidago glaberrima* of Martens. *Solidago serotina* is common in moist places, and on the borders of meadows grows to immense proportions. Late in August *Solidago nemoralis* is found in dry places, and is readily identified by its one-sided panicles. Another autumnal golden rod is *Solidago rigida*, probably the most common of them all, persisting in old pastures. Perhaps *Solidago canadensis* is equally common. In some of its forms it seems to be the variety *gilvocanescens* of Rydberg. Another August plant is the wild liquorice, *Glycyrrhiza lepidota*. Its yellowish flowers open in July, but its brown seed pods with glandular prickles make it more noticeable in August. No use is made of it for its medicinal properties. In taste the root resembles the liquorice of commerce, but it is more bitter. Among the tall August grasses may be noted *Panicum virgatum*, *Sorghastrum nutans*, and *Bromus kalmii*. The varieties or species of *Physalis* found on the prairies in August are of difficult limitation. Some seem to be *Physalis longifolia*, of Nuttall, some approach *Physalis lanceolata*, of Micheaux, and others are clearly *Physalis virginiana* of Miller. *Amaranthus blitoides* and *Amarantus graecizans* are common in waste places, especially on new breaking. The latter forms a bushy clump, and in autumn breaks loose at the root and goes bounding across the prairie before the wind. The Russian thistle, *Salsola tragus*, is becoming a common weed in similar locations and shows the same tendency to become a tumble weed. It is uncertain whether or not the common purslane, *Portulaca oleracea*, was a native of this region; but it is frequently found in such locations as to suggest that it was here before the advent of white men. The evening primrose is a common August flower and may be called either *Onagra strigosa* or *Oenothera strigosa*, but the plant needs more study. A small prostrate spurge, probably *Euphorbia glyptosperma*, is a common plant on wild prairie, but more noticeable on new breaking. The prairie dock, *Rumex mexicanus*, is most common on moist ground. Among the grasses of late summer may be noted *Muhlenbergia racemosa* and *Eragostis major*. The latter is common in gardens and on cultivated ground.

A stately plant of early autumn is *Pernathes racemosus*, growing on rich ground, sometimes to the height of six feet. The only gentian common on the autumnal prairie is the *Gentiana puberula*, and it opens its blue flowers very late, sometimes blooming even in October, when the prairie grasses have taken on the brown tints due to frosts. The prairie is now whitened with *Aster multiflorus* and its allies. It is easy to find plants which may be called *Aster exiguus*, (Fernald) Rydberg, and on the plains of South Dakota are plenty of forms that may be called *Aster comutatus*, of Torrey & Gray. However there seems to be so many connecting forms that it seems about as well to call the whole group *Aster multiflorus*.

2. The Slough Flora.

Perhaps the earliest spring flowering plants of the prairie sloughs and marshes are the water crowfoots. When the water is low *Ranunculus delphinifolius* is found blooming in muddy places in the latter part of May, or if the water is high, it will be found a little later blooming in the water itself. *Ranunculus abortivus* is found in moist places at about the same time, and *Ranunculus sceleratus* soon follows. In deep sloughs and in the still waters of rivers *Ranunculus circinatus* and *Ranunculus aquatilis* are seen showing their white flowers in June. An *Eleocharis* which seems to be *E. palustris glaucescens* may be seen growing in shallow water or in wet places early in June. *Scirpus fluviatilis* and *Scirpus polyphyllus*, together with *Juncus nodosus*, *Juncus lurida*, *Carex festucacea*, *Carex arcta*, *Carex cephaloidea*, *Carex vulpinoidea* and *Carex gravida* furnish much of the grass-like vegetation of the sloughs in June. In the shallow water of creeks a true grass, *Alopecurus geniculatus*, may be found showing its timothy-like heads. In deeper water the common cat-tail, *Typha latifolia*, may be seen, The tuffted loose strife, *Lysimachia thyrsiflora*, may be found nestling among the reeds and grasses, and in deep open water, that reptile-like appearing plant, *Hippuris vulgaris*, may frequently be found. Another plant found in the sloughs in June, is *Steironema lanceolatum*. It is toward the close of June, too, that the only shrub common to the sloughs, *Spiraea salicifolia*, is in bloom.

With the beginning of July another loose strife, *Steironema ciliatum*, is in bloom. It was on July 12th, 1888, that the writer collected *Bacopa rotundifolia* in a prairie slough in Lac qui Parle county, perhaps the only Minnesota collection ever made of this plant. Another slough plant to be looked for in July is *Lycopus americanus*. The arrow heads, *Sagittaria latifolia* and *Sagittaria cuneata* are now in bloom and *Scirpus lacustris* and *Scirpus americana* are fruiting in rather deep sloughs, along with *Sparganium eurycarpum*.

With the beginning of August the swamp milkweed, *Asclepias incarnata*, begins to bloom in grassy sloughs. *Bérula erecta* is found in slow streams while *Cicuta maculata* and *Sium cicutaefolium* are found in deeper water. With the drying up of the sloughs in August several species of *Potentilla* become noticeable. Some of these are clearly *Potentilla monspeliensis*, others appear to be *Potentilla pentandra*, while still others may be Rydberg's *Potentilla leucocarpa*. It is in August too, that *Pedicularis lanceolata* is in bloom, while *Radicula hispida* and *Radicula palustris* are common in muddy places. This plant has been called *Nasturtium* and *Roripa*. *Phragmites communis* is now waving its shining purple panicles in the deeper sloughs, and in springy and boggy places the great water dock, *Rumex brit-*

tanica, is conspicuous. *Polygonom lapanthifolium* is common on moist grounds, while *Polygonum emersum* shows its dense rose-colored spikes in the deeper sloughs. This last mentioned plant when touched by the autumnal frosts gives forth a spicy fragrance never to be forgotten by one who has once inhaled it. *Beckmannia crucaeformis* is blooming in muddy places, or more generally growing out of the water. *Ranunculus macounii* may now by looked for on moist ground.

Early in September *Helenium autumnale* and *Solidago graminifolia* open their yellow heads on ground that has been wet all summer. The mininutive *Eleocharis acicularis* is growing in muddy places covering the ground like a carpet. *Ambrosia psilostachya* is now found in moist places. *Boltonia asteroides* is in bloom on all wet grounds, and its white star-like flowers do much to make the low lands look as white as the upland prairie where *Aster multiflorus* is in bloom. *Aster paniculatus* is found in the same low sloughs. The later autumnal flowers of low ground are *Bidens frondosa*, *Bidens leavis* and *Artemisia biennis*, and soon frost puts an end to the whole prodigal show.

3. The Prairie Meadow Flora.

The earliest of prairie grasses, *Hierochloe odorata*, has already been referred to. This grass matures so early as not to be an important constituent of the prairie meadows. *Poavcompressa* has been occasionally found, but is by no means common. A tall *Poa* collected at Clara City was identified at *Poa pseudopratensis* by Prof. Scribner. *Poa pratensis* is not often found in a natural meadow, but it is crowding out the native grasses by road sides and in pastures. *Panicum scribnerianum* is quite common in prairie meadows early in June; but it ripens early and does not contribute much to the hay crop. *Agrostis alba*, seemingly native, is quite common, but much more common is *Poa triflora*, a grass that forms a large part of the hay of prairie farmers. Among the weeds in the native meadows, must be classed *Hordeum jubatum*, a grass that seems to be more than maintaining itself. It furnishes good pasture early in the season, but its rough barley-like awns are very injurious to stock and often cause great damage to the hay crop. Among the coarser grasses of the prairie meadow is *Spartina cynosuroides*, growing to the height of from three to five feet. *Echinochloa crus-galli* is found blooming in August in the wetter parts of the prairie meadows. In many meadows the bulb-producing wild onion, *Allium canadense*, is common.

4. The Alkali Flat Flora.

On some western Minnesota prairies the soil is strongly impregnated with alkaline salts, especially where the surface is so level that the drainage is poor. In such places it would seem that "lye" from the ashes left from frequent burning of the prairies has accumulated until few plants can survive the trying conditions. On these flat prairies *Astragalus hypoglottis*, looking strangely like red clover, is frequently found. This is a circumpolar plant, and extends in similar locations across the steppes of Siberia. It is occasionally found in valley lands. Another plant of these locations is the common lousewort, *Pedicularis canadensis*. One might conclude from the notation of its range given by Britton and by Macmillan, that it is to be found only in wood-lands; but in western Minnesota, it is never found in such locations. The small white lady slipper, *Cypripedium candidum*, once common on these flat prairies, seems to have wholly disappeared. Another plant of early June quite indicative of alkaline conditions is *Zygadenus chloranthus*, with its long racemes of greenish flowers. Here too, several *Senecios* are to be found, probably *Senecio balsamitae* and *Senicio plattensis*. The long stemmed hawksbeard, *Crepis runcinata*, is to be looked for where alkali is unusually abundant. It seems to be a xerophytic plant with a large thickened root from which the long stems shoot up early in June. Britton's manual gives the habitat of *Zizia cordata* as "in woods"; the "Metaspermae of the Minnesota Valley" says that it grows in thickets and on gravelly banks in the southeastern part of the valley, but it is common in western Minnesota on flat alkaline prairies or around the borders of prairie meadows. It never grows in woods or thickets in this part of the state. The characteristic dock around the margins of saline springs is *Rumex persicarioides*. The red goosefoot, *Chenopodium rubrum*, common in the sea coast marshes, appears again in wet places in the alkaline prairies of western Minnesota. *Ranumculus septentrionalis* is common in valleys and on the borders of alkali spots; but the characteristic crowfoot of these locations is *Rannunculus cymbalaria*. Both of these plants are largely progagated by stolons; but the *Cymbalaria* is one of the finest examples of this mode of propagation. *Stachys palustris* is common in abandoned fields where the soil is too wet and alkaline for cultivation. It is quite variable and most of the leaves seem to be petioled. Perhaps it should be regarded as a distinct variety. In some of its forms it is very similar to *Stachys teucrifolia* Rydberg. The wild mint found here has generally been referred to *Mentha canadensis*, but this species has been reduced to a variety of *Mentha arvensis* in the seventh edition of Gray's Manual. *Lithrum alatum* is especially abundant on the flat sandy prairies of Swift county. A *Pycnanthemum* is also found—probably *P. virginianum*. It is well to remember in passing that in the region under consideration there is very little land so impregnated with alkaline salts as not to be covered with prairie grasses. There are mainly such species as are found in prairie meadows, dwarfed somewhat by the inhospitable soil.

5. *The Valley Flora.*

It has been said that the prairie flora is deficient in species but rich in individual plants. One who has journeyed for any great length of time on the open prairie becomes weary of the endless repetition of individuals, and comes out with a sense of relief upon a broad river valley such as that of the Minnesota. He will not find the grasses greatly different from those of the prairie meadow, unless it be those of bluff sides, and these will be spoken of further on.

On rich dry river bottoms one will find *Elymus virginicus L* in place of *E. canadensis L.* On low grounds he will find *Panicum capillare* and *Echinochloa crus-galli;* on river banks *Eragrostis hypnoides*, dwarf and creeping, and possibly in the slow river itself the stately and beautiful *Zizania palustris*. On low valley lands the grass flora differs but little from that of the prairie sloughs. Here we find as the prevailing grass *Sparatina michauxiana Hitch*, and here it reaches its best development. On higher lying bench lands is found *Andropogon furcatus*, associated, if the soil is pretty dry, with *Andropogon scoparius*. In early spring *Hierochloe odorata* is very noticable, and on lower ground later in the season *Panicum capillare* is common. Several species of *Cyperus* are found on river banks, and among them *C. erythrorhizos* and *C. strigosus*. The pasque flower is common on bench lands, and on lower levels in early May *Anemone caroliniana*, the most beautiful of spring flowers, opens its pale blue and white petals. The wild strawberry is now in bloom and appears to be *Fragaria virginiana illinoiensis*. The violet of our river bottoms has been thought to be *Viola pratinicola* Greene; but it needs more study. Some of our plants appear to be *Viola cucullata* Ait, or *Viola papilonacea* Pursh. *Viola palmata* has been collected here but is very rare. *Caltha palustris* is a common spring flower here, occurring in wet meadows. *Sisymbrium incisum* Engl. or *Sophia incisa* Green is common on bench lands. The variety *hartwigianum*, or *Sophia hartwigiana* Greene, has been collected at Big Stone lake. *Capsella Bursa-pastoris* is an introduced weed, while *Ellisia Nyotelea* is a very common native, and sometimes becomes a troublesome weed in grain fields and gardens. *Corydalis aurea* is plentiful near rocky ledges, blooming in the latter part of May.

Among the valley flowers of early June are several *Senecios*. *Senecio palustris* is found on the shores of lakes, as well as in the valleys. *Senecio integerrimus* Nutt and *Senecio atriapiculatus* Rydb, are both referred by Dr. Greenman in his revision of Senecio in the seventh edition of Gray's manual to *Senecio integerrimus*, but the Montevideo specimens seem to be quite distinct. Perhaps a further study of a larger number of specimens would show that the two species run into each other. The wind flowers make a brave show in early June. The most common of these, *Anemone canadense* L. *Anemone virbineana* L., is quite rare here, but *Anemone cylindrica* is quite common. Its fruiting heads continue to elongate after the flowers are gone and become quite conspicuous. The spiderworts are now in bloom. Our plant appears to be *Tradescantia bracteata* Small. The typical milkweed of the river bottoms is *Asclepias syriaca* L, although *Asclepias ovalifolia* is occasionally found. *Asclepias speciosa* is confined to wet places on the high prairie. *Erysinum chiranthoides* is common along the borders of timber on dry soil. *Erysinum styrticolum* Sheldon has been collected at Ortonville, but in the opinion of Dr. Robinson it should be united with the rather more common *Erysimum inconspicum* MacM., and both plants referred to *Erysimum parviflorum* Nutt. *Silene antirrhina* L. is more or less common, and *Silene noctiflora* L, has been collected on the railroad track at Montevideo. *Euphorbia dictyosperma* Fisch & Mey has been collected in the valley both at Montevideo and Granite Falls. The Montevideo Station is the only one referred to in the "Metaspermae of the Minnesota Valley." The new edition of Gray's manual omits Minnesota from its range. This is doubtless due to the reduction of *E. arkansana* and *E. missouriensis* to the above named species. *Potentilla anserina* is common in wet meadows, and *Potentilla paradoxa* has been collected at Big Stone lake. *Galium boreale* is a very common valley plant in the latter part of June. When in full bloom it frequently whitens acres of land at a time. Thot cosmopolite, *Achillea millefolium*, is also found. *Scrophularia leporella* Bicknell is frequently found on the edges of valleys. *Myosurus minimus* is a very rare plant in this region, but it has been collected at Ortonville and Montevideo. *Camelina sativa* has been collected on the railroad right of way at Montevideo. *Prunus pumila* has been collected at the foot of Big Stone lake, and on the Leaf hills in Otter Tail county. Perhaps the shrub found at the latter location is *Prunus cuneata Raf.* The common cornel found in the valleys here seems to be *Cornus stolonifera* Michx. The fact that it is not stoloniferous has led Dr. Rydberg to propose for it the varietal name of *interior*. *Cardamine bulbosa* is frequently found in spring brooks.

The July flora is not so conspicuous. The two sweet clovers, *Melilotus officinalis* and *Melilotus alba*, both introduced plants, are blooming on waste grounds. In similar locations *Lappula virginiana* a distinguished looking plant when young, is producing its inconspicuous flowers or ripening its prickly-barbed fruit, a sad disappointment to one who has watched its growth. *Euphorbia marginata* Pursh is not common in this region, but is found on the southwesterly edge of our area growing in alluvial soil. *Lobelia spicata hirtella* is common in valley meadows. *Teucrium occidentale* Gray, or its variety *boreale* (Bicknell) Fernald, is found at the foot of bluffs where the soil is rich. *Apocynum androsemifolium* is now blooming in open places, and *Apocynum cannabinum* in its variety *hypericifolium* is found along the edges of timber land. *Echinocystis lobata* is twining its graceful stems over shrubs and fences, opening its long racemes of pale flowers in profusion. *Utricularia vulgaris* in its variety *americana* is thrusting up its yellow flowers in marshy ponds; *Erigeron philadeplhicus* is blooming in moist places, while the small flowered *Erigeron ramosus* is blooming on dry bench lands. Other Compositae are now beginning to bloom, *Sylphium perfoliatum* in rich alluvial soil, *Veronia fasciculata* in low grounds, and *Eupatorium purpurem* in still moister places.

August shows many more blooming plants. Perhaps the rarest of these is *Cassia Chamaecrista* found on the river banks at Granite Falls. *Scutellaria lateriflora* is blooming in wet places, while *Ranunculus pennsylvanica* is ripening its fruit in similar locations. At the foot of bluffs are found *Verbena hastata*, *Verbena stricta*, *Verbena urticaefolia* and at Big Stone lake *Verbena bracteosa*. The pink umbels of *Allium stellatum* are now seen on rocky banks everywhere. *Sisymbrium officinale* is ripening its seeds in waste places, while *Sisymbrium altissimum* is becoming a troublesome weed along railway tracks and in grain fields. *Plantago major* is exceedingly common and was doubtless a native here. *Cuscuta gronovii*, *Cuscuta glomerata* and perhaps *Cuscuta arvensis* are found on various plants, mostly *Compositae*. *Hieracium umbellatum* is quite a rare plant in this region, but has been collected at Big Stone lake. It is believed that *Artemisia graphalodes* has been collected in the valleys here, but as that species has been united with *Artemisia ludoviciana* it will have to be called by the latter name. *Dalea alopecuroides*, formerly *Parosela Dalea*, is occasionally found on river bottoms here. *Polanisia trachysperma* T. & G, seems to have been collected in the river valley at Montevideo, although that location is somewhat outside of its range. *Polanisia graveolens Raf*, is a very common plant on lake shores. *Acorus Calamus* has been collected at Carlton lake, Montevideo, but is very rare in this part of the state. *Strophostyles pauciflora* (Benth) Wats., a rare leguminous plant here, is found at Big Stone lake. The typical river valley thistle is *Cirsium altissimun*, sometimes growing to the height of seven or eight feet. In the Minnesota river near Biw Stone lake there has been collected *Mryiophyllum spica tum* and *M. verticillatum* and they are doubtless common in suitable locations throughout this part of the state. The common blazing-stars of the river valleys are *Liatris scariosa* and *L. pycnostachya*, the former growing on higher and dryer ground. The river valley sunflower is *Helianthus grosse-serratus* Willd., while the broad-leaved species found near the edges of the timber is *Helianthus tuberosus*.

In late summer *Lobelia syphilitica* is common in wet meadows. The *Lactucas* are represented by *L. canadensis*, *L. hirsuta*, *L. ludoviciana*, and *L. pulchella*, the latter being quite common. *L. scariola integrata* is too common in gardens. *Thlaspi arvense* is spreading rapidly along railway embankments and promises to become a troublesome weed. What seems to be *Spiranthes gracilis* is frequently found in wet meadows. *Grindelia squarrosa* is found at Montevideo near the railroad track, and along the State line south of Gary.

Among the fall asters of the river valleys may be mentioned, *Aster salicifolius* and *Aster lateriflorus* growing on low ground. *Aster laevis* is found on higher ground along the edges of timber, while *Aster novae-angliae*, the most beautiful of asters, is found along spring brooks. *Boltonias* are common in wet places and contribute much to the beauty of the autumnal landscape.

6. *The Bluff Flora.*

It is along the bluffs of the river valleys that there is found the greatest number of plants having a western range. The grass flora resembles that of the upland prairie, including *Andropogon scoparius*, *Bouteloua curtipendula*, *Bouteloua oligostachya*, *Agropyron smithii*, *Agropyron tenerum*, *Stipa spartea*, *Sporobolus heterolepsis* and *Calamovilfa longifolia*.

Among the early spring flowers may be noted *Agoseris cuspidata* with flowers much like a dandelion. This genus has been called *Troximon* and *Nothocalais*. One of the showiest bluff flowers is *Pentstemon grandiflorus*, but it is rather rare in this region. *Pentstemon gracilis* has been collected at Ortonville, and *Penstemon albidus* is plentiful at Montevideo. Two other common bluff flowers are: *Lithospermum angustifolium* and *L. canescens*. *Geum triflorum* with its purple calyx and long plumose styles is a very showy object in May and early June. Another May flower on prairie knolls is *Allium reticulatum*. It is quite dwarf and has white flowers. *Astragalus adsurgens* forms dense caespitose masses on prairie knolls, its dense spikes and purplish flowers making it look something like red clover. *Astragalus lotiflorus*, Hook, is found on dry banks, or near the tops of bluffs where the ground is very dry and hard. In suitable locations it is quite plentiful. The flowers are inconspicuous. *Astragalus missouriensis* Nutt., while not admitted into the new edition of Gray has been collected at Ortonville. The "Illustrated Flora" gives its range as from Nebraska to the Northwest Territory and south to New Mexico. It seems to be native at Ortonville, and not an introduced plant. *Astragalus flexuosus* Doug. has been collected at Montevideo and is very plentiful near the railway station at Ortonville. *Oxytropis lamberti*, Pursh. is a very showy plant on bluffs throughout the upper Minnesota valley. It has been called a loco weed, but I have never heard of stock being poisoned by it. *Onosmodium hispidissimum*, Mackenzie, is very common throughout this district. It was impossible to make our plant agree with any of the descriptions in the old manuals and it is some satisfaction to know that there is a new species for it. *Gaura coccinea* is not an uncommon plant here. Its rose or scarlet flowers make it very beautiful. *Oenothera serrulata* is another June plant very common along bluffs. Its yellow flowers remain open all day. Our larkspur seems to be *Delphinium azureum*, and it too, is quite conspicuous along the bluffs in June.

Two yellow flaxes are very noticeable along the bluffs during July —*Linum rigidum* and *Linum sulcatum*. *Ascelepias verticillata* is often found on bluffs and may be counted a bluff plant, although it is found on level prairies as well. Another mid-summer plant found on bluffs and high rolling prairies is *Brauneria angustifolia*, noticeable for its large heads and long purplish rays. This plant was known to old frontiersmen as thirst weed. Its gray-colored thickened roots were used by early travelers as an antidote for thirst. Taken into the mouth it has a salty, peppery taste, increasing the flow of saliva so that the weary treveler forgets that there is no good drinking water to be had. *Coreopsis palmata* is another July Composite, quite showy and beautiful. In dry sandy places one is quite sure to find the golden aster, *Chrysopsis villosa*, with its rough gray leaves and branches and yellow flowers. Another July bluff plant is the green milk weed, *Acerates viridiflora lanceolata*. A typical xerophytic plant found on sandy bluffs is *Lygodesmia juncea*. It has scarcely any leaves and seems to delight in the dryest and most sterile soil. Quite a rare plant on dry sandy bluffs is *Oenothera pallida*, a white flowered evening primrose. It has shreddy white bark. Our horsemint appears to be *Monarda mollis* and is found on dry banks in early August. *Polygala verticillata*, with greenish flowers, is found on dry ground. It is not a conspicuous plant, and is one that is apt to be overlooked. *Artemisia frigida* is found on the dryest bluffs, sometimes whitening the whole bluff side, as seen from a distance. *Artemisia longifolia* is quite common in similar locations. A not uncommon aster on the bluff lands is *Aster oblongifolius*, with beautiful purple flowers. Another striking plant of the bluffs is *Aster sericius* with silvery silky leaves. *Kuhnias* are very common plants on the bluffs. Our plant seems to be *Kuhnia eupatoroides*. The attempt to separate this variable species into two or more species seems to have ended in failure. The blazing stars of the bluffs are *Liatris cylindricea* and *Liatris punctata*, the latter more common. *Liatris scariosa* is also frequently found on bluff lands, where *Lepachys columnaris* is also quite common. *Rudbeckia hirta* is not very common near the Minnesota river but is found on the Leaf hills. *Oxybaphus nyctagineus* and *Oxybaphus hirsutus* are both found on dry banks, the latter more common. Both open their flowers late in the afternoon. *Polygonum ramosissimum*, Michx, is the name now given to our tall dry-land knot-weed. Heretofore we have called our plants *Polygnomum camporum*—at least for the most part. *Artemisia dracunculoides*, Pursh is an early autumn plant on dry land. *Artemisia caudeta* is found on thinner soil, usually near rocks.

7. *The Rock Flora.*

The Minnesota valley, as we have remarked, is crossed in several places by ridges of archaic rocks. Near these rocks and in crevices in them, the conditions are even more xerophytic than on the bluffs. The grass flora of these rocky areas does not differ greatly from that of the bluffs. *Bouteloua oligostachya* here reaches a better development. Indeed this valuable grass seems to be more than maintaining itself, and is becoming an important constituent of dry pastures. *Sporobolus brevifolius* belongs in the same plant society as the *Bouteloua* and is usually found with it. *Festuca octoflora* is found on thinner soil and ripens its seed in early summer. *Agrostis hyemalis* is another rock grass, although of course it is found in many other places. Growing in shallow pools on the rocks is a dwarfed form of *Alopecurus geniculatus*, not more than two decimeters high. It seems to be a distinct variety. Growing among the grasses in these rock areas, *Juncus tenuis* is quite a common plant.

Selaginella rupestris is common on the rocks with many interesting mosses and lichens. The common fern found in the crevices of these rocks appears to be *Woodsia ilvensis*. The only other ferns that have been found here are *Cystopteris fragilis* and *Polypodium vulgare*, but both of these are quite rare.

The earliest spring flower in these areas is *Lomatium orientale* (Coulter & Rose). It blooms in April, sending up its umbel of white flowers from a thick fusiform root stock. Blooming at a time when the prairies are still gray with the last year's grasses, it is a difficult plant to find. Early in May *Androsace occidentalis* is a very common but rather inconspicuous flowers. Associated with this plant, but not so common is *Draba Caroliniana*, another very dwarf plant. Growing on the rocks, or where the soil is very thin *Draba nemorosa* is very common. It is very small in early spring when it commences to bloom, but the plant forks repeatedly and continues to bloom and fruit until it reaches a height of at least three decimeters. *Aquilegia canadensis* grows under the shadow of these rocks and is one of the most beautiful spring flowers. *Arenaria lateriflora* has been found in similar locations. *Myosotis virginica* is a rather common plant growing in the crevices of the rocks. *Gillia linearis*, a western plant, is found on the rocks at Cedar lake near Montevideo, but is not very common. *Acerates lanuginosa* is another rare plant of these rocky ledges. Perhaps one of the smallest plants to be found among these rocks is

Centunculus minimus. Another diminutive rock plant is *Gratiola virginiana* growing in the shadow of rocks. *Plantago purshii* is very common on dry ground near these rocks. *Hedeoma hispida* is common too growing on rocks, while *Heuchera hispida* grows on dry soil near by. *Arabis hirsuta* as found on the rocks here is a plant of considerable size. *Isanthus brachitus* is a little plant blooming in the crevices of rocks in July. *Manillaria vivipara* is found on granite ledges near Ortonville. Its bright red flowers are very beautiful. *Opomeia fragilis* is common on the rocks in all parts of the upper Minnesota valley. *Hosackia americana* (lotus) is quite plentiful around Big Stone lake and has been collected as far east as Montevideo. Other plants of a western range collected at Montevideo are:

Potentilla hippiana; Potentilla pennsylvanica strigosia Pursh.; *Potentilla pennsylvanica; Talinum parviflorum* Pursh.; *Houstonia longifolia*, common on the rocks; *Polygonum tenue*, also very common on gneiss rocks, fruiting in September. *Pernathes aspera* Michx, is frequent on rich bench lands near rocks. It is a stately looking plant with a southwestern range.

8. *The Bog Flora.*

There are few bogs in western Minnesota, consequently the list of bog plants is short. Among the plants found about springs and in wet places are: *Epilobium coloratum*, Muhl.; *Epilobium densum*, Raf.; *Epilobium adenocaulon*, *Mimulus glabratus Jamesii*, Gray, found in cold springs; *Callitriche heterophylla*, Pursh, collected in Spring creek, near Montevideo; *Gentiana procera*, Holm., found in marshy bogs near Glenwood.

Lobelia kalmii, L. found in spring bogs in Pope county, *Parnassia caroliniana* found in bogs around lake Minnewaska.

Some of the names used in this paper have an unfamiliar sound. This is due to the action of the Vienna Congress in restoring to use certain generic names that have not been used by American botanists for many years. For the sake of uniformity it is likely that their use will have to be acquiesced in.

THE PRAIRIE LEGUMES OF WESTERN MINNESOTA.

By Lycurgus R. Moyer, Montevideo, Minn.

It may seem presumptuous in one whose knowledge of field botany is only that of an amateur to come before this Academy with a paper on so threadbare a topic. The general subject of the Minnesota flora has already been ably discussed by Dr. Upham in his "Catalogue of the Flora of Minnesota," published as Part VI. of the annual report of progress of the Geological and Natural History Survey of Minnesota, for the year 1883. This scholarly work, while admittedly incomplete, was contributed to by botanists from all parts of the state. and represented at the same time the field observations of Dr. Upham himself while engaged in the actual field work of the geological survey. Eight years later, in 1892, there appeared the much more elaborate and pretentious work of Prof. Conway MacMillan, entitled "The Metaspermae of the Minnesota Valley." Of this work it may be said that it was based on insufficient field work, and so abounds in conclusions not warranted by the facts. Valuable papers on the Flora of Minnesota appeared from time to time in the "Minnesota Botanical Studies," particularly the papers by Sheldon, Heller and Wheeler. The only special report on the flora of western Minnesota, is a paper by William A. Wheeler, entitled "A Contribution to the Knowledge of the Flora of the Red River Valley in Minnesota," (Vol. 2 Minn Bot. Studies 569), in which there are enumerated twelve prairie plants and shrubs belonging to the Leguminosae. The second volume of Britton & Brown's "Illustrated Flora of the Northern United States and Canada" appeared in 1897, and covered western Minnesota in a more satisfactory way than any other publication. It seems likely, in view of the Vienna agreement, that its system of nomenclature will soon seem antiquated. Robinson & Fernald's "Gray's New Manual of Botany" is a very helpful book, but its plant descriptions are too brief to be entirely satisfactory, and it already appears that it omits some Minnesota plants. Coulter & Nelson's "New Manual of Rocky Mountain Botany" is a disappointment in that it is quite locally confined to a small part of the Rocky Mountain region with Wyoming as a center, and does not purport to cover the plains and prairies at all. It has been the hope of western botanists when they found that the "New Gray's Manual" was limited to the regions east of the western boundary of Minnesota, that the New Rocky Mountain Botany would cover the adjacent regions to the west. The book was therefore a disappointment, but it leaves the field open for some enthusiastic young man to write a plains flora, or perhaps a Flora of the Mississippi Valley. It may be said that the plains flowers are not very attractive, but it will be found that they are well adapted to their environment, and therefore worthy of careful study.

It is perhaps generally known that western Minnesota is for the most part a high rolling prairie, from 1,000 to 1,800 feet above the level of the sea. The largest area of level land in this region is the

Red River valley, the ancient bed of the glacial Lake Agassiz. The observations noted in this paper are more pertinent to the high rolling prairie regions lying south of the Red River valley proper. These prairies are practically all of a drift formation. The regions to the north of them, or perhaps western Minnesota itself, seems at one time to have been underlain by extensive formations of limestone which became food for the glacier, and was ground up and incorporated with the other materials in such a way as to produce a soil of surpassing fertility. In respect to the amount of decomposing limestone found in the soil, western Minnesota differs markedly from eastern Minnesota, or from Wisconsin, and the difference is all in its favor. An outcrop of granitic rocks crosses the state from its northeast corner to its southwest corner, but the material from which the extraordinarily fertile soil of western Minnesota was formed was very largely sedimentary rocks abounding in carbonate of lime. Very few exposures of this rock are now to be found remaining in place. There is found on the northeasterly side of Big Stone lake about half a mile from its head an outcrop of shale bearing many concretions, apparently gypsum crystals, but the exact nature of these so far as the writer knows has not been determined. Prof. Todd of the United States Geological Survey is of the opinion that this outcrop is Carlisle shale of the Benton group. Should this opinion prove to be correct one might hazard a guess that the immense number of large and powerful springs found along the southwesterly side of Big Stone lake are due to the running out in this locality of the water bearing Dakota sandstone.

Rich as this soil is minerally, it is probable that part of its fertility is due to the action of nitrifying bacteria which found congenial hosts on the roots of leguminous plants formerly so abundant on the prairie. This is merely suggested without any purpose of going into the extensive literature of this branch of the subject. Certain it is that those parts of the prairies lying highest and driest and apparently possessing the least fertile soil have produced the best crops for many years, some having stood continuous wheat cropping for forty years. Lands lying on a somewhat lower level and apparently possessing much more soil humus, have not been nearly so productive; and it is a fact that the original prairie sod in such locations did not contain nearly so many leguminous plants. It has been noticed, too, that those portions of the original prairie that have been fenced and long pastured and afterwards broken up and planted to ordinary farm crops have not been nearly so productive as the prairies that were broken without being pastured. It is reasonable to believe that there must be some connection between this lack of fertility and the fact that the leguminous plants were so quickly destroyed by cattle.

Like the buffalo the leguminous flora of western Minnesota has now practically passed away, and the traveler on the prairies sees only farm crops, or waste pieces of land bearing weeds of various kinds, many of them bing immigrants from Europe. It seems proper to put on record some account of these plants before the memory of them entirely dies out. They practically exist now only in herbaria, or as isolated individuals in waste places or along railway rights of way; and even in such places they are being rapidly driven out by more persistent vegetation. Kentucky blue grass is driving out the original prairie grasses as well as the leguminous plants.

As nearly as the writer can remember the most common of the prairie legumes was *Psoralea argophylla* Pursh, and it was the silvery silky-white pubescence of this plant that contributed so much toward giving the prairies their prevailing gray tint. It is a plant of wide distribution all over the northwestern plains.

On high rolling prairies, and on bluffs and ridges, one was sure to find *Psoralea esculenta* Pursh, a hairy grayish looking plant with the aspect of a lupine. Deep in the tough prairie sod was buried its oval or oblong farinaceous root. Encased in its tough leathery exterior these roots supplied a white starchy and mealy interior of agreeable flavor. This plant, the tipsini or teep-se-nee of the Indians, the Pomme de Terre of the French voyageur, was the source of a large part of the food supply of the natives. It is said the Indians dried it and made it into flour which was used for thickening soups and for other purposes. The young men who followed the early breaking plows on the western Minnesota prairies can testify that the roots were very good eaten raw. The Pomme de Terre river received its name from the abundance of this plant on the sandy prairies along its banks near where it was crossed by the old Joe Brown trail.

When Prof. Holzinger was a home missionary in Cottonwood county he collected *Psoralea tenuiflora* Pursh, in that county, but it was a rare plant. It was afterward collected between Morton and Granite Falls by Prof. MacMillan.

The common ground-plum of the Minnesota prairies was known as *Astragalus caryocarpus* Ker. in the old manuals, and bears the same name in Robinson & Fernald's New Manual. Dr. Rydberg separated it from Astragalus and proposed it the new genus Geoprumnon. Prof. Nelson in the New Manual of Rocky Mountain Botany leaves the plant in Astragalus as did Dr. Britton, but favors the division of the old species so that our plant becomes *Astragalus crassicarpus* Nutt. It was very common in the early days, and tradition tells us that its fleshy pods were frequently cooked by travelers as a substitute for green peas. One writer has testified that its flavor is midway betweeen that of green peas and asparagus. For many years back the plant has been so infested with "pea bugs" that no one would care to eat the dish.

The widely distributed *Astragalus Carolinianus* L, or *A. Canadensis* L. extends throughout western Minnesota but it was nowhere very common. It was found on prairies, in valleys and along river banks. The specific name "canadensis" is used in the new Gray's Manual and by Dr. Rydberg in his Flora of Colorado, while the New Manual of Rocky Mountain Botany follows Dr. Britton and Dr. Small in preferring the name "carolinianus." It seems that both names appear in Linnaeus' "Species Plantatrum," "carolinianus" being No. 9 and the other No. 10.

At widely separated intervals over the prairies of the western part of the state there are found knolls often of considerable height formed of drift materials, which may be considered as either remnants of moraines or water formed kames. It is an interesting fact of plant distribution that it was on the tops of these kames, and nowhere else on the prairies, that were to be found in the early days fine specimens of *Astragalus nitidus* Doug., usually called *Astragalus adsurgens* Pall. in the early reports. This plant grew from a deep tap-root, and its exceedingly numerous stems, branching only at the base, formed a dense matted clump. Its compact spikes of purplish flowers have something of the aspect of heads of the common red clover. The New Gray's Manual regards the plant as identical with *Astragalus adsurgens* Pall, but that species is regarded as growing only in Asia by Dr. Rydberg, and by the New Manual of Rocky Mountain Botany.

On flat alkaline prairies and sometimes in river valleys *Astragalus hypoglottis* L. was very common in the early days. It is a slender little plant and does not form dense clumps as do many other of the Astragali. The New Rocky Mountain Botany regards it as identical with *Astragalus goniatus* Nutt., but Dr. Rydberg is of a different opinion and regards the Siberian plant as distinct from the American.

On the slope of a railway cut at Ortonville there were collected in 1898 a few specimens of *Astragalus missouriensis* Nutt. This plant is new to the flora of the state, and the writer was at first inclined to think that it had been introduced by the railway; but a visit to the same locality a few years later led to finding many specimens in the vicinity growing in the original prairie sod, so that it may be regarded as truly indigenous. The plant is not mentioned in the New Gray's Manual so that it is an addition to the "Manual region" as well as to the flora of the state. This plant has been separated from Astragalus by Dr. Rydberg, and is placed by him in his new genus Xylophacos.

Growing toward the summits of rather steep banks and bluffs where the sod is somewhat broken up by the washing of rains one is apt to find *Astragalus lotiflorus* Nutt. This plant is placed by Dr. Rydberg in the old genus Phaca. But if one will compare a well developed fruiting specimen of *Astragalus lotiflorus* with a similar specimen of *Astragalus missouriensis* it will be very hard to believe that the two plants belong to two distinct genera. It seems best to leave them both in Astragalus. Perhaps some of our western Minnesota plants belong to Sheldon's *Astragalus eliocarpus* but a comparison of the plants with specimens from Colorado leave the matter in great doubt.

Astragalus flexuosus Doug. was collected at Montevideo in 1885 but the station soon became obliterated. It is quite common near the railway yards at Ortonville. Dr. Rydberg would place this plant in Nuttal's old genus Homalobus.

Sheldon reports the collection of *Astragalus tenellus* Pursh in Otter Tail county, and it seems likely that one of the writer's collections at Ortonville was this species. Dr. Britton places this species in Homalobus, as does Dr. Rydberg in his Flora of Colorado.

Along the summits of bluffs and on prairie knolls *Aragallus Lambertii* (Pursh) Greene is a fairly common plant, and always an object of interest. It is one of the Loco weeds and is common in bluffy pastures, but no instance of cattle poisoning from eating it has come to the writer's knowledge. The New Gray's Manual uses the name Oxytropis for the genus, while Dr. Britton used the name Spiesia in the Illustrated Flora and the name Aragallus in the Manual.

Wild Licorice, *Glycyrrhiza lepidota* Pursh, was fairly common on rich moist prairies, growing sometimes where the soil was partly alkaline. The root of the wild species seems not to be so sweet as the licorice of commerce.

The boys who broke the prairies of western Minnesota forty years ago have vivid recollections of the Devil's Shoe Strings, the plant with so tough a root that it would double around the sharpest plowshare and clog the breaking plow. This plant is *Amorpha canescens* Pursh, and it was very common. Its whitened foliage did much to give the prairies their characteristic gray tint. *Amorpha nana* Nutt., called *Amorpha microphilla* Pursh in the New Gray's Manual, was less common. Its foliage was green and glabrous and its spikes of bright purple flowers were very showy. *Amorpha fruticosa* L. was common on the banks of streams, but it could hardly be called a prairie plant.

Parosela dalea (L) Brit. or *Dalea alopecuroides* Willd. as it is called in the New Gray, was found occasionally, but it was a rare plant.

Among the prairie clovers *Petalostemon candidus* Michx was common, and it is probable that *Petalostemon oligophyllus* (Torr.) Rydb. was common too, but the two species have so much in common as to be difficult to distinguish. *Petalostemon purpureus* (Vent.) Rydb, was common, too, while *Petalostemon villosus Nutt.*, so common in the eastern part of the state, was either absent or very rare.

The Perennial Pea, *Lathyrus venosus* Muhl., was quite common in especially rich ground, near gopher mounds. *Lathyrus palustris* L. was common, too, especially in its variety, *Lathyrus palustris linearifolius* Ser.

One Lespideza, *L. capitata* Michx., may be recorded as a prairie plant, but it was nowhere very common. It was usually found on dry banks and bluffs.

Lotus americanus (Nutt.) Bisch., or as it is called in the New Gray's Manual *Hosackia americana* (Nutt.) Piper, appears never to have been very common in this region but has been collected by the writer at Big Stone lake and Montevideo, and by Sheldon at Lake Hendricks.

These western prairies can scarcely claim more than one Desmodium, *D. canadensis* (L) DC., and this was nowhere very common, and did not grow far from bluffs and river valleys.

Strophostyles pauciflora (Benth.) Hook. has been collected by the writer as far west as Big Stone lake, but it can hardly be called a prairie species.

Vicia americana Muhl. was common throughout the prairie region, in rich moist places, and *Vicia linearis* (Nutt.) Greene, a western species, has been collected as far east as Ortonville.

In conclusion it may be said that the prairie Legumes while belonging to but few species were rich in individuals, and probably contributed much to the fertility of the prairies.

PREHISTORIC ABORIGINES OF MINNESOTA AND THEIR MIGRATIONS.

N. H. Winchell.

[Paper written for the Minnesota Historical Society, and read Feb. 9, 1907.]

(ABSTRACT.)

Prof. Winchell based his dscussion on the latest results of the study of the Glacial period, and the conclusions of the Bureau of American Ethnology. He said that by the former the farthest back that we hope to trace the human occupancy of Minnesota is not more than five or six thousand years, that being the approximate date at which the state became habitable after the retirement of the ice of the last Glacial epoch.

He called attention to the map of late major Powell showing the distribution of the original linguistic stocks of the American aborigines, which number between fifty and sixty; and to some of the remarkable features of that distribution. He showed that after the Glacial period the tribes resident along the Pacific and the Atlantic coasts, and on the gulf coast began a slow migration into the country that had before been uninhabitable lying toward the north. The vanguard of the tribes moving from the southwest was held by the Athapascan and the Algonquian, and from the southeast by the Iroquois and the Sioux. Remnants of these tribes still reside in their pristine seats, and their dialects, which have been carefully studied, are found to be more archaic than the body of the same now known further north, showing that these remnants were the parents of the more northern dialects.

The valley of the Ohio and much of the adjacent country were occupied by the migrating Sioux and they became the celebrated mound builders of the region. The Algonquian, moving from the southwest, took possession of the timbered region of the northwest, extending to Hudson's bay, the whole of Minnesota probably being occupied by them. This constituted the first great migratory movement.

Then began a great war—the result of which was the disruption and expulsion of the Ohio mound builders. This is confirmed by traditions, and by some sub-historic facts. The Algonquians of the northwest moved southeastwardly and crossed the Mississippi in a hostile incursion near the southern boundary of Minnesota, and finally drove the mound builders who have now been learned to have been

the Cherokees and some cognate subtribes, out of Illinois and Ohio and into Virginia and North Carolina, where they were met by De Soto and where they were still building mounds.

Many of them escaped down the Ohio valley, and at its mouth they divided, a part of them returning again to Minnesota and to Iowa, and there establishing, or renewing, the dynasty of the mound builder, this later phase being distinctively called the Minnesota dynasty. It is this migration that brought the present Sioux into the northwest, an event which is believed to have been not more than 500 years ago.

After this the Ojibwa (Algonquian) stock made another successful raid on the Dakota tribes, and gradually pushed them again further south, and recaptured the northern half of the state of Minnesota. This last movement is verified by some historic facts, and by abundant tradition. It was during this war that the whites appeared on the scene. The conclusion of the paper summarized the human migratons that have passed over Minnesota as follows:

1. Algonquian occupancy from the southwest. (During this epoch the Ohio mound builders flourished.)

2. General hostile movement against the mound builders by the Algonquian (Kilistino?) tribes from the northwest, resulting in the destruction of the Ohio dynasty.

3. Fugitive mound builders return up the Mississippi river and possess the country under the second, or Minnesota, dynasty, occupying the southern part of the state, say 500 years ago.

4. The Sioux again driven away, at least from the northern part of the state, by the Algonquian stock, 150 years ago.

5. Aryan civilization.

HENNEPIN AT THE FALLS OF ST. ANTHONY.

N. H. Winchell, Minneapolis.

[Read June 2, 1908.]

In order to appreciate the personal circumstances which characterized the historic scene of Hennepin's discovery of the falls of St. Anthony, it will be necessary to recall briefly the events that led up to the discovery.

It will be remembered that he was a Franciscan priest, somewhat of an adventurer, who had formerly been a soldier, and who had volunteered to accompany La Salle on his perilous exploration of the Mississippi river. With two traveling companions he had been dispatched by La Salle in the spring of 1680 from his fort on the Illinois river, to ascend the Mississippi and inaugurate friendly relations with the Indian tribes and incidentally to begin a trade in beaver skins, for which latter purpose he was furnished with a supply of goods and trinkets such as are desired by the natives. At the same time, geographical knowledge of the unknown regions which would serve to extend the domains of the king of France, and the conversion and baptism of the savages, which would extend the influence of the Roman Catholic church, were subsidiary objects which were to be always borne in mind.

This party was surprised and captured, and robbed, by a roving party of Sioux Indians at some point not far above the mouth of the Wisconsin river. They were conducted, as captives, across the country from some point near Dayton's bluff, in St. Paul, to Mille Lacs in Mille Lacs county, the source of the Rum river. During this arduous trip the Indians quarreled amongst themselves as to the division of the spoils which they had won, and which they laboriously carried along with them. Hennepin became sick and exhausted, but was treated by the Indians, on their arrival at the end of their journey, with a hot steam bath, for which they specially constructed a suitable hut, and after which repeated three times a week, he regained his health and his usual strength.

Hennepin remained several months amongst the Sioux at Mille Lacs, where according to his account of his captivity, he was held as a captive and as a slave. It will be well to enumerate some of the deprivations which he suffered:

(a) His canoe had been broken to pieces when they left the Mississippi at St. Paul.

(b) His goods had been pillaged and divided amongst three of the Sioux bands.

(c) He was adopted by Aquipaguetin as his son, and was consigned to the care of his wives, with instructions to regard him as one of their children, as a substitute for one that had been killed by the Miami.

(e) His sacred articles were taken away from him, and in order to perform baptism on a dying child he wrested a half of a linen altar cloth from the hands of an Indian who had stolen it from him, and put it on the body of the baptised child.

(f) His chasuble had been desecrated by the son of Aquipaguetin, who had used it to wrap up some of the bones of his deceased relatives, and swinging the bundle over his shoulders had paraded through the village. It had then been presented to some of their allies, situated about 500 leagues to the west.

(g) Hennepin was required to serve as barber for the heads of Indian children, and as surgeon for bleeding persons afflicted with asthma, and he also administered a never-failing drug (orvietan) to others who were sick.

It appears therefore that his life with the Sioux at Mille Lacs was one of deprivation and of hunger; and when the Indians were preparing to take him on their annual buffalo hunt his fellow countrymen heaped upon him the crowning act of ingratitude and insult. The three Frenchmen were given a canoe for their joint use in descending the Mississippi; but Accault and Du Gay refused to give him passage in it, and paddled off without taking him, one of them shouting out to him that he had paddled the Franciscan far enough already. He was afterward taken in however by two Indans. It is evident that in this emergency Hennepin was reduced to the lowest pittance of earthly possessions. In this condition he was compassionately conveyed by the Indians as far as the mouth of Rum river where the whole party halted for some time for the purpose of replenishing their stock of canoes.

Events which took place here, united with what precedes, have an important bearing on the personal appearance of Hennepin at the falls of St. Anthony. At the Indian camp Hennepin remembered that La Salle had promised to send him additional supplies and messages from the Illinois, to meet him at the mouth of the Wisconsin river. This delay, at the place which is now known as Champlin, opposite the mouth of Rum river, was galling to him, and he solicited permission from the chief of the Sioux to descend in advance of meet these dispatches at the mouth of the Wisconsin. This was granted and Du Gay was also permitted to accompany him, Accault preferring to remain with the Indians. These two forlorn and adventurous Frenchmen set out in a small, leaking, birch canoe. They were given an earthen pot, and a gun and a knife. They had a single robe made of beaver skins which was to serve them together. They had no guide nor assistants. *This is the party that discovered the falls of St. Anthony.* It consisted of two, ragged and hungry Frenchmen hastening to an appointed place to get supplies and news from La Salle.

The particulars of this discovery are given briefly by Hennepin in the following words:

"This cataract is forty or fifty feet high, divided in the middle of its fall by a rocky island of pyramidal form. * * * As we were making the portage of our canoe at the falls of St. Anthony of Padua we perceived five or six of our Indians who had taken the start, one of whom had climbed an oak opposite the great fall, where he was weeping bitterly, with a well-dressed beaver-robe, whitened inside and trimmed with porcupine quills, which this savage was offering as a sacrifice to the falls, which is in itself admirable and frightful. I heard him, while shedding copious tears, say, addressing this great cataract: 'Thou who art a spirit, grant that the men of our nation may pass here quietly without accident, that we may kill buffalo in abundance, conquer our enemies, and bring slaves here, some of whom we will put to death before thee; the Messenecqz (Sauks and Foxes) have killed our kindred, grant that we may avenge them.'"

The significance of this prayer is understood when we recall the statements of Rev. S. W. Pond, long a missionary amongst the Sioux. According to Mr. Pond the dwelling place of the god of the waters was beneath the falls of St. Anthony. He had the form of a monster ox, and his spirit permeated all streams and lakes. He was called Oanktehi, and as his bones wer occasionally found in bogs and swamps by the superstitious natives Mr. Pond says the Indians worshipped the mastodon (or the mammoth) whose skeletons are still found in such positions. Oanktehi was the evil god, and needed to be propitiated by gifts and sacrifices. He was always contending with the thunder-bird who was the good god and presided over everything. This conflict is brought out vividly by Huggins and by Gordon in their legendary poems "Winona," and "The Feast of the Virgins."

What a setting for some painter to put upon the canvas!

Two wandering, half-starved Frenchmen portaging an old canoe along the east bank of the river.

The falls of St. Anthony just above them to the right.

The foaming rapids just below them.

A superstitious savage offering a beautiful beaver robe to Oanktehi, displaying it on the branches of an overhanging oak tree.

The rising sun in the morning sky.

The scant-forestetd hills and undulating prairies stretching from both banks into the limitless distance.

That is the psychological moment that awaits some skilful artist to be portrayed on the canvas. That is the conjunction in one great scene of the most prophetic and momentous elements in the history of Minnesota.

There is native, original Minnesota in all its untrod magnificence, pregnant with all its potential promise. There is the wild man, its sole occupant, with his feeble energy and superstitious faith.

Conjoined to these in the same scene is the tread of the first European, with all that his civilization implies. In that footstep is the embodiment of geographic exploration prompted by commerce and Christianity, the intelligence and education of Hennepin contrasted with the degradation of the savage. All the art which has followed after that scene, all the manufactures, the science, all the education, all the improved methods of human livelihood are foreshadowed and concentered in the discovery of the falls of St. Anthony. No single individual scene, no event in all our history, carries with it so much of the natural and so much of the possibility of the artificial in our history as the portaging of that canoe round the falls of St. Anthony by Father Hennepin and his companion Du Gay.

It is lamentable that in the Capitol of the state, on the wall of the governor's room, is a travesty of this scene—a painting on which the youth of the state are expected to look and from which to draw impressions of the historic discovery of 1680. When I first glanced at that painting I turned my face away in a feeling akin to disgust, and for three years I did not look upon it again. I have recently examined it, in order that I may be able to render a truthful description. As a work of art and fiction it may be worthy of praise, as a historical picture it is a misrepresentation and an abortion.

The painting shows seven persons, of whom five are seated and two are standing. Of the former one is black-whiskered Du Gay. He has a flint-lock gun, a buffalo gunpowder horn, and a game pouch suspended from his shoulder resting at his right side. He is well clothed and capped. On either side of him are four Indian warriors seated, and apparently interested in the speech which is being made by Hennepin. A red pipestone calumet lies across the gunwale of the canoe. At the right of the picture is an Indian squaw just approaching, with a bundle of baggage suspended by a head-strap, lying across her shoulders. She has Caucasian features and a copper-colored skin. It is to be inferred that the bundle belongs to Hennepin, and the squaw is a slave in his service. The bundle is nicely wrapped and strapped in what appears to be a Mackinac blanket, although it may be meant to indicate a beaver skin robe, for it is hard to believe that such an anachronism as a Mackinac blanket would by any one be introduced into such a painting. A birch canoe is on the rocks in the midst of the group, the ostensible means of travel for the whole seven.

Standing boldly to the front, and facing the falls, appears Hennepin. The spot is apparently some distance below the falls on the east bank. The point of view enables one to overlook the falls and see a small part of the river above, and hence must be supposed to be located on the brink of the gorge. At the same time it is plain that the portage round the falls has already been made and that the arrival of the squaw carrying Hennepin's baggage is the last act in the "carry." Hence it has to be inferred that the scene is at the lower end of the portage line, and at the place where they can again push their canoe into the river. This inherent inconsistency cannot be explained by any one except the artist.

The most remarkable character in this fantastic group, as is natural and was to be expected, is Hennepin himself. His cowl is thrown back upon his chasuble, revealing a shaven face and a tonsured caput. He stretches forward and upward both arms, in the left holding a crucifix as if he were proclaiming the double dominion of St. Anthony of Padua and of the king of France. A robe covers him down to his ankles. His feet are lightly sandaled, and his shoulders and back are covered with a chasuble which tapers downward to a narrow strip, extending about to his hips. The sleeves of the gown are large and flowing, and the priest's waist is girted by a twisted (or braided) heavy cord, the ends of which hang down the right side and show several ornamental enlargements. From the laborious attitude of the squaw it is evident that the whole party have but just arrived, and that the appearance of Hennepin is designed to represent him in his ordinary traveling costume, leaving it open to imagination as to what part of Hennepin's baggage the squaw carried.

The divergencies of this remarkable picture from historic truth are so glaring that the merest tyro in state history can but discern them. To the novice in state history, and to the multitudes who visit the room who know nothing about our state history it conveys a wrong impression. As a work of imaginative art it is finely executed and appropriately colored.

There is, however, a higher element in art than mere mechanical execution. True art is true to nature and to facts.

"Art is the child of nature; yes, her darling child, in whom we trace the features of the mother's face"—*Longfellow.*

In the absence of a knowledge of facts it would be warrantable to supply them, but the result ought to be labeled, not a historic painting but an imaginative restoration of history. Poems are thus built up. Novels are "based on history." Milton's "Paradise Lost," most of the dramas of Shakespeare, are of this character. But they are not history and do not claim to be history. The known events of those histories are scant or too prosaic. The poets were justifiable, in constructing their works, in supplying lacking parts.

In the case of the discovery of the falls of St. Anthony, what an opportunity for a truthful painting! the scene, the historic event, the lively description by Hennepin—the very details are all available..

Osborne Reynolds.

THE STRUCTURE OF THE UNIVERSE; BEING A PRESENTATION OF PROFESSOR OSBORNE REYNOLDS' THEORY OF GRAVITATION.

(With Experiments.)

By John Mackenzie, Minneapolis.

First Statement of Reynolds' Theory in This Country.

The title of my lecture this evening sounds high. When one talks about the structure of the universe it would seem that he has a large subject on his hands. I may also state that as far as I know what I will present to you this evening has not up to the present time been presented to or dealt with by any other scientific, philosophical or literary society in this country, and with the exception of the general mention of Reynolds' theory of gravitation by my friend Professor Henry Crew of the Northwestern University, in his recent work on "General Physics" I am not aware that the theory has yet been noticed in the United States.

Wonderful Developments of Modern Science.

Numerous and wonderful have been the discoveries of science from the time of Newton to the present day; and the end is not yet. As Henry C. Jones, Professor of Physical Chemistry in Johns Hopkins University in his work entitled, "The Electrical Nature of Matter" remarks: "It seems not too much to predict that as the 19th century surpassed the preceding 18th in the development of scientific knowledge and the discovery of truth, just so the twentieth century will exceed them all in the gifts of pure science to the story of human knowledge." I hope my lecture this evening will show you to some extent how true this is, and that indeed, already in this century the portals have been opened by the master mind of Osborne Reynolds to a new and further advance of dynamical science by the solution of the problem of all problems,—the cause of gravitation.

As To Professor Reynolds.

Professor Osborne Reynolds was born at Belfast, Ireland, on Aug. 23, 1842. He graduated at Queen's College, Cambridge, in 1867, his name being fifth in the list of wranglers in the mathematical tripos.

In 1868 he became Professor of Engineering in Owens College, Manchester, England,—an institution which is regarded as probably the greatest engineering college in the world. Owing to ill health he resigned his professorship a year and a half ago. Professor Reynolds' researches and contributions dealing with various mechanical and dynamical subjects rank very high with all engineers, and, as all students of the subject know, his researches have largely created the modern science of hydrodynamics.* The third volume of Reynold's

* He has been presented with many honors by various scientific institutions, and his name is familiar throughout the world to all who take an interest in the physical sciences.

Scientific Works is entitled: "The Sub-mechanics of the Universe," and is published under the auspices of the Royal Society. This is a work of pure science, is highly technical, and deals wth the structure of the universe from a dyamical and mechanical point of view, and explains the cause of universal gravitation. Combining as Reynolds does the rare gifts of pure science and practical science, we get a tangible definite theory or rather explanation as to the structure of the universe, which is the result of twenty years of experimental and mathematical investigation, and which is something very different from the fruitless speculations on gravitation which have been indulged in by many of the speculative philosophers in the past. We have here at last a simple, sensible, dynamical theory of the physical universe and gravitation. The problem, however, as you will realize later, is solved by an apparent paradox.

Newton Discovered the Law But Not the Cause.

We are aware of the fact that Newton discovered and enunciated *the law* of universal gravitation, but he did not discover *the cause.* Newton proved the law by which all the material bodies in the universe were governed. This law, as you know, states that all masses of matter in the universe attract each other with forces proportional to the masses and inversely proportional to the square of the distance between them. This law governs the smallest particle of matter as well as the mightiest sun in the universe. But, while Newton *speculated* on the cause of gravitation, or the *reason why* bodies act in this way, he was unable to solve the problem. There have been many attempts since the time of Newton to solve the problem. The history of physical science is replete with the baffled efforts of the greatest intellects to find the solution. One has only to read Taylor's "Kinetic Theories of Gravitation" to realize the many fruitless attempts to solve this problem in the last two centuries, and indeed some philosophers came to the conclusion that the problem could never be solved. There are indications that Fourier and even the great Laplace considered gravitation as one of the "primordial causes" which might remain forever impenetrable to us.

The Gifts of Pure Science to Practical Science.

In the eyes of a certain class of people the many long years of toil and patient investigation of the true scientific investigator count for nothing unless they immediately bring forth some brilliant, or sensational discovery, or one which can be immediately turned into money. Some people have no use for science unless they can see immediate money in it. We should not forget, however, that the so-called "practical" fellows would very soon have nothing to work on were it not for the researches carried on and the principles discovered by the students of pure science. We have only to reflect on the practical value of Newton's discovery of the law of gravitation. This was a discovery in pure science, and has it not given the world its science of mechanics? Were it not for the mighty Newton and the great Galileo, who, out of their pure love of scientific investigation laid down the laws of motion and pure mechanics, the world could have had no engineers. And coming down to modern times, were it not for Faraday and Maxwell who discovered the principles of electric induction and electromagnetic waves there colud be no Edison or Marconi to apply them.

The Vast Apparently Empty Space of the Universe Compared to the Small Space Occupied by Matter.

When we look into the sky on a clear dark night through a powerful telescope the stars and planets appear to be set in a vast vault-like space showing the perspective of distance to a certain extent. They seem to lose the appearance which they present to the unaided eye of being set simply on a plane background. As we look into the vast abysses of space we realize that notwithstanding the great number of stars the actual space they occupy in the universe is as nothing compared to the vast spaces all round them which appear to be absolutely void. We may say that the room taken up or occupied by what we call "matter" in the universe is exceedingly small compared with the space which seems to be empty. Professor Newcomb has stated that probably there are about 100 million suns in the universe, averaging five times larger than our sun. This would give a total amount of matter of 500 million suns equal to our sun, and he supposes these suns to be equally distributed throughout a sphere 30,000 light years in diameter. In other words, light, which travels, as you know, at a velocity of 186,000 miles per second would take 30,000 years to pass from one side of such a universe or sphere to the other side. This would mean a sphere billons of billions of miles in diameter; whereas, our sun, which is something like 800,000 miles in diameter, even if enlarged 500 million times would still be but an infinitesimally small speck of matter in such a vast universe of otherwise empty space.

What is This Apparently Empty Space?

The question occurs, What is the nature of this apparently empty space? Is it a complete void or vacuum, or does it contain a medium of some kind? Now, on this point there have been many speculations. To all appearances the planets, moons, stars, comets and meteors which move through this space with great velocities meet with no resistance from this medium, if there be a medium. The earth moves through it at a speed of 19 miles per second in its journey round the sun, and recent experiments of Professor Michelson seem to prove conclusively that if there be a medium in this space none of it is entangled with the earth or carried along with the earth in its motion through space.

Another question arises. Is the powerful force of gravity which binds the different bodies of the solar system together, and in fact the whole material universe, conveyed through absolutely empty space? In other words, can momentum be transmitted across an absolute void, or is there such a thing as "action at a distance?" We know that the gravitative pull of the sun on the earth is equal to a force more than a million million steel rods, each seventeen feet in diameter could stand. The earth is 92,000,000 miles from the sun. Is this immense force transmitted across an absolute void? While the eye sees nothing in space, it would seem to our better judgment that there must be some sort of mechansm which transmits this gigantic force. Other considerations lead us to this conclusion. We know that powerful magnetic storms originating in the sun are transmitted instantaneously to the earth and throughout the whole solar system with such intensity occasionally as to put many of the telegraph instruments and wires in the country out of commission until they pass.

The Density of the Medium.

Until recent years very little of a definite nature has been known as to the nature of the medium of space. So far as any evidence it gives of its existence to our senses is concerned, it would appear to be something very unsubstantial, and for this reason it has been called the "ether." Newton had an idea that it was a very thin, highly attenuated fluid which pervaded all space, so very thin in fact, that if you could scatter a pill box full of air throughout the space of the solar system its density would then be about the density of the ether of space.

With the development of electrical science and the study of electric and magnetic forces, however, different ideas began to be entertained as to the density of the so-called ether, until to-day we have the leading physicists postulating the necessity for an ether of very high density and very much greater than the density of any known substance. In his Yale lectures on "Electricity and Matter" Sir J. J. Thomson, in discussing the nature of electrical mass, says: "The view I wish to put before you is that it is not merely a part of the mass of a body which arises in this way, but that the *whole* mass of any body is just the mass of ether surrounding the body which is carried along by the Faraday tubes associated with the atoms of the body. In fact, that all mass is mass of the ether, all momentum, momentum of the ether, and all kinetic energy kinetic energy of the ether. This view, it should be said, requires the density of the ether to be immensely greater than that of any known substance." And in his presidential address to the British Association at Winnipeg last August he said: "Since we know the volume of the corpuscle as well as the mass, we can calculate the density of the ether attached to the corpuscle; doing so, we find it amounts to the prodigious value of about 2,000 million times that of lead." He states, however, that this density would be the density of the ether only in the immediate vicinity of the corpuscle, and that its density in free space would not be so high if the ether is not compressible. Sir Oliver Lodge, in his last edition of "Modern Views of Electricity" also says: "The ether is now turning out to be by far the most substantial body known,—in comparison with which the hitherto contemplated material universe is like a vapor of extreme tenuity,—a barely perceptible filmy veil."

These conclusions of Thomson and Lodge as to the density of the medium of space are arrived at by the study of electromagnetic and electrostatic forces. Professor Reynolds works out his conclusions from mechanical and dynamical considerations, and arrives at the density of the medium of space as being ten thousand times that of water, or 480 times denser than platinum, which is the densest matter on earth.

In view of this great density of the medium of space, does it not seem rather paradoxical that what we call matter, that is, the planets, suns, moons, comets and so forth, which are so much less dense than the medium should move through the medium apparently without resistance and at such high velocities? Our earth, as you know, moves in its orbit at a velocity of 19 miles per second. You have all seen bubbles moving in water. Reynolds shows that the earth and all the other material bodies move through space in a similar manner. They are less dense than the medium in which they exist, and, as we shall see, their movements are due to differences of pressure in the surrounding medium. They are like so many filmy soap bubbles which a child blows from the stem of a pipe. Real mass is not in the material things which we see, but in space where the eye sees nothing. The sober conclusion of the most advanced dynamical science is that matter is a negative thing so far as its mass is concerned, and that the space occupied by "matter" contains very much less mass than the space where no "matter" exists.

Is the Medium Continuous or Granular?

We now come to another important point. I have here on the table a glass full of small shot and another glass full of jelly, The glass of shot we will take to represent a universe composed of what we will call a "granular medium," that is, a medium composed of discrete or separate parts or grains; the jelly represents a universe composed of what we will call a "continuous medium," that is a medium not made up of discrete or separate parts, but continuous in its structure. These two kinds of structures represent the two views which are held as to the nature of the structure of the medium of space. We have ascertained that this medium is very dense; now let us endeavor to find out the character of its structure. On the correct answer to this question hinges the true solution of the problem of gravitation.

We have had atomic systems of philosophy from the earliest ages. Democritus and Lucretius are the ancient fathers of the atomic systems. In his great poem on the origin of things Lucretius speculates on the atomic system of the universe, and tries to show that the origin of the universe was due to a "concourse of atoms." There have been many speculations on this point from that day to this; but it has remained for modern science, with its experimental and mathematical methods, to arrive at the truth.

Analogy would suggest that the medium of space would be granular in its structure. We are not acquainted with anything that cannot be divided into parts. The atomic theory in chemistry, whose modern founder was Dalton, and which has proved so fertile, postulates that the chemical unit is the atom, and that the atom is the unit from which is built up systems of molecules, organic and inorganic, in the universe around us; that all things are combinations and compounds of atoms. The atom, indeed, has been weighed and measured. Maxwell and Kelvin did this for us, and we know in fact about how many atoms could be laid alongside each other in the length of an inch. They tell us that from ten million to one hundred million atoms could be laid alongside each other to make up an inch in length. Of course, anything so small as this is inconceivable; but we know that the inconceivability of a thing now-a-days does not mean that it is impossible. Kelvin stated that if a drop of water were enlarged to the size of the earth, which we know is about 8,000 miles in diameter, the atoms or molecules of which it is composed would appear about the size of base balls.

In recent years, however, somethng very much smaller than the atom has been discovered by science. You have all heard of the electron. An electron is an atom of electricity. It is now maintained by physicists that the ordinary chemical atom which I have just spoken of, is a compound thing, and is composed of aggregations of thousands of electrons. An electron has been defined as an "electric point charge" in the ether. It seems to be an almost infinitely small point of electricity, and the idea is that aggregations of these electric point charges or electrons, when combined into a system form what is known as the chemical atom. Configurations of such a system have been worked out by Thomson, Larmor and others, and it would appear that the system of the chemical atom which is an aggregation of electrons is far more complicated than the solar system. The infinitely small is turning out to be more complex than the infinitely great. The universe within the atom seems to be more complicated than the universe outside. The electron is, of course, very much smaller than the atom, and, like the atom, its size is inconceivable. One may get an idea of the size of the electron as compared with the size of the atom if we suppose the electron to be about as large as the head of a pin revolving inside the Minneapolis Auditorium, the Auditorium being taken to represent the size of the atom. These electrons which make up the atomic system move with very high velocities in the atomic system. The mass of the moving electron has been measured, as well as the electric charge which it carries.

So we see that by the discovery of the electron we have simply discovered a smaller kind of atom than the old chemical one. The electron theory, then, still maintains the granular structure of the ether or medium of space. I ought to say, however, that there are still some physicists, notably, Sir Oliver Lodge, who seem to maintain that the medium of space is not granular or of a discrete structure, but that it is a "perfectly continuous, incompressible and inextensible medium filling all space without interstices or breach of continuity." The continuous medium theory, however, has so far completely failed to give the slightest clue to the cause of gravitation, and all that Lodge has to say is that "gravitation is explicable by differences of pressure in the medium, caused by some action between it and matter not yet understood." He is right in saying that it is caused by differences of pressure in the medium, but he cannot find the proper mechanism to produce these necessary differences of pressure in his continuous medium.

By an elaborate analysis Reynolds shows that the medium of space must be granular in its constitution. He shows that space is occupied by uniform spherical grains of changeless shape and size. It is occupied by what he calls "spherical grains in normal piling." The opening statement in his "Sub-mechanics of the Universe" is:

"By this research it is shown that there is one and only one, conceivable purely mechanical system capable of accounting for all the physical evidence, as we know it, in the universe."

"The system is neither more nor less than an arrangement of indefinite extent, of uniform spherical grains generally in normal piling so close that the grains cannot change their neighbours, although continually in relative motion with each other; the grains being of changeless shape and size; thus constituting to a first approximation, an elastic medium with six axes of elasticity symmetrically placed."

It is worthy of note that Newton also had tbe conception that the real sub-stratum of the physical universe is granular in its structure, for in the fourth edition of his "Opticks" page 375 he says: "All things considered, it seems probable that God in the beginning formed matter in solid, massy, hard, impenetrable, movable particles, of such sizes, figures and with such other properties, and in such proportion in space as most conduced to the end for which he formed them, and that these primitive particles being solids, are incomparably harder than any porous bodies compounded of them; even so very hard as never to wear or break to pieces; no ordinary power being able to divide what God himself made one in the first creation."

The question has been asked, why are most sports but the variants of one object, the propulsion of a sphere? Billiards, baseball, polo, golf, slinging, marbles, squash, handball, football, racquets, cricket, hockey, bagatelle, tennis, shooting, pelota, all have as their basic pursuit the driving of a ball, the propulsion of a sphere. Tipcat, shuttlecock and top spinning are the employment of modifications of the sphere. May the reason not be that poor mortal man attempts by these means to get in a small way into the tremendous scheme of the universe, which is the everlasting movement of the spheres?

The Fundamental Atom.

We considered above the size of the chemical atom and also the approximate size of the electron, aggregations of which, according to the electron theory make up the chemical atom. We saw how very small the electron is as compared with the chemical atom. We shall now enquire as to the size of the grain in Reynolds' granular medium. Reynolds shows that its diameter is the seven hundred thousand millionth part of the wave length of violet light. A wave of violet light is about the 70 thousandth part of an inch in length. Reynolds' cosmic grain, then, is very much smaller than even the electron. It is at least as much smaller than the electron as the electron is smaller than the chemical atom, the sizes of all three being equally inconceivable. This cosmic grain of Reynolds is the absolute or fundamental atom of the universe. It is the smallest entity which can exist in space. Reynolds has shown by dynamical and mathematical considerations that this grain is the smallest possible entity which can exist in the universe. It is the "absolutely rigid granule, ultimate atom or primordian." In Section VIII. of the "Sub-mechanics" he says:

"Although the absolutely rigid atom is as old as any conception in physical philosophy, the properties attributed to it are outside any experience derived from the properties of matter. In this respect the perfect atom is in the same position, though in a different way, as that other physical conception—the perfect fluid. Both of these conceptions represent conditions to which matter in one or other of its modes, apparently approximates, but to which, the results of all researches show, it can never attain, although this experience shows that there is still something beyond. * * * It becomes clear therefore that any fundamental atom must be considered as something outside—of another order than—material bodies, the properties of which are not to be considered as a consequence of the laws of motion and conservation of energy in the medium, but as the prime cause of these laws."

This last statement involves a very important principle; for, whereas other theories of the atom have been based on the motion of a so-called perfect fluid continuously filling space, like Kelvin's vortex atomic theory, or upon an electronic system of electrostatic and electromagnetic forces, as developed by Thomson, Larmor and Lodge, the atom in these systems being the *result* of the laws of motion and conservation of energy, Reynold's fundamental atoms or cosmic grains, by their *motions and arrangements* are themselves the cause of the laws of motion and conservation of energy, the whole explanation and philosophy being purely dynamical, just as Newton's explanation of the law of gravitation is purely dynamical.

Arrangement or Piling of the Grains.

We come now to one of the most important points in the whole subject; that is, the arrangement or piling of the grains in the medium. We have all doubtless seen cannon balls piled in heaps on military reservations. Now, there are different ways in which shot or other spheres may be piled. I have here before me on the table six different regular arrangements or piling of small rubber balls, and in these different arrangements the number of balls varies in proportion to the total volume or space occupied by the balls. There are six regular arrangements in which balls touching each other may be piled, shown by these six models, and in each of these arrangements, as stated, the full spaces or the spaces occupied by the balls, and the empty spaces or the interstices between them vary. I have calculated the relation or proportion of full space to empty space in these six different arrangements, and find that in the closest arrangement or piling, where the grains are arranged in parallel tiers in triangular form, taking the total volume of the pile as 100, the full space occupied by the balls amounts to 79.818 and the empty space to 20.182, or about 4 to 1, whereas in the most open arrangement of piling, where the grains are placed vertically over each other in parallel tiers in the square position, like this model, the full space is only

52.381 and the empty space 47.619, or about 11 to 10. The other four methods of piling lie between these two extremes. I append to this lecture the figures of the proportions of full space to empty space in the six arrangements.

One of Reynolds' most inportant steps toward the discovery of the cause of gravitation was the discovery of the dilatancy of granular media under pressure. For instance, when shot or sand or other spherical grains are put into a bag or other closed surface and shaken, they settle into a very close position, and when in this position the spaces or interstices which exist between the grains are about the smallest possible. They may then be said to be in what Reynolds calls "normal piling" and when in this position the shape of the bag containing the shot or grains cannot be changed without at the same time changing its bulk or volume; because if you endeavor to change the shape of the containing vessel under such conditions, you are at the same time disturbing the grains from their closest possible positions into another arrangement less close, whereby the spaces or interstices between the grains are enlarged, thereby producing a vacuum, or working against atmospheric pressure. I have here two hollow rubber balls, one filled with small shot and completely closed, except for a small opening which does not allow the shot to escape, and into which a glass tube is inserted to measure the dilatation. Colored water is poured into the bag through the tube to fill the interstices between the shot, and if the bag is then subjected to distortional squeezing, as it now is, the water, as you see, sinks in the tube. It is drawn into the bag to fill the expanded spaces between the grains caused by the distortion. This is an experimental model universe. I have here another similar bag filled only with water, but, as you see, when it is similarly squeezed the water rises in the tube. I have here also one of these thin rubber balloons which children play with, filled with sand and just enough water to fill the interstices between the sand when lying flat as you see it now. It is closed tightly so as not to admit any air. It is now placed on its edge, and, as you see, sustains a weight of 200 pounds without flinching. This appears to be nothing short of magical, but when the phenomena of dilatation of granular media under pressure is understood it is perfectly simple. (Experiment.)

This remarkable property of dilatancy of all granular media was discovered by Reynolds. It also furnished him the clue to the cause of gravitation. In order to get granular media under pressure it must be bounded by a closed surface. Reynolds says: "If, as in the universe, the grains in normal piling extend indefinitely, there can be no mean motion of the boundaries, whatever the pressure may be; and thus the grains are virtually within a closed surface."

Here is a model made out of small rubber balls of the way the cosmic grains are arranged in space according to Reynolds. This arrangement is what he calls "normal piling," and is such that the grains are placed in a set of squarely formed layers horizontally, each sphere resting on four in the layer below, and in its turn supporting four in the layer above, these last four being vertically over the first four. Besides touching these eight in adjoining layers it touches four in its own layer, making twelve in all. There are therefore twelve grains piled around each grain. This then is the arrangement or piling of the grains throughout the universe of space where no matter exists.

Matter is Absence of Grains.

Where matter exists there is a different arrangement in the piling of the grains, and the regular or normal piling of the grains is broken. There is a less number of grains per unit volume in the spots where matter exists than there is in the regular medium of space. Where this deficiency which results in what we call "matter" exists, there is what Reynolds calls "abnormal piling" of the grains. This deficiency forms a sort of crack, or gap, or loose joint in the medium, and there is a break in the gearing of the grains between the matter and the medium outside. An atom of matter consists of a nucleus of grains in normal piling surrounded by a surface or spherical shell of grains in abnormal piling. The grains in abnormal piling form what Reynolds calls "a singular surface of misfit" between the regular piling inside, which forms the nucleus of the material atom and the normally piled grains of the medium outside. This "surface of misfit" or spherical shell together with its nucleus is called a "negative inequality" and the magnitude of the negative inequality is reckoned by the number of grains which are deficient, and as the number of grains present in a given volume of the medium determines the mass of the medium, an absence of grains means an absence of mass. Therefore, matter is absence of mass or negative mass. These surfaces of misfit or spherical cracks in the medium are places of weakness in the medium, and it is shown that they travel through the medium after the manner of solitary waves.

Mean and Relative Motion of the Medium.

We have now to consider whether the grains of the medium are fixed and stationary in their places, or whether they have motion among one another. Reynolds shows that the grains of the medium are not fixed but that they have a mean and relative motion. The medium is not inert and rigid and lifeless. It thrills with energy and pulsates with universal motion. It possesses two kinds of motion, first, the relative motion of the grains among one another, and, second, a mean motion, which is a motion of the mass of the medium as a whole from one position in space to another. The average relative velocity of the grains among one another is shown to be about one and one-third feet per second, while the mean path of the grain, that is, the average distance a grain has to move before it strikes its neighbor, is shown to be the four thousand millionth part of the diameter of the grain. It is the relative motion of the grains among one another which renders the medium elastic, and, as Reynolds says, is the prime cause of elasticity in the universe. The mean and relative motions of the medium are illustrated by the movement of a cloud of dust, a swarm of bees, a shower of hail, a current of air, a stream of water, or a cloud in the sky. In each of these phenomena we have movement of the mass of the particles as a whole and also the individual movement of the particles of which the mass is composed with relation to each other. The movement of the mass as a whole is called the mean motion, and the relative movement of the particles in the mass is the relative motion of the medium.

The Pressure and Stress of the Medium.

Let us now ask, What is the pressure of this medium of space? We certainly do not feel its pressure; neither do we feel atmospheric pressure, though we know that the atmospheric pressure on the surface of the earth at sea level is nearly 15 pounds on the square inch. At great ocean depths we also know that the hydraulic pressure amounts to several tons per square inch; and we also know that as we go down into the earth the pressure of the surrounding rocks and strata increases very rapidly, until at great depths it amounts to hundreds of tons on the square inch. We probably do not realize that every square foot of surface of a man's body is subjected to an atmospheric pressure of about one ton, so if the surface area of a human body is say 10 feet, that body is subjected to a total pressure of about 10 tons. We are ordinarily unconscious of such a pressure, because it presses upon us equally in all directions, but if this pressure should be suddenly removed from one side of our body we would soon realize it, and the pressure on the other side would hurl us through space with the speed of a cannon ball.

Located as we are on our tiny earth, which is whirling through infinite space at a speed of 19 miles per second, we are immersed in a vast ethereal ocean. Can we ascertain whether the medium of this ocean has any pressure? Reynolds shows that the mean pressure of the medium of this universal ocean of space is nearly seven hundred and fifty thousand tons on the square inch, being more than three thousand times greater than the strongest material can sustain. A statement like this seems paradoxical, and we cannot by any stretch of the imagination conceive of such a pressure existing in what we have hitherto regarded as empty space. Yet such is the sober truth, found necessary to account for the physical facts that we know. Clerk Maxwell, the great Scotch mathematician and physicist, arrived at the same conclusion as to pressure and stress of the ether from a consideration of electromagnetic and electrostatic forces. In his article on "Attraction" in the Encyclopoedia Brittanica, after discussing this subject, he says: "The state of stress, therefore, which we must suppose to exist in the invisible medium is 3,000 times greater than that which the strongest steel could support."

Now it seems rather strange to us at first that the medium of space is of such great density. We have been accustomed all our lives to think of matter as being in fact the only solid reality, and universal space as simply nothing. It will thus be seen that the old style philosophical materialist will find slight comfort in Reynolds' theory, for the materialist's so-called real matter is shown to be only a kind of froth or foam or bubble in the universal granular ocean, which is ten thousand times denser than water. The presence of what we call "matter" in space means a place where there is a sort of crack, a gap or fissure in the uniform medium. It may be interesting here to mention Kelvin's vortex atomic theory of matter, from which so much was expected, but which has failed to give any clue to gravity, and any theory of matter which does not contain a solution of the problem of gravitation can have no permanent value, for gravitation is the supreme problem before physics to-day. The next great advance in physical science lies in the solution of this problem.

The Vortex Atomic Theory.

Kelvin conceived a perfect fluid continuously filling space, and he supposed that what we call an atom of matter is the rotating portion of this fluid. We can make air, water or any other fluid more or less rigid by imparting rapid motion to it. The motion differentiates that portion of the fluid which is in motion from that portion which is not in motion, like the smoke ring which sometimes ascends from the funnel of a locomotive. The idea was that if the fluid were frictionless and vortex motion once started in it that motion would continue forever. He conceived that atoms might be composed of such rings of ether in motion, the ether being supposed to be the perfect fluid. The atoms were a sort of ether squirts. This theory of matter was quite interesting and something new at the time, and the dynamics of the theory were worked out by Helmholtz and J. J. Thomson, but notwithstanding that it promised so much, it has been for the most part given up, and it has not been able to throw any light on the problem of gravitation. I spoke about the electron theory of matter in a previous part of this lecture. Neither has this theory, however fascinating in many respects, been able to produce an explanation of gravity. The gravitational force is entirely different from and belongs to another order than the electrostatic and electromagnetic forces, and all the endeavors to get an explanation of gravitation out of them have led to negative results.

Mass.

We have spoken about mass. Now let us see what mass is. Of course, mass has been defined as the amount of matter in a body, or the inertia of a body. We should not confound mass with weight. The book which is lying on this table has a certain weight here which can be ascertained exactly, but if I transferred it to the Equator of the earth it would weigh less than it does here, and if I took it to the North Pole it would weigh more. In other words, the weight of a body on the earth's surface depends on its distance from the center of the earth, and *vice versa*, and we know that the surface of the earth at the Equator is 13 miles further away from the center of the earth than the North Pole is. But the book at any place on the earth's surface would still have exactly the same mass, and indeed it would still have the same mass at any place in the universe. Weight depends on the force of gravity, and we know the force of gravity varies at different points of the earth's surface, according to their distance from the earth's center; but the mass does not vary so long as the law of the conservation of matter holds good. If the book were placed millions of miles from the earth away out in interstellar space where there was no planet or sun to attract it, it would remain suspended in space without motion, and would have no weight; but its mass would be the same as before. How is this? Because it would require exactly the same amount of force to move it over a certain distance in a certain time. Mass is measured by the amount of force required to move it over unit distance in unit time, and unit mass is that quantity of mass which is moved unit distance in unit time by unit force, no matter in what part of the universe it may be placed, whether it may be on earth, or on the planet Mars or Jupiter or billions of miles away in interstellar space. But this only gives us a measure of mass. It does not tell us what mass is. It is only in recent years by the study of X rays, cathode rays, and other electrical discharges in the Crookes' tube that physical science has been able to gain some definite knowledge on this subject. As I stated in a previous part of this lecture, a good deal is now known about the behaviour of the particles, called electrons or corpuscles, which make up the discharge which passes from the negative to the positive pole of the tube. The mass of these particles, the electric charge which they carry, and the velocity with which they travel have been measured. These particles may be called electric points, or electric point charges, and it is found that their mass is not a constant quantity, but that it varies with the speed with which they travel in the tube. As their velocity is increased their mass becomes greater, as it is diminished their mass becomes less; so that their mass is a function of their velocity. They have no mass apart from motion. This being the case, their momentum is also a function of their velocity, as is also their energy, for momentum is the product of mass and velocity and energy the product of mass and the square of the velocity. I spoke about the electrons which whirl around inside the system of the atom with very high velocities, in some cases with nearly the velocity of light. Calculations have been given by Sir J. J. Thomson showing the enormous amount of electronic energy due to the motions of the electrons inside the atomic system. It is found that inside the atoms of one gram of hydrogen gas there is contained an amount of electronic or corpuscular energy, which if set free, would be sufficient to raise one million tons 300 feet high. We know the energy which is liberated in an explosion of dynamite or guncotton. That is atomic energy, caused by what we call chemical affinity. But we see how much greater sub-atomic energy is. Perhaps the day will come when man will know how to set free this sub-atomic energy, but for the present it is probably better that he does not know.

Negative Inequalities.

The ordinary chemical atom, then, seems to be a sort of hole or sink or hollow place in some medium which fills space, and to be a locus or point into which pours tremendous energies from this medium. This hole or sink or hollow place in space which is the locus of the atom is what Reynolds calls a "negative inequality" in the medium, or a "singular surface of misfit" due to a deficiency of grains below the number in the regular normal piling in the surrounding space. He calculates that the real core of the atom consists of the normally piled grains, and that this normally piled core is surrounded by a spherical shell containing a deficiency of grains, the thickness of this spherical shell being probably about five times the diameter of the grain. This spherical shell is surrounded on the outside by the normally piled grains which extend outwards into space indefinitely. Wherever these spherical negative inequalities exist, however, there is set up in the medium surrounding them a system of strains due to the pressure of the medium, which result in producing a curvature in the normal piling of the medium.

I will now try to show how the motion of these negative inequalities which we call matter is possible in such a medium, and how these negative inequalities gravitate toward each other through the medium according to the law of gravitation. How does matter move through space? How does the earth move through space at the rate of nearly 20 miles per second? Reynolds' solution of the problem is very interesting. It moves by propagation. He compares it to a bubble rising in water. He says: "* * * it follows as two negative centers approach each other under their mutual attractions the mass in the medium recedes, which is an inversion of the preconceived ideas. Such action however is not outside experience, since every bubble which ascends from the bottom of a glass of soda water involves the same action. The matter in the bubble having the density of air requires the descent of an equal volume of water at a density 800 times greater than that of air. It is the negative inequality in the density of matter, which under the varying pressure of the water causes the negative or downward displacement of the material medium—water and the positive or upward displacement of the negative inequality in the density within the singular surface."

Propagation of "Matter" Through Space.

I have here a dozen billiard balls, divided into two rows of half a dozen each close together, one row a little higher than the other and resting in a continuous groove, so the upper ones may run down and strike the lower ones. There is a gap of say 18 inches between the two rows. We allow the upper six balls to run down and strike the end of the lower six one by one. The result will be that as each ball from the upper row strikes the end ball of the lower row the ball at the far end of the lower row will run away from the lower row the moment of the impact of the ball from the upper row, and it will run away with the same speed as the speed of the impinging ball which strikes the front end. In other words, all the motion or momentum of the striking ball will be communicated through the whole row of lower balls instantaneously and will be delivered to the last ball, which will carry away the motion or momentum. Meantime, as each ball runs away from the rear end and one comes in in front the whole six balls have run down and taken up their positions in front, delivering their momentum to the lower row, the whole row of lower balls will have moved forward its entire length, or six diameters. This illustrates how positive and negative momentum may move through a body at the same time in opposite directions, for as each ball strikes the front end it communicates a certain amount of positive momentum to the mass as a whole, which travels through the mass in a positive direction, and an equal amount of momentum travels through the mass in an opposite, or negative direction, which results in the motion in the opposite direction of the mass as a whole. The real motion of the mass is in the opposite direction to that of the impinging balls. If the balls moved quick enough the eye would lead us to suppose that the motion of the lower row of balls was continuous, and not done by successive impacts, just as in moving pictures which appear to represent a continuous scene, but which we know is made up of a multitude of separate scenes taken in rapid succession. We may take the gap between the two rows of balls to represent the inequality which is to propagate through the medium, for instance the earth moving through space. There is an incoming of grains in front and a leaving of grains in the rear, the momentum of the incoming grains being transmitted instantaneously throughout the whole mass from front to rear, the real mass of the medium moving in the opposite direction to that of the inequality. Reynolds says: "If the medium is stationary and the molecules are moving with the earth the grains within the surfaces do not partake of the mean motion of these surfaces, being replaced continuously by other grains by the action of propagation, by which the singular surfaces in their motion are continually absorbing the grains in front and leaving those behind without any mean effect on the motion of the grains. And thus there is perfect freedom of the molecules or aggregate matter, although the grains which constitute the nuclei are changing at the rate of 20 miles a second. To be standing on a floor that is running away at a rate of 20 miles a second without being conscious of any motion is our continual experience, but to realize that such is the case is certainly a tax on the imagination. Such motion has all the character of a wave in the medium, and that is what the singular surfaces which we call matter are—waves. We are all waves."

Cause of Gravitation.

We now come to what is really the most important part of our subject, namely, the cause of gravitation, and if you have been able to comprehend what has already been stated, I think you will have no trouble in understanding what is now to be explained, that is, why two bodies or masses of matter in space may approach each other according to the Newtonian law of gravitation.

In the first place we must rid our minds of the idea that there is any such thing as "attraction" inherent in masses of matter themselves. Though in popular language we speak about the sun attracting the earth, the earth attracting the moon, etc., in reality they do not attract each other. All motions are really produced by pressure of some kind or other exerted upon the bodies which move. Air currents, ocean currents, the tides, as well as movements of rigid bodies are produced by pressure exerted in some way, and the gravitation or motion of bodies in universal space is no exception to this. Reynolds shows that wherever these "negative inequalities" or "singular surfaces of misfit" which we have seen to be matter, exist, there we have a sort of gap or crack in the granular medium, which forms a surface of weakness, and it is shown that the pressure of the medium is less between these "negative inequalities" or surfaces of weakness than it is on the outside. There is a strain set up in the granular medium in normal piling between them, which produces a curvature in the normal piling. This produces space variations or dilatations between the grains in the curved normal piling. These spaces vary according to the degree of the curve, and the total of the enlarged spaces or dilatations so produced by the curvature is exactly equal to the total of the spaces from which the grains are absent in the negative inequalities which produce the curve. Owing to this, as has been said, the pressure of the medium is less between the negative inequalities or masses of matter than it is in the medium outside, with the result that the extra outside pressure drives the negative inequalities together. The old physics calls this "space variation of the potential." As the bodies approach the curvature is annihilated and the medium is restored to the regular normal piling.

It is somewhat difficult at first for one to understand this process; but the dynamical reasoning upon which it is based is thoroughly sound. Reynolds says: "This law of attraction, which satisfies all the conditions of gravitation, is now shown by definite analysis to result from negative local inequalities in an otherwise uniform granular medium under a mean pressure equal in all directions, as a consequence of the property of dilatancy in such media when the grains are so close that there is no diffusion and infinite relative motion and further it is shown to be the only attraction which satisfies the conditions of gravitation in a purely mechanical system."

"Gravitation is not the result of that dilatation which results from uniform *parallel* strains in the medium in normal piling, but results solely from those components of the dilatations caused by the *space variation of the inward strains.*

"Thus, as long as the dilatation strains are parallel there is no attraction; but if there is curvature in the strains there will be efforts, proportional to the inverse square of the distance, to cause the negative inequalities to approach from a finite distance.

"Thus gravitation is the rsult of those components of the dilatations (taken to a first approximation) which are caused by the variations of the components of the inward strains, caused by curvature in the normal piling of the medium.

"The other components of the strains, being parallel distortions, which satisfy the conditions of geometrical similarity, do not affect the efforts.

"Then, since if the grains were indefinitely small, while the curvature in the normal piling was finite, there would be no effort. And multiplying this parameter by the curvature of the medium, and again by the mean pressure of the medium, the product measures the intensity of the efforts to approach.

"The dilatation diminishes as the centres of the negative inequalities approach, and work is done by the pressure outside the singular surfaces, to bring the singular surfaces of the negative inequalities together.

"The efforts to cause the approach of the centers correspond exactly to the gravitation of matter if matter represents the absence of mass, and thus the inversion of preconceived ideas is complete. Matter is measured by the absence of mass necessary to complete the normal piling. And the effort to bring the negative inequalities together is also an effort on the mass to recede; and since the actions are those of positive pressure, there is no attraction involved, the efforts being the result of the virtual diminution of the pressures inwards, and in this inversion we have a complete, quantitative, purely mechanical explanation of the cause of gravitation.

"The mechanical actions on which this attraction depends are completely exposed in the foregoing analysis, and offer a complete explanation of the cause of gravitation."

Positive Inequalities.

In addition to their being "negative inequalities" in the medium or places where there is an absence of grains, there may be places where there are a greater number of grains than exists in the normal piling, and such places are called "positive inequalities" in the medium. In these cases the curvature which will exist in the normal piling between two "positive inequalities" will be the reverse of the curvature in the case of two negative inequalities, producing a repulsion between two such positive centers, which will drive such positive inequalities or centers away from each other, just the opposite of gravitational attraction. There would, therefore, be no evidence in the universe of such positive inequalities, as through the force of repulsion they would be scattered to the remote regions of the universe.

Other Phenomena Explained.

What is electricity? Reynolds explains that electricity is due to what he calls a "complex inequality." That is, a certain cluster of grains may be by some means moved from one position in space to another, and a current of electricity is a flowing back of these grains to their former positions. Calculations are given to show that the efforts to revert in the case of such complex inequalities correspond to electricity.

Magnetism is due to rotational stresses in the medium between spherical clusters and surrounding grains, the stresses being opposite ways round in different portions. The strains accompanying these rotational stresses involve dilatation, and attractions and repulsions will be exhibited.

The theory also explains other physical phenomena, such as cohesion, light, heat, aberration, refraction and polarization of light, the association and dis-sociation of molecules, the dispersion of the spectrum, and other natural phenomena. Reynolds says: "Considering that not one of these phenomena had perviously received a mechanical explanation it appears how indefinitely small must be the probability that there should be another structure of the universe which would satisfy the same evidence."

Steps Taken By Reynolds.

Some may ask, if Reynolds' theory is such a great one why is it that we do not hear more about it? Also what does the scientific world think of the theory? In answer to the first question I may say that there has scarcely yet been time since the publication of Reynolds' work for the theory to become known. The "Submechanics of the Universe" was published in 1903, but the mathematical difficulties of the work are so great, that few are able to grasp the proofs. Neither are all the proofs of the theory in this work. The final theory is the result of five successive steps or discoveries. These steps or discoveries were made, as Reynolds says, "apart from any idea that they would be steps towards the mechanical solution of the problem of the universe." These steps and discoveries are to be found in Volumes I. and II. of Reynolds' Scientific Papers. The first of these steps was taken in 1874, the second in 1879, the third in 1883, the fourth in 1885, and the fifth in 1895. Each deals with a particular physical problem, and taken altogether they form the base on which the great superstructure, "The Submechanics of the Universe" is built. I append to this lecture the names of the subjects dealt with in the five successive steps referred to. So it need not be a matter of surprise that more is not heard of the theory yet.

Solved By A Paradox.

In addition to this the ideas which flow from the theory seem at first strange to our minds and to our preconceived ideas, and it is only by rational analysis that we can arrive at the conceptions which the theory contains. The solution of the problem of gravitation seems to be solved by a paradox. Yet this should not deter us from attacking it. The history of science rather proves that every intellectual advance realizes a paradoxical opinion, and that "intellectual development may be traced to the successive discomfitures of common sence." Who ever believes progress to be as certain in the future as it has been in the past, must admit, *a priori* the existence of phenomena which conflict with what we know at present, and from the fact that man's knowledge about the world has received continual additions, it immediately follows that to *every time* other truths are given than those hitherto demonstrable. Every generation has supposed that it stood on the apex of the pyramid, and has supposed all phenomena of nature to be deducible from just those laws known to it, so that all future generations had the mere subordinate task of dragging new stones on to a structure of which the architectural conception was complete. But true progress is not extensive but vertical, and so it has always been such investigators as were free from this prejudice who have been destined to make revolutionary discoveries.

The history of knowledge is like the development of a mine. When the ore has been worked out down to one level a new level must be started deeper down. The ore on one level will only last a certain time, and if we would keep enlarging the mine the explorations must go to deeper levels. In like manner in the history of science we find that science reaches a certain stage under the domination of some reigning method or idea, and that it is then unable to go any further until a new discovery is made, or until the mine of knowledge is tapped, as it were at a deeper level. This gives science a new impulse and new ideas and knowledge flow from such discovery. Such for instance were the great discoveries of Copernicus and Newton, and I think that Reynolds' theory of the cause of gravitation is destined to be another epoch making discovery. It is an inversion of ideas hitherto conceived as to matter and mass, from which will probably flow a series of wonderful discoveries as to the true mechanism of the universe in which we live.

Reynolds' explanation of the motion of matter through space is in itself a new and most wonderful conception. It takes place by propagation. Propagation means generation, renewal. The motion of the earth through space is not a *bodily translation*, but the movement of a form or wave having the shape of the earth, by means of an exchange of momentum between the cosmic grains on opposite sides of the surface, just as the gap between the two rows of balls in the experiment which you saw, moves forward as the balls pass across from one surface to the opposite one. The gap between the two rows of balls is the "negative inequality," which we call "matter." Reynolds puts it: "Thus it is that the inequality in density, the integral of which is the volume of the grains, the replacement of which would restore the uniformity of the medium, obliterating the inequality, constitutes the mass propagated. And as this, for a negative centre is negative, its propagation requires the displacement of an equivalent positive mass in the opposite direction to that of propagation of the negative inequality." This is the supreme paradox of the whole theory, and leads to an inversion of ideas as to the structure of the universe. It would strike us as chimerical were it not established by sound mathematical and dynamical investigation. Remember also the statement of Sir J. J. Thomson, arrived at from another line of investigation that "all mass is mass of the ether, all momentum, momentum of the ether, and all kinetic energy kinetic energy of the ether. This view, it should be said, requires the density of the ether to be immensely greater than that of any known substance."

From these new views and conceptions I look for great developments in philosophy in the near future.

Notices of the Theory.

In regard to the scientific world, the theory has scarcely as yet entered the stage of criticism. There have been some notices of the theory in England. The "Sub-mechanics of the Universe" was published in 1903. Whetham in his "Recent Development of Physical Science" published recently, referring to Reynolds' work, says: "The mathematical analysis by which these deductions are established is attempt will stand the criticisms that will be directed against it; but very complex and difficult, and it is yet too soon to say if this bold

Professor Osborne Reynolds' great reputation and the twenty years he has labored at this research will ensure for it a careful consideration from those competent to judge of its merits."

Professor J. D. Everett, at the end of an article on "Normal Piling" published in the Philosophical Magazine, says: "I have not made any attempt to verify the elaborate statistical calculations with which Professor Reynolds' paper abounds. My present purpose is not controversy but explanation, and the style of the paper is so exceedingly technical that a good deal of explanation seems to be necessary before an intelligent controversy can begin. I have chiefly aimed at an explanation of the geometrical conditions which underlie the system supposed, thereby clearing the way for more searching criticism, and helping towards the working out of the very fruitful suggestions which the theory contains,"

Professor G. H. Bryan, in a review of Reynolds' work in "Nature" concludes by saying: "It may safely be described as one of the most remarkable attempts that have been made in recent years to formulate a dynamical system of accounting for all the physical phenomena at present known. A theory such as is here set forth may not improbably play the same part in modern science that was assumed by the atomic theory and the kinetic theory of gases in the science of the time when these theories were propounded. It may be confidently anticipated that Professor Osborne Reynolds' granular medium will play an important part in the physics of the future."

Influence on Philosophy.

What will be the influence of Reynolds' theory on philosophy? So far as this is concerned I think it is destined to play a very important part in philosophy. Previous systems of philosophy have been very ignorant as to the structure of the universe. They have been composed mostly of metaphysical guesswork. Philosophy requires the aid of positive science to explain the fundamental arrangement of the universe; and hitherto no medium has ever been suggested which would cause a statistical force of attraction between two bodies at a dinstance. The explanation of gravitation as enunciated by Reynolds carries with it probably the greatest scientific conception that has ever entered the mind of man, and any philosophy of the future which has any pretentions to arrive at the truth must take Reynolds' theory into consideration. Notwithstanding all the great systems of philosophy which have been spun from the brain of man throughout the ages, not one of them has been able to explain the simplest and most familiar phenomenon, viz., the fall of a stone to the ground. Ever since man has been upon the earth he has seen the phenomena caused by gravitation. He has seen the avalanche hurtling down the mountain side, the rivers rolling onward to the sea, and countless other phenomena caused by gravity which happened daily before his eyes. To the astronomer every movement of the heavenly bodies is caused by gravity; the geologist has constantly before his eyes evidences of its action in the formation of the earth, and the physiologist sees its action in the structure of our bodies; in short, there is not a single department of nature where gravity has not played a most important role. It is the most universal agent known. And, notwithstanding all this does it not seem strange that its cause has remained unknown until now? Yet, this need not surprise us; for the predominant characteristic of man is, and has always been his ignorance of the things concerning himself and nature around him. Taking the history of mankind as extending over several thousand years at least, we may say that it was only yesterday that he learned that his blood circulated in his body, that the atmosphere had weight, and that the earth went round the sun. With the liberation of man's mind through the aid of science he is now beginning to realize something of his own possibilities, and to cast a prophetic eye towards the future, which holds within its womb possibilities for him yet undreamed of, as the fruit of his knowledge. Man's mind is not yet exhausted. It is only beginning its career of conquest over nature.

Dr. Carl Barus in his "Progress of Physics in the Nineteenth Century" remarks: "Just as the 19th century began with dynamics and closed with electricity, so the 20th century begins anew with dynamics to reach a goal, the magnitude of which the human mind can only await with awe."

March 8, 1910.

List of the Steps Which Led Reynolds to the Discovery of Gravitation.

1. On the Extent and Action of the Heating Surface of Steam Boilers. Pages 81-85, Vol. I. Papers on Mechanical and Physical Subjects. 1874-5.
2. On Certain Dimensional Properties of Matter in the Gaseous State. Pages 257-390. Vol. I., Papers on Mechanical and Physical Subjects. 1879.
3. On the Equations of Motion and the Boundary Conditions for Viscous Fluids. Pages 132-137. Vol. II., Papers on Mechanical and Physical Subjects. 1883.
4. Experiments showing Dilatancy, a Property of Granular Material, possibly conected with Gravitation. Pages 217-227, Vol. II., Papers on Mechanical and Physical Subjects. 1886.

   On the Dilatancy of Media Composed of Rigid Particles in Contact. With Experimental Illustrations. Pages 203-216. Vol. II., as above. 1885.
5. On the Dynamical Theory of Incompressible Viscous Fluids and the Determination of the Criterion. Pages 535-577, Vol. II. Papers on Mechanical and Physical Subjects. 1895.
   —*Cambridge University Press, London.*

Relation of Full Space to Empty Space in Different Pilings of Round Particles.

	Space of Volume.	Full Space.	Empty Space.
1. Vertical Position	100	52.381	47.619
2. First Triangular Position.............	100	59.864	40.136
3. Second " "	100	69.841	30.159
4. Third " "	100	79.818	20.182
5. Fixed Pyramidal "	100	72.877	27.123
6 Fixed Quadrilateral "	100	74.830	25.170

THE EVENING GROSBEAK IN MINNESOTA.*

A. O. U. No. 514. HESPERIPHONA VESPERTINA VESPERTINA (*W. Cooper*).

By Thomas S. Roberts, Minneapolis.

Minn. Ref. *Fringilla vespertina* WILLIAM COOPER, Annals Lyc. N. H. N. Y., I, ii, 1825, 219-222 ("common about head of Lake Superior, at Fond du Lac, etc."; first record for locality later included in Minn.)—WILSON AND BONAPARTE, Am. Ornith., IV, 1831, 135 (common about head of Lake Superior, at Fond du Lac, etc.)—NUTTALL, Man. Ornith. U. S. & Can., I, 1832, 526 (upper extremity Lake Superior).—NUTTALL, Man. Ornith, U. S. & Can., II, 1834, 594 (borders of Lake Superior).—*Coccothraustes vespertina* SWAINSON AND RICHARDSON, Fauna Bor. Am., I, 1831, 269 (frequents the borders of Lake Superior).—COOKE, Rep. Bird Migr. Miss. Val., 1888, 178 (winter dates, notes, etc., scuthern Minn.)—CANTWELL, O. & O., XV, 1890, 134 (common winter visitor).—CHAMBERLAIN, Nutt. Ornith., I, 1891, 367 (upper extremity of Lake Superior).—HATCH, Notes Bds. Minn., 1892, 291-293 (biog.)—McILWRAITH, Bds. Ont., 1894, 291 (St. Cloud, St. Paul, Minneapolis, Red Wing).—STONE, Bds. East Penn. and N. J., 1894, 109 (eastward to Lake Superior, etc.)—DART, Ool., XI, 1894, 84-86 (Litchfield).—ROBERTS, Wilcox Hist. Becker Co., 1907, 179. *Hesperiphona vespertina* COOPER AND SUCKLEY, Rep. Pac. R. R. Surv., XII., pt. ii, 1860, 196 (east to Lake Superior).—BAIRD, CASSIN AND LAWRENCE, Bds. N. Am., 1860, 409 (east to Lake Superior).—HATCH, Bull. Minn. Acad. Nat. Sci., 1874, 58 (winter visitant from November till early spring, etc.; first definite Minn. record).—BAND, BREWER AND RIDGWAY, Hist. N. Am. Bds., I., 1874, 450 ("east to Lake Superior')'.—HOLDER, Mus. Nat. Hist., III, 1877(?), cxliii (east to Lake Superior).—TIFFANY, Am. Nat. XII, 1878, 471 (occurrence at Minneapolis, habits, etc., based on observations of Roberts, Herrick & Williams).—ROBERTS, Bull. Nutt. Ornith. Club, IV, 1879, 237-238 (late spring departure, dates Minneapolis).—COUES, Bull. Nutt. Ornith, Club, IV, 1879, 62, 71, 72 (synonymy, two references, Ames [should be Hatch] and Tiffany; latter also referred to in text).—[ALLEN], Bull. Nutt. Ornith. Club, VI, 1880, 51 (bib. ref. to article by Tiffany in Am. Nat.)—ROBERTS, Geol. Nat. Hist. Surv. Minn., 9th Ann. Rep., 1881, 379 (regular winter visitant, habits, dates, localities, etc.)—HATCH, Geol. Nat. Hist. Surv. Minn., 9th Ann. Rep., 1881, 364 (winter visitor).—COOKE, Auk. I, 1884, 244 (White Earth, Chippewa name).—HERRICK, Bull. Sci. Lab. Dennison Univ., I, 1885, 5-15, 2 plates (biographical matter based on observations made in Minn. followed by a detailed description of the osteology of the species with brief reference to the myology; an indifferent colored plate of the female and a plate exhibiting chiefly osteological characters).—SELOVER, Sunny South Oologist, I, 1886, 33 (Lake City).—[WINCHELL], Geol. Nat. Hist. Surv. Minn., 14th Ann. Rep., 1886, 144, 148 154, 156 (Minneapolis and Pelican Rapids, twenty specimens, dates, etc.)—SHARPE, Cat. Bds. Brit. Museum, XII, 1888, 34 (range east to Lake Superior).—CANTWELL, O. & O., XV, 1890, 90 (Lake Minnetonka, had not left

* This article was prepared in its present form for a Report on the Birds of Minnesota in course of preparation by the Minn. Nat. Hist. Survey. It is here offered in full as it will probably have to be much condensed when used for the purpose intended. The annotated synonymy or "Minnesota References" arranged so as to give a chronoligical history of the species so far as Minnesota is concerned is in part the work of Dr. L. O. Dart, while the description of the species was prepared by Mrs. F. W. Commons from technical works on Ornithology, chiefly Ridgway's Bds. N. & M. A., aided by the study of a considerable series of skins in the collection of the Survey.

May 15, 1888).—COUES, Key N. Am. Bds., I, 1903, 377 (regularly to Lake Superior).—*Cocothraustes vespertina* [HATCH], Trans. Minn. State Hort. Soc., VII, 1879, 90 (arrive about first of November; plentiful on Nicollet Island).—[ANON.], Birds, II, 1897, 80 (upper Miss. Valley, Lake Superior).—GIBBS, Minn. Hort., XXXII, July, 1904, 255 (McCray's list; also in "Trees, Fruits and Flowers of Minn.", XXXII, July, 1904, 255).—*H. vespertina* BAILEY, O. & O., IX, 1884, 62 (Elk River, regular winter visitor, notes on food).—COOKE, O. & O., IX, 1884, 65 (common in Minn. this spring, etc.)—*Coccothraustes vespertina vespertina* MEARNS, Auk. VII, 1890, 246, 248, 249 (reference to seventy-two specimens taken at Fort Snelling, Minn.; part of series used in separating *C. v. montana*).—*Coccothraustes vespertinus* APGAR, Birds of U. S., 1898(?); 115 ("western British provinces east to Lake Superior," etc.)—SCOTT, Bird Studies, 1898, 163 (more regular than elsewhere (winter) in Minn., Wis., etc.)—*Hesperiphona vespertina vespertina* RIDGWAY, Bds. N. & M. Am., I, 1901, 40-41 (synonymy, four references: "Lake Superior in summer," Swains & Rich.; W. W. Cooke; Tiffany; Roberts)—*Evening Grosbeak* ROBERTS, F. & S., XIV, 1880, 328 (seen April 7).—ROBERTS, F. & S., 1880, 428 (May 3).—G. [LEASON], The Kingdom, X, 1898, 609 (winter visitant).—G. [LEASON], The Kingdom, X, 1898, 626 (occasionally in winter).—GLEASON, The Kingdom, XI, 1899, 286 (photo; habits, food, etc.)

Sp. Char. *Adult male.*—Top of head, black; forehead and line over eye, yellow; a narrow black line separating the yellow of forehead from base of bill and extending down on either side to join a black area in front of each eye; rest of head with neck and upper back, plain olive changing gradually to clear lemon yellow on scapulars and rump; upper tail coverts and tail black; wings black with a conspicuous white patch formed by innermost greater coverts and secondaries which are pure white, the former sometimes edged with yellow and frequently in fall and winter specimens with more or less dull black on inner edges and tips; under parts shading from yellowish olive on chest to lemon yellow on abdomen and under tail coverts; longest feathers of under tail coverts sometimes partly white and rarely with a broad, transverse black band near the tips; leg feathers black, narrowly tipped below with yellow; bill varies from greenish horn color to light yellowish green; iris brown; legs and feet dusky flesh color. *Adult female.*—Top and sides of head dark gray, separated from the lighter gray of the back by a more or less distinct band of yellowish olive green; back more or less tinged with yellowish olive; rump paler gray or buffy, posterior feathers sometimes extensively black at the base; throat white or whitish with a more or less distinct dusky streak along each side; under parts light buffy gray, usually more or less tinged with yellow especially on sides of chest; abdomen paler gray; under tail coverts white; under wing coverts chiefly light yellow; wings dull black, with innermost greater coverts largely dull white, tertails largely light gray with white terminal margins and often more or less blotched with black; primaries more or less edged with white or pale gray, sometimes only obliquely tipped with this color; the three outermost quills white at the base, forming a distinct patch; secondaries more or less marked with white, the inner ones extensively so; upper tail coverts black with large terminal spots of pale grayish or white; tail black, with inner webs of feathers broadly white at the ends, these white markings most extensive on outer feathers, occasionally occupying the terminal one-third and sometimes including the outer webs of all the feathers showing white at tips. *Young.*—Similar to adult female, but colors duller and more brownish with markings less sharply defined; dusky streaks on sides of throat less distinct or wanting; under parts paler and more buffy with little if any gray; bill dull horn color or brownish. Length 7.50-8.25; extent 13.50-14.12; wing 4.25; tail 2.63-3.00; bill .75 long, .67 deep, .60 broad.

General Range.—"Central North America. Breeds in western Alberta; winters in the interior of North America south of the Saskatchewan and east of the Rocky Mountains, and south more or less irregularly to Missouri, Kentucky, and Ohio, and east irregularly to western Pennsylvania, New York, New England, and Quebec." (*A. O. U. Check-List.*) Represented in western North America by subspecies *montana.*

Minn. Range. Irregular visitant from the north into all parts of the State during fall, winter and spring—Sept. 28 to May 19. Most common in late winter and early spring.

Migration Dates.

Fall.

KITTSON Co.: Oct. 4, '81 (several near Hallock), *Roberts;* Sept. 28 (one), Oct. 23 (one), Oct. 31 (nine), '95 (all at St. Vincent) *Peabody;* ITASCA Co.: Oct. 6, '95 ("a flock of about a dozen," several taken) *Ogden;* ST. LOUIS Co.: Nov. 16, 1900 (several at Ely) *Warren;* OTTERTAIL Co.: Oct. 17 (Deer Lake), Oct. 27 (Lake Lida, "a flock of six"), '85, *Washburn;* SHERBOURNE Co.: Oct. 17, '84 (one male at Elk river), *Bailey;* WRIGHT Co.: Oct. 27, '98 (two at Monticello) *Nutter;* HENNEPIN Co.: Dec. 19, '75 (first); Dec. 19, '76 (first); Oct. 28, '80 (two males and four females; first, all at Minneapolis), *Roberts;* Nov. 7, '84 ("about 50"), at Minneapolis, *Stebbins;* FILLMORE Co., LANESBORO: Oct. 18, '85; Oct. 27, '89 (several); Nov. 1, '91 (one, the only one seen during the winter of 1891-2); Nov. 1, '96 ("several hundred feeding on fruit of hackberry; first of season" at Lanesboro), *Hvoslef.*

Spring.

FILLMORE Co., LANESBORO: May 13, '84 (abundant, last seen); May 4, '86 (last, common all winter); Apr. 13, '87 (last, unusually abundant during winter of 1886-7); Apr. 2, '88 (small flock, not seen during winter); May 4, '89 (last, a flock); May 14, '90 (last); Apr. 11, '91 (last); Apr. 25, '97 (last) *Hvoslef;* HOUSTON Co.: May 8-13 (various years at La Crescent) *Harrison;* HENNEPIN Co., MINNEAPOLIS: May 17, '76 (many; the last); May 6, '77 (a flock; the last); May 19, '79 (a flock; the last); Apr. 11, '80 (many) *Roberts;* STEARNS Co.: May (three killed at Sauk Center; year not stated) *Barker.*

There is, perhaps, no bird that comes to Minnesota that is more singularly beautiful in the full perfection of its nuptial plumage, or that attracts more lively interest among all bird-lovers than the Evening Grosbeak. Fitful and uncertain in the manner of its appearance and coming unheralded, as it does, from the little known boreal region where it makes its summer home, there is ever a captivating mystery surrounding it, that adds a certain piquancy to its charm. Wild and secluded as its native haunts are known to be, the unexpected tameness and confiding nature which it displays while a visitor among the dwellings of men, but serve to make it the more an object of admiration. Its disappointing illusiveness, too, disappearing as is its wont just when a temperate-zone summer seems about to claim it for its own, arouses a speculative interest which commands the attention year after year. Lingering thus in the springtime until surrounded by all the fullness of verdure and many settled activities of late May and associated then on intimate terms with a varied throng of feathered comrades who are busily engaged with their domestic duties, it, suddenly, just as it seems certain that it has at last decided to take up its abode among these strangers, disappears from its long familiar haunts, between one day and the next, and vanishes no one knows exactly whither, or for how long a sojourn. A life time may be spent in close intimacy with birds and yet the clear whistle or a gleam of the unique tri-colored vestments of the Evening Grosbeak, never fails to secure a pause in one's occupation and a moment passed in admiration and wonderment. Until the remarkable and previously unnoted advent of thousands of these birds into the whole northeastern portion of the United States in the winter of 1889-90 the Evening Grosbeak, except in a few favored localities, was a veritable will-o'-the-wisp, a sort of disembodied bird-spirit to most ornithologists.

In the northern portions of Minnesota the Evening Grosbeak often makes its appearance early in the fall and as it frequently does not leave the southern part of the State until late in the spring it is evident that many individuals of the species do not linger long in their arctic nesting places after the duties directly incident to nidification are completed. The considerable array of dates given above will serve to show, in a definite manner, the times of arrival in the fall and departure in the spring for a number of years and at various localities throughout the State. The earliest date, it will be seen, is Sept. 28, 1895, when a single bird was seen by Peabody at St. Vincent in the Red River Valley close by the International Boundary Line. There are early October records for other localities in the northernmost counties and by the last of that month they may occasionally be found as far south as Minneapolis; but usually they are seen for the first time in the southern part of the State during November or early December. In the spring they frequently, if not generally, remain in the southern part of Minnesota until May and have been kept under daily observation at Minneapolis, latitude 45°, as late as the third week of that month (May 17, 1876; May 19, 1879) and at Lanesboro, Fillmore County, latitude 43° 45′, Dr. Hvoslef has several times recorded the "last" during the first half of May—(May 13, '84; May 4, '86; May 4, '89; May 14, '90). They are sometimes more common during the spring months than during the winter, seeming to congregate in large flocks, in favored localities, before taking their departure for the north. Thus Dr. Hvoslef writes that after having been common at Lanesboro throughout the winter of 1883-4, the Evening Grosbeaks assembled in the valley of the Root River during April and early May in such great numbers that they were sometimes among the most abundant birds in the timber below the village, "making the spring woods resound with their noisy notes." Some years they are entirely absent or very rare or appear only in certain places for a short time wandering over the country in an erratic manner. Other winters they are abundant and are to be found almost everywhere in considerable flocks. During the first three months of the year 1890 there was a remarkable incursion of these birds into the northern United States.* They appeared in great numbers not only in their accustomed winter haunts, but in regions where they had not previously been known, as throughout almost all of New England. The winter was a comparatively mild one and it is probable that their southward movement was determined by a failure further north of the food supply upon which they depend rather than by climatic conditions.

From the time of their appearance in Minnesota in the fall until the spring months they are commonly seen in little companies of six or a dozen individuals. Single birds or pairs may now and then be encountered probably separated for a time from their companions. Their movements, the places where they assemble and the length of time they stay, are entirely dependent upon the food supply. They are especially fond of the keys or fruit of the box elder, sugar maple and ash and from this source they derive their chief sustenance during their stay in southern Minnesota. They are very adroit in neatly cutting transversely with their powerful beaks the dry covering of the juicy kernels and dexterously and quickly extracting the latter. The light wings of the keys go eddying to the ground below which is soon thickly strewn with these bits of refuse and gives plain indication of the feeding places of the Grosbeaks. The fruit of the box elder and ash they nimbly secure from the clusters hanging throughout the winter on the ends of the branches but the keys of the sugar maple, shed the previous season, they pick up from the ground usually after the snow has melted in the spring. They eat also the seeds of the berries of the hack-berry, high bush-cranberry, mountain ash, juniper, cedar and probably also when hard pressed the seeds of any edible berry or fruit that offers. The skins and pulp they always reject, even splitting open crab apples to get at the seeds within. They generally locate wherever they find an abundant supply of this sort of food and remain in the vicinity until it is exhausted or they are called away by the migratory instinct. As spring comes on they are apt to assemble in sugar maple groves and pass their time partly on the ground picking up and shelling out the sprouting keys and partly in the branches above piping in unison their spring notes. Frequent mention is made by writers of this grosbeak eating the buds of various trees, but after close observation and the examination of many stomachs I am confident that it is very rarely, if at all, that this

* Brewster in Appendix to Minot's Land-Birds and Game-Birds of New England, second edition, 1895, 470-471; Butler, Auk, IX, 1892, 238-247.

practice is indulged in. I have seen them apparently feeding among the buds of trees and in spring among the catkins of various trees, but examination showed that they had not eaten either. When thus engaged they may be in search of insect food in some form.

In years gone by there was usually in the spring time a goodly assemblage of Evening Grosbeaks in the sugar maple grove on upper Nicollet Island between east and west Minneapolis, where it was an easy matter to keep in daily touch with them and here many of the observations forming the basis of this article were made by the writer and his father. They still resort occasionally to this ancient trysting place in spite of the encroachments of a big and noisy city. The commonly observed fact that this bird is found so frequently about the streets and yards of cities and towns is probably not due to any particular desire for the company of man, but rather to the circumstance that box elder and hackberry trees have been planted so universally of late years as shade trees, that a supply of food is there offered of which their fearless and unsuspicious nature enables them to unhesitatingly avail themselves. So tame are they that they feed without the least fear about the very doorsteps and porches of dwellings and will remain unconcernedly among the lower branches of small trees when approached within a few feet. Indeed they may even be encouraged in the wild state to feed from the hand or alight upon the person as entertainingly narrated by Mr. Wm. Rogers Lord in an illustrated article in Bird Lore for January-February, 1902, and when captured become quickly reconciled to confinement and make very docile and entertaining pets.*

The Evening Grosbeak has, while with us at least, nothing that may be dignified by the name of song. Butler in his Birds of Indiana states that towards spring they have a "rambling, jerky warble, beginning low, suddenly increasing in power, and as suddenly ceasing, as though the singer were out of breath;" but in a long experience I have never heard any such song nor can I find any other reference to it so conclude it must be of very infrequent occurrence.*

Its usual utterance is an unmistakable, loud and forcible whistle or pipe, sometimes rather shrill and rasping, at other times almost bell-like in quality. It is possessed by both male and female alike and is heard as the birds call to one another from their various stations in the tree-tops or as they pass overhead in their erratic and undulatory but rapid flight. They have also a weak, short, "beaded"

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* Shufeldt, Notes upon Coccothraustes vespertina as a Cage bird, Auk, VII, 1890, 93-95; Butler, Auk. X, 1893, 156-157.

* Since writing the above I have come upon the following by C. L. Herrick in his article on the Evening Grosbeak in the Bull. of the Scientific Laboratories of Dennison University, Granville, Ohio, 1885: "In spring, upon the approach of the breeding season, the males cultivate the muses in an odd but not displeasing little song. This song consists of several successive repetitions of a short warble, followed by a similar strain closing with a shrill cry, like the finale of a black-bird's song. The phrase which makes up the body of the song is musical, but is so abruptly terminated (as though from lack of breath or of ability.) that it is annoying when heard singly, for one is subjected to much the same nervous expectancy felt in listening to a hen's cackle when quite leisurely "working up the agony" sufficiently to sound the final note. A flock of a dozen or more singing together produce a very musical effect."

note or scream, somewhat resembling that of the Waxwing, most commonly heard while the birds are feeding in a flock or sitting quietly about among the branches of a tree. As spring advances all these notes assume a softer or more mellow character and when a score or more of the now richly vested Grosbeaks assemble in some leafy treetop and give vent in unison to their joyous feelings there results an unbroken medley of whistles and trills unique in bird-music. Satisfied as the birds appear with their effort there is no particular melody about the performance which can be compared quite accurately with the chorus produced by a lot of frogs piping in a woodland marsh of a summer evening. While feeding the birds are either silent or utter the above notes in a quiet, subdued undertone.

The nest and eggs of the eastern form of the Evening Grosbeak are still little known and indeed the exact region to which it retreats in the nesting season is not clearly defined.* It is probably somewhere in the vast boreal regions to the west of Hudson Bay. Several nests of the western subspecies (*Hesperiphona vespertina montana*) which breeds at high altitudes in the Cascade, Sierra Nevada and Rocky Mountains as far south as Arizona and New Mexico have been found and as they would in all probability be indistinguishable from those of the eastern form, a brief description of them will serve to indicate the manner of nidification of the species as a whole. The first published account was of a nest found by Mr. E. H. Fiske in Yolo county, California, and described by Mr. Walter E. Bryant in a paper before the California Academy of Science on June 20, 1887. "The nest, containing four eggs, was taken May 10, 1886, but incubation was so far advanced that he was unable to preserve them. In general shape, color and markings, they were similar to eggs of the Black-headed Grosbeak, but in size he thinks they were somewhat larger."

"The nest was built in a small live oak, at a height of ten feet, and was a more pretentious structure than is usually built by the Black-headed Grosbeak, being composed of small twigs supporting a thin layer of fibrous bark, and a lining of horse hair."* On June 5, 1884, Mr. John Swinburne of Springerville, Arizona, found a nest of the Evening Grosbeak in a thickly wooded canyon some fifteen miles west of that town. "The nest was a comparatively slight structure, rather flat in shape, composed of small sticks and roots, lined with finer portions of the latter. The eggs, three in number, were of a clear, greenish ground color, blotched with pale brown. They were fresh. The nest was placed about fifteen feet from the ground in the extreme top of a thick willow bush." This was at an altitude of 7,000 feet. This was probably the first nest of this species ever found by an ornithologist but it was not reported until after the California nest.* Others have since been found and Mrs. Florence Merriam Bailey

* In the Auk, Vol. XXVI, Oct. 1909, pp. 390-400, is an article by Sidney S. S. Stansell entitled "Birds of Central Alberta," in which is the following note in regard to the Evening Grosbeak: "Quite rare, I located a nest in June, 1908, which contained a dead full-fledged young male. The nest was up 40 feet in a white birch tree."

* Bull. Cal. Acad. Sci., II, 1887; J. P. Norris, O. & O., XII, No 9, Sept. '87, 144.

* Auk. V, Jan., 1888, 113-114.

sums up the information to date in the general statement: "Nest.—15 to 50 feet from the ground in the top of a conifer or thick willow, a comparatively flat, slight structure of small sticks, roots, and sometimes tree lichens lined with finer roots. Eggs.—3 or 4, clear green, blotched with pale brown."†

As the Evening Grosbeak possesses such a fascination for nearly all bird students it will no doubt be of historical interest to many to peruse the rather curious notes which accompanied the original description of the species, more especially as they are not readily accessible to the general reader. William Cooper first described the Evening Grosbeak in a communication read before the Lyceum of Natural History of New York City, January 10, 1825, and published in the Annals of that Society for the same year, Vol. I, part the second, pages 219-222. After a technical description of a male in full plumage the following account is given: "The specimen from which the description is taken, was sent to the Lyceum from Sault Ste Marie, near Lake Superior by Mr. H. R. Schoolcraft, and is labeled Paushkundamo, the name given it by the Chippewa Indians. Mr. Schoolcraft has since favored me with the following account. It is a little singular that the meaning of the Chippewa name should so nearly coincide with that of the subgenus in the language of the system."

"'Paushkundamo.' This word is derived from the Chippewa verb paushka-un, to break. The termination indicates the object acted on, and is in accordance with one of the rules of their language, which permits the formation of compound words from a verb and substantive, dropping one or more syllables of each for the sake of euphony. The word paushkaun is the animate form of the verb, and is used only in particular reference to soft, fleshy or vegetable substances, as a fly, a berry, etc. The word will therefore admit of being rendered fly-breaker, berry-breaker, etc.

"This bird appeared about Sault Ste Marie, M. T., during the first week in April, 1823. The individual under examination was shot on the 7th of April, in the Evening. An Indian boy was attracted into the woods by its peculiar, and to him strange note. There were a few birds in company: they were seen for a short time about the place; but none have since appeared. The species is said to be common about the head of Lake Superior, at Fond du Lac, etc."

"Major Delafield, in the execution of his duties as agent of the United States for boundaries, met with the same bird in the month of August, 1823, near the Savannah River, northwest from Lake Superior, and has obligingly communicated th following extract from his notes at the time:"

"'At twilight, this bird which I had before heard to cry in a singular strain, and only at this hour, made its appearance close by my tent, and a flock of about half a dozen perched on the bushes in my encampment. They approached so near, and were so fearless, that my canoe-men attempted to catch them, but in vain. I recognized

† Handbook Birds Western U. S. 1902, 307.

this bird as similar to one in possession of Mr. Schoolcraft, at the Sault Ste Marie.'"

"'Its mournful cry about the hour of my encamping, (which was at sunset) had before attracted my attention, but I could never get sight of the bird but on this occasion. There is an extensive plain and swamp through which flows the Savannah River, covered with a thick growth of sapin trees. My inference was then, and is now, that this bird dwells in such dark retreats and leaves them at the approach of night.'"

The latter part of this account, though presenting as it does, a mistaken impression, evidently furnished the suggestion for both the scientific and common names of this bird. That it is an evening singer or is in any special way associated with the decline of the day is erroneous and the name by which it is now universally known is without any particular significance.

EXTINCT PLEISTOCENE MAMMALS OF MINNESOTA.

N. H. Winchell.

PLATES X. AND XI.

[Read May, 1909.]

There was an epoch of geological history,—how long in years or centuries we do not know, but it must have been long—which preceded the Glacial epoch, or epochs, and which followed after the Tertiary, which is commonly called Pleistocene. During the Pleistocene the climate of Minnesota was approximately the same as the present, and the country was clothed more or less with a flora similar to that of the present. The general configuration of the surface, however, was rough. There were deep-cut gorges, in the bottom of which flowed the streams. The uplands were diversified with projecting rock cliffs, about whose bases was accumulated the waste of many centuries. The only boulders that could be found were such of the fallen cliff-masses as had not yet decayed. The soils were light and fine, resulting from the disintegration of the rocks. They were sandy, or in some places clayey, depending on the conditions of drainage. There were extended tablelands, sometimes rising bench after bench one above the other. In the Archean areas there were peaks of granite and of gneiss that rose more irregularly above the general surface. Amongst these granitic knobs and along the bases of the terraced tablelands, the streams meandered with about the same crookedness as those of to-day, but with greater agreement with the boundary lines separating the different formations. They followed prevailingly the erosible outcropping edges of the softer formations, and when they passed from one formation to another they were likely to form local lakelets, or cascades, or larger waterfalls, and these waterfalls receded up their

Elephant's Tooth, from the gravel terrace of the Mississippi at Wabasha.

valleys amenable to the same forces of erosion as those of the present day, until the streams finally reached the stage of senescence, and the waters descended quietly without waterfalls, like the base-leveled streams of southern latitudes at the present time.

With such a climate, and with such adaptable and attractive physical conditions, nothing was wanting for the existence of a fauna of the most diversified types. Indeed we know that the present fauna has its ancestry in the Pleistocene. The Glaçial epoch simply caused the migration of the Pleistocene animals southward, and on the recession of the ice-border allowed the same fauna to return to re-occupy the renovated lands. It is needless to dwell on the change produced in the local physiography by the ice age. Suffice it to say that on the retirement of the ice the present conditions, approximately, were inaugurated. The river gorges were filled, the streams turned from their courses, the granitic crags were thrown down and buried and the whole country rendered more smooth.

But the fauna had suffered somewhat by the glacial cataclysm. Some of its largest species had become extinct, and some had become so dwindled in number, or so reduced in vigor, that their post-Glacial representatives are sometimes not recognized as the same species, although probably genetically the same as the Pleistocene. Of these extinct large mammals I wish to call your attention to a few whose remains have been found in Minnesota. Some of these survived the Glacial period, and returned to Minnesota and flourished during the inter-Glacial and post-Glacial epochs. If we consider these remains in the order in which they have been discovered they will appear about as follows:

1. *Eliphas primigenius*, the mammoth.

It is well known that in Siberia and Alaska the remains of the mammoth are common. It is but recent that an entire animal was found incased in ice and the flesh preserved. This specimen was photographed in its place and afterwards it was remounted in the museum at St. Petersburgh in the attitude in which it had when found. The remains of the elephant, which was without much doubt only a southern species (or several species) of the mammoth of the north, have been found over a wide extent of latitude in North America, extending as far south as Mexico.

The geologic and geographic relations of the elephant with the Glacial drift, and his chronologic relations with man, have been the subject of considerable investigation. There is abundant evidence that the elephant inhabited Minnesota in late Pleistocene time. His skeleton and especially his teeth, have been discovered in several places. In general throughout the central part of the United States the remains of the elephant and of the mastodon appear to have about the same age, and it is certain that they both survived the vicissitudes of the Glacial epoch by migrating toward the south where they found more genial climate.

In the case of the discovery of a tusk only, it is usually impossible to distinguish between the elephant and the mastodon, since they both carried enormous tusks of ivory. But their teeth were quite different. Both tusks and teeth were found at Stockton, in Winona county prior to 1885 and were brought to the attention of the Geological Survey by Prof. John Holzinger. All the facts of this discovery are published in the tenth annual report of the survey and the conclusion seems to be warranted that these remains represent the great mammoth of the north. They were embedded in the loess of that locality, which is now referred to the Iowan stage of glaciation. In the loess at points in Iowa similar elephantine remains have been exhumed, sometimes accompanied by flint arrowheads and other human relics.

The remains of what was presumed to be a mastodon were found near Northfield in the excavation of a gravel bank in 1879. But, as the specimen consisted of only a part of a tusk it may have belonged instead to an elephant. This discovery is mentioned in the final report of the Geological Survey, vol. 2, p. 670.

A similar statement concerning the finding of mastodon remains in Winona county, at Minnesota City, is to be found in vol. 1, of the final report, p. 264; and further, in vol. 2, p. 397, at Stillwater in Washington county. These may also have been elephant tusks, since in neither case was the identification reliable in the absence of the characteristic teeth. It is to be noted that in both these cases the remains were imbedded in terrace gravel pertaining to the flooded-river stage of the Wisconsin epoch, and hence probably much later in date than the elephant remains found in the loess at Stockton in Winona county.

According to Mr. E. E. Woodworth a large elephant's tooth and a large bone from the skeleton were found some years ago in a marsh near Fair Haven, Stearns county. These were very hard and black, and the tooth particularly had a hard shining surface.

Some years ago a large elephant's tooth was found in Nobles county, in the southwest corner of the state. According to Mr. T. B. Walker who procured it and presented it to the Museum of the Minnesota Academy of Science, where it is still preserved in good condition, it was found in gravel at about twenty-seven feet below the natural surface.

Judge Crosby, of Hastings, recently presented to the Historical Society, at St. Paul, a large fragment of (apparently) the top of the femur of an elephant, which was found in gravel in the terrace of the Mississippi.

Mrs. Harriet C. Amberson, of Minnesota, also lately presented to the University museum similar large fragments of the skeleton exhumed in Minneapolis about fifteen years ago at the site of the car-shops of the Minneapolis & St. Louis railroad.

The writer was in Europe at the time of this important find, and the specimens were scattered, and largely lost sight of. According to the Minneapolis *Times* a cylindrical tusk was found that measured nine feet in length and eight or nine inches in diameter, and bones of all sizes and shapes were so numerous as to prove the former presence of an entire animal. A single tooth was found but was ruthlessly crushed by the workmen, its fragments indicating, according to the description, that it was elephantine. Mr. S. C. Amberson, foreman, made an attempt to get all the pieces together. After his death Mrs. Amberson preserved the large fragment of the femur, which she lately presented to the University Museum.

According to statements made in the Minneapolis *Journal* Nov. 19, 1908, a number of mammoth bones were found at lake Minnetonka by workmen in dredging in thirty feet of water off Huntington's point, near Arcola, about 100 feet from the shore. These remains embraced a hip bone, eight vertebræ and a leg bone. I have not been able to see these bones.

In 1891 Prof. A. F. Bechdolt, of Mankato stated that he found a "tooth of a mastodon," with a fragment of the lower jaw, in a ditch being dug by the city in one of the streets of Mankato.

Capt. Jos. Buisson stated that a mammoth tooth was found opposite Lake City, near Stockholm, on the shore of lake Pepin.

Toward the northwest, in North Dakota, Dr. Upham has given the particulars of the finding of elephant's (or mammoth's) remains at an excavation through the Herman beach near Ripon in Cass county. This is published in his memoir on Lake Agassiz for the United States Geological Survey, p. 322. In this case several teeth and vertebræ, as well as tusks, were found. These lay below the gravel of the beach and about a foot below the upper surface of the Wisconsin till sheet. These fossils must be considered as of about the same date, as the teeth taken from the river gravels further south, though probably somewhat later.

About two years ago a small elephant's tooth was found at Wabasha, in the gravel terrace of the Mississippi river, and I gave a description of the circumstances and of the nature of this tooth in a paper read before this Academy in May, 1907. It was brought to me by Mr. John D. Stritch, but was found by his brother George P. Stritch who was superintendent for the railroad in the excavation of the terrace for ballast and grading. By the steam shovel it was thrown on the car with the gravel, was transported to Greathorn spring, which is between Dresbach and River Junction, in Winona county, where, in unloading the car by steam plow, it was scraped off the car with the gravel, and was first observed on the dump by Mr. Stritch.* It is illustrated by plate X.

This tooth contains ten double plates of hard enamel folded close so as to make double transverse ridges, the dentine in each plate being quite scant. The width of the intervening layers of cementum is but slightly more than that of the plates. The greatest width of the tooth is three inches and its greatest length, on the grinding surface is 4½ inches.

The interesting feature exhibited by this tooth is its gravel-worn exterior, showing that it was for a time subjected to the rolling and wearing action incident to the transportation and deposition of the gravel and stones of the terrace, and hence that it dates from the

*At present this tooth is owned by Mr. O. O. Whited of Minneapolis.

time of the formation of the terrace, which was the Wisconsin epoch. The cementum which on one side, and at one end, spreads outward from between the plates and covers by a continuous layer the whole side of the tooth, is worn off on the other side. That side of the tooth which is the opposite to the grinding surface is worn away so that it presents a smoothly rounded yet bluntly wedge-shaped edge, the enamel and the dentine being cut by the gravel-worn surface uniformly, and together showing a polished rounded form resembling that of numerous boulders and stones that were subjected to the wear and tear of the tumultuous and driftladen waters. The enamel of the plates expands and becomes a continuous mass, with no dentine nor cementum, and this fact seems to have given the tooth greater firmness and endurance in the root portion than in the crown. If, within the jaw, the tooth had any connection with a porous bony tissue, or terminated at the roots by any processes or vanishing plates of enamel, it shows no trace of such articulation. The view on the left of the photograph* shows the grinding surface and one side almost entirely denuded of cementum which on the other side is so nearly intact as to wholly cover the enamel plates. The view at the right shows the rounded condition of one end of the tooth, together with a portion of that side which is still covered by the spreading cementum. It also shows the rounded form of the root where the enamel and the cementum are equally worn down to a smooth surface.

This list of elephant remains of Minnesota is probably far from complete.

There is evidence therefore, within Minnesota, that the mammoth was a denizen here from the time of the loess of the Iowan epoch, that he continued through the fourth inter-glacial stage, the Peorian, survived the intensity of the Wisconsin ice epoch (which was the last) and lived on the surface of the Wisconsin till sheet long afterwards; and, considering his late extinction in Siberia, it is reasonable to infer that the ancestors of the American Indian were familiar with his enormous bulk, and slew him with their stone-headed arrows.

As to the Mastodon, it is very probable while no remains have been sufficiently demonstrated within the limits of Minnesota, and those of the Mammoth are well verified, and we cannot safely therefore affirm that the Mastodon ever inhabited the state, yet that he did, and that his remains are liable to be discovered. Judging from the comparative numbers of the mastodon and the elephant found at the celebrated Big Bone lick in Kentucky, it seems that the range of the mastodon was more southerly than that of the mammoth. Of the teeth found at that celebrated locality, the relative numbers were such that the mastodon were five to one of the mammoth.

2. *Castoroides ohioensis.* Next in order of discovery, was the great extinct Ohio beaver, whose size was about that of the present black bear. This discovery was made at Minneapolis, at the corner of Washington avenue and Fifteenth avenue north in 1879, in the process of digging for a cistern. There is a full description of this dis-

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* Plate X.

covery in the eighth annual report of the Geological Survey of the state, and from it are taken the following facts:

The specimen was eight feet below the surface, under the sandy loam that lies on the brick clay, and about 20 feet above the level of the river, near the bottom of the sand and gravel. It was accompanied by some Unio shells. Its relation to the gravel, and to the topography of the valley, indicates that the animal inhabited the region when the border of the ice-sheet had already retired to the northward of Minneapolis, but that the river was maintained at a maximum flood stage by the dissolution of the ice fields that lay further north, and probably covered the northern part of the state. That is, it was cotemporary with the closing stages of the Wisconsin epoch. The specimen found at Minneapolis is preserved in the museum of the University. It consists of the left ramus and the lower left incisor. Its size indicates an animal somewhat larger than the specimen first found in Ohio and described by Foster, and also larger than that found in New York. It is however a little smaller than that described by Wyman from Memphis, Tennessee. The whole length of the specimen, when the parts are united, is 9½ inches, of which 5¼ inches consist of the projecting, uncovered incisor, a portion of the jaw having been broken away on the under side. The jaw contains four molars, perfectly preserved. Their outer surfaces are finely striated perpendicularly, and crossed transversely by undulations of growth, while the great incisor is externally grooved longitudinally with eighteen or twenty grooves, which are about twice as wide as the ridges that separate them. The four molar teeth have a structure like that of elephant's teeth, i. e., they are composed of transverse hollow lamellæ of enamel, embedded in a cementum, which also seems to fill, at least originally, the interior of the lamellæ.

According to Prof. A. J. Allen the Castoroides cannot be put into the same family as the modern beaver, but has affinities that ally it with the chinchilla, the vescacha, as well as the muskrat. The entire skeleton has never yet been found. It ranged over the whole United States, from South Carolina to New York and to Mississippi, and from Texas to Minnesota.

3. *Ovibos cavifrons.* In 1903 the skull of the musk ox was found by Mr. J. W. Franzen, now curator of our museum, where he has kindly placed the specimen. This discovery was made on the farm of Mr. McCracken, between Wabasha and Theilman, near the railroad from Wabasha to Zumbrota. The specimen was about ten feet below the surface, in a gravel terrace, of the valley. By Mr. Franzen I have been furnished with the accompanying photograph of this specimen. It consists of a skull, but without any teeth. The broad horn cores are conspicuous, but they do not embrace any of the curving horn terminations. The whole specimen is considerably worn and reduced so as to have lost most of its projecting angularities.

It belonged to a small animal, probably not mature: width transverse 5½ in., extreme width, including the horn cores, 8½ inches, length, front to rear 8¼ inches.

The region in which this specimen was found is within the "driftless area" of the state, as usually limited, but it is not as yet known how much drift pertaining to some of the older epochs of the Glacial period may still exist below the veneer of loam with which the region is covered. There is a conspicuous terrace formation extending along the Mississippi valley, which also ascends the tributary valleys, meeting with a series of terraces which were of the same date but which were formed from material derived from the west, brought down the valleys by the rivers whose sources were within the glaciated area. These conspicuous terraces are of the age of the Wisconsin epoch, and doubtless contain materials derived for the most part from the Wisconsin ice, but also embrace the wastage of the Iowan loess, which forms a surface mantle over the region. Indeed the Iowan loess must have suffered greatly from the action of the flooded streams of the Wisconsin epoch. From present knowledge it is impossible to affirm whether this skull dates from the Iowan loess epoch or from the terrace epoch of the Wisconsin, although it seems to have been found in a Wisconsin epoch terrace.

The interesting and important fact however is this,—that the musk ox occupied the region during either the loess epoch of the Iowan ice age, or the closing stage of the Wisconsin ice age. In either case it implies that the climate was considerably colder than the present climate,—a conclusion which is indicated also by the existence of what we know only as an arctic animal in temperate latitudes. It may be inferred that the Mississippi and its tributary gorges were a favorite habitat for arctic species.

The extinct musk-ox species, O. cavifrons, is regarded as specifically different from the living musk-ox, O. moschatus, although the latter is also regarded as the genetic descendant of the former. Like the mammoth and the reindeer the musk-ox retreated southward as the country became enveloped in ice on the approach of the Glacial epoch, or successive epochs, so as to destroy his feeding grounds, and on its retirement, probably in company with the Eskimo, followed the ice border again to the arctic region.

The remains of the musk-ox have been found at several places further south, viz., in Iowa, Missouri, Arkansas, Oklahoma, Kentucky, Ohio and West Virginia. These localities are all too far south to suppose that the Wisconsin ice sheet was the prime cause of the migration that brought the musk-ox into that latitude, but they might be due to the incursion southward of the earlier Iowan ice-sheet. This leads us to refer the Minnesota specimen to the loess of the region rather than to the terrace gravel of the Wisconsin.

4. *Bison* (*latifrons?*) About a year ago I was shown a couple of large fossil teeth by Mr. Edstrom, a student at the University, who had procured them from the discoverer. They were found near Mora, in Kanabec county, in Minnesota, in excavating for a drainage ditch. They were below several feet of tenacious clay, and were embraced in it. They are stained a dark brown, almost black, as teeth thus buried are frequently known to be. They were associated with several other teeth, and bones, probably belonging to the same animal, but the rest were scattered and lost. In the determination of the species to which these teeth belong I have been aided by Prof. S. W.

Teeth of Bison, near Mora.
Skull of Musk Ox.

Williston of Chicago University, and by Prof. W. J. Sinclair of Princeton University, and they concur in the following statement by Prof. Sinclair: (See plate XI.)

"They are the lower molars (2nd right and 3rd left) of two individuals of a large species of Bison, differing in several respects from a specimen of the recent species in our collection. I do not think that it is possible to be certain about the species. Your specimens are quite different from either Cervalces, the wapiti, or the moose."

These two teeth are quite different from each other. One is not worn at the crown, and appears to have been immature. It is 2½ inches long and 1⅜ inches wide. The outer incasing enamel embraces a roughly plano-convex cylindrical area which is loosely occupied at the root by two curved enamel lamellæ which are hollow, and which give the exterior of the tooth the appearance of being double, as they cause the body of the tooth to be divided into two main longitudinal parts. The outer side of the tooth has five prominent ridges of enamel separated by four furrows, all caused by undulating folds of the enamel. The inner side of the tooth shows simply the two main, rounded, vertical body-portions. Below the gum is a parasitic, simply tubular tooth, adherent between the two body portions in the outer angle formed by them. The roots are open below.

The other tooth is not so long vertically but is wider, and has been much worn away on the grinding surface. Its width is 1⅞ inches and its vertical length is two inches. This tooth is divided into three body-parts, but two only have internal lamellæ of enamel. The roots are closed at the bottom.

The only extinct Bison of America, so far as I can learn, is B. latifrons, and to that species these specimens may be provisionally referred until the discovery of more material may correct or confirm it. That was found in the Pleistocene of Texas, and has been supposed to be the progenitor of the present Bison.

These four species are only a part of the fauna of large animals that flourished in the United States in Pleistocene time. Their companions embraced extinct species of reindeer, elk, horse, lion, bear, sloth as well as the mastodon, and this fauna was spread apparently over the whole country, though not perhaps contemporary. Great and remarkable as this fauna appears, in contrast with the present, it was but the dwindling remnant of the Tertiary fauna which preceded it. From the Tertiary to the Pleistocene there was a reduction not only in the number of genera but also in the average size and number of individuals, and a similar change has continued to the present time. What may have been the cause of this extinction of the great mammals is unknown At the present time the agency of man is paramount, but we can hardly appeal alone to that cause in the Tertiary and the Pleistocene, in the dearth of evidence that man flourished cotemporary with these great mammals. The natural and inevitable effect of the Glacial period was certainly to confine some of the great mammals to restricted quarters and to reduced food supply. They probably also combatted each other, the young especially suffering from the attacks of cotemporary carnivores. To the Glacial period is due, probably, the practical extermination of this remarkable mammalian phase of animal life.

Whatever may be the cause, it is evident that the present exhibits but a depauperate state of the past, so far as concerns the physical and animal part of animate creation. The large, bizarre, and powerful types of life have given place to smaller and quicker-moving types. If rank, in the animal kingdom, were to be determined by the bulk of the animal, we would be justified in concluding that there had been a retrogressive evolution. But, while the body has become smaller, speaking of the average of mammalian life, there is reason to believe that there has been an increase of average cephalic power, particularly so far as regards man. The dominance of mind over matter has become more pronounced. The real progress of evolution therefore has not been retrograde, but ascensional. In place of brute force, there has appeared a greater sway of psychic force.

While therefore, from a physical standpoint, we may agree with Wallace, that we occupy a stage in the history of the earth's animal evolution, from which the largest and highest forms have just disappeared, we can affirm, it seems to me with equal assurance, that we have entered upon a stage in animal development which is higher in rank than any stage that has preceded the present, in proportion as the predominance of mind is higher than the predominance of selfish brute force.

THE DEVELOPMENT OF THE MINNEAPOLIS SEWER SYSTEM.

By Andrew Rinker, City Engineer.

The first sewer of the city of Minneapolis was begun June 15, 1871, 17 years after the founding and naming of the city. As I happened to come to Minneapolis that day I saw the first brick laid in the first sewer.

As I was soon afterwards connected with the city engineering department and was appointed City Engineer in April, 1877, and have continued in that position ever since, with the exception of the years 1892 to 1902, when I was in Montana, the sewer system has largely grown under my direction and supervision. But I desire here to acknowledge the faithful, able, and efficient work of my special Sewer Engineers, Mr. W. D. VanDuzee from 1870 to 1894 and Mr. Carl Ilstrup, from 1894 to the present time, to each of whom has been built a lasting monument of the best fame in these foundation civic improvements of a modern city.

From a topographical survey of the original town of Minneapolis the natural watershed into the Mississippi river was determined on for sewer drainage on the gravity system. This gravity system has been adhered to with an average ffow of 2¾ miles per hour, there being as yet no pumping of our sewage. The division of the city's surface into separate trunk systems discharging into the river has developed on the basis of the natural topographical divisions of the city, modified, of course, by the irregular growth and varying necessities of the districts of a western city.

The first sewer was built on Wash. Av., from 8th Av. S. to Hennepin; was 44″ in size, and designed to drain ultimately from 300 to 400 acres. Using the experience of Milwaukee and Chicago their formulas were adopted for determining the size of the sewers to the acreage drained. But the maximum of 1 inch of rain per hour as the basis of this formula was found by experience not to be sufficient for this locality where the average rain fall for 47 years has varied from a minimum of 16 inches to a maximum of 39 inches, and where a sharp shower will precipitate at the rate of over 2½ inches per hour. So the Adam's formula was adopted, allowing for 1½ to 2 inches of rainfall per hour.

The region drained by this first system, as the sewer extentions draining into this 8th Av. outlet were gradually built, in roughly bounded by 8th Av. S. to 3d Av. N and back to 7th St., with a loop taking in Western Av. to the railway and Hawthorn out to Lyndale. Only two and a half miles of trunk and collateral sewers were built in this first district during the first 11 years, i. e., to 1882.

By 1882 the growth of the city demanded the beginning of a second sewer system and a 6 foot brick sewer was started from the river at the foot of 11th Av. S. and going up that avenue, it was designed to drain the district bounded roughly by 9th and 13th Avs. S. out to 8th St., thence west to include Nicollet and south to include Franklin. Similarly in 1882 was begun the third system by starting another 6 foot brick sewer coming up 4th St. S. from the river and turning up 15th Av. S. This system was to drain the district bounded by the river, 14th Av. S, and Franklin, with a loop between Bloomington and Chicago Avs. out to 25th St.

In connection with the third section of this 11th Av. S. system, the blocks from 15th St. to Franklin, occured the important change from construction by contract to construction by the city by day labor. This change was occasioned by the contract bids for this sewer being $40,000 above the City Engineer's estimate. So the City Council provided $5000. for tools and the work was done under our department within the estimate and with a few thousand dollars to spare. The first sewer had been built by contract by Spink & Nichols; and the 25 miles constructed by contract up to the end of 1885 were built by E. T. Sykes & Co., J. J. Palmer; Trainer, Forestall & Brandt; J. Gleason & Co., Tobin & Fallon, Thos Daley, Andrew Dolan, J. Burnes, J. H. Nevins, and R. M. Riner. But beginning with 1886 all sewer work has been done by the City Engineer's Department. This has been found a better plan in that it insures more thorough workmanship,—for sewers must be built for permanance rather than cheapness,—and it is not more expensive than contract construction when the costly extras of contract work are eliminated, as they are by the city work.

The beginning of the sewer systems of the East Side of the City were also made in this epoch-making sewer year of 1882. A small 15 inch sewer was begun on Central Av. to drain the area bounded 4th Av. S. E. to 2d Av. N. E. and back to Division St. The outlet of this Central Av. sewer was later changed from a direct discharge into the river to emptying into the mill race of the Pillsbury A Mill at 4th Av. S. E. Another East Side system was likewise begun in this same year from the foot of 10th Av. S. E. and running up that avenue to drain the district bounded by 5th to 16th Avs. S. E. and back to Spring St. Thus in 1882 3½ miles of new sewers were constructed, including the large trunk sewers for the new 11th Av. S. 4th St. S., Central Av., and 10th Av. S. E. systems, comparatively making a large amount of work as against the total 2½ miles up to that date from the beginning in 1871.

For the next 6 years the sewer construction was the extension of the branches of the systems already enumerated. But as yet only the central, south and southeast quarters of the city had been provided with trunk sewers. Some plan had to be begun for North and Northeast Minneapolis.

As the city supply of water was then pumped from the two pumping stations at the falls and on Hennepin Island it was not safe to empty sewerage into the river above the falls. This situation, together with the low elevation of the Bassett's Creek valley in North Minneapolis, determined the plan of starting a tunnel from the foot of 8th Av. S., below the falls, going up to 2nd St. thence diagonally to 6th Av. below Wash., up 6th Av. S. to 4th St., up 4th St. from 6th Av. S. to Hennepin Av. and thence diagonally to 5th St. and 4th Av. N. This tunnel, begun in 1889, was 8' in size, thru the sand rock beneath the limestone ledge, averaging 81 ft. beneath the street surface. Up 4th St. it followed a seam in the rock from which much water came into the tunnel. But by inserting in the masonry over 1000 seepage pipes from 1 to 8 inches in diameter, this flowing soon practically all ceased. At the 1st Av. N. shaft a fault was struck in the lime stone ledge, from which a large amount of water was pumped. Owing to those unexpected difficulties the contractor, who had undertaken the job, failed and the city then continued and completed the tunnel, as it had for five years been building its sewers, thus carrying thru the 1.37 miles of tunnel at a cost of about $202,000, or $28.— per foot.

From the end of the No. Mpls. tunnel at 5th. St. and 4th Av. N. a large 7 ft. sewer was built up 5th St. to 8th Av. N. at Bassett's Creek, where it divides into two branches. The smaller branch continues out 5th St. to 10th Av. N., thence turning to Wash. Av. where it extends northward to beyond 20th Av. N. By the aid chiefly of a 2 ft. sewer out Plymouth Av. this river section of North Minneapolis up to 20th Av. N. is drained by this N. Wash. Av. branch.

The larger branch of the 5th. St. N. 7 ft. sewer turns out 8th Av. N. to Dupont Av. N. thence south (for three blocks below the bottom of the straightened Bassett's Creek) to Ontario Av. and turns over to Lyndale. By dividing down Hennepin and Harmon Pl on the one hand and out Hennepin and Lyndale on the other hand it drains the north slope of the bluffs out to Franklin nearly to Nicollet, and the slope towards the bluffs down as far as 13th St. A 4 1-3 ft. sub-branch of this Bassett's Creek sewer has been built (in 1906) from 1st Av. N. and Irving south under the Creek and across its valley on the line of Irving Av. to Laurel Av. in Bryn Mawr. Much difficulty was experienced in crossing this bog. The oval shaped concrete sewer was made on a grillage of timbers resting on piles from 30 to 60 ft. long; while the lateral pressure of the slippery blue clay below the peat caused a tremendous pressure on the sheathing and bracing.

With the planned extension from the present end at Laurel Av. up the Avenue the Bryn Mawr district will get sewerage connections. Another sub-branch is planned from 1st Av. N. and Irving to the Cedar Lake road and up Logan Av. N., to complete the drainage of this northwest section of the city up to about 20th Av. N.

The natural drainage character of this Bassett's Creek Valley and its difficult engineering character as a peat and clay bog without the city's usual underlying foundation of limestone are interestingly explained by our state geologist as due to the former course of the Mississippi river thru this valley. By turning southward from its present bed at its junction with Bassett's creek the Mississippi river once evidently flowed through the present Bassett's creek valley in the city and thru the chain of lakes from Cedar to Harriet, and thence, it is supposed, into the Minnesota river. During the thousands of years of this course of the river the lime stone stratum was worn away and a deep channel was excavated, which was later filled with a deposit of silt and vegetable matter. The advance of the last glacial age blocked this channel and turned the river into its present course from Bassett's creek to Fort Snelling. Only this little creek, then, now remains in this engineeringly troublesome valley and meanders in a reverse direction from the once mighty river which dug out the valley.

The importance of this Bassett's Creek valley is also seen in its size. Within the city limits it drains 2800 acres, or 4.37 sq. miles; while its additional drainage adjacent to the city makes a total of about 25 sq. miles. The volume of water in the creek varies from nothing in a dry season to 1,000 cub. ft. per second in a flood season, with an average of some 10 to 12 cub. ft.

The plan of diverting the creek into Cedar Lake and so out thru the chain of city lakes into Minnehaha Creek would only take off about half of this natural flow. (For a discussion of this proposed divertion of Bassett's Creek see my report "On the Proposed Diversion of Bassett's Creek," presented to the City Council, June 8, 1906). Could this storm water drainage, which will always thus be considerable, be confined into an open or closed channel, as in the straightened portion between Western and 6th Avs. the large region of present bog would undoubtedly be drained dry as Hoag's Lake, between 4th and 6th Avs. ..., was dried up by the North Minneapolis tunnel. Also where a natural means of surface drainage is at hand it is good policy to utilize this means and thus tax the sewer systems only with the house sewerage; as has been done in our Kenwood district where the storm water drains into Lake of the Isles, so that only a 18" pipe from the end of 27th St. around the boulevard is sufficient for the house sewerage.

The further development of the North Minneapolis sewer systems was determined by the establishment in 1889 of the new pumping stations for the city water supply at 42d Av. N. in Camden Place and the later North East Station still higher up the river in 1904, with the consequent abandonment of the old pumping stations at the falls and on the Hennepin Id. Thus the new systems could be again planned for the immediate exits of natural drainage areas directly into the river, without the long and expensive circumlocution of the North Minneapolis tunnel system. Thus in 1890 the 20th Av. N. system was begun from the river foot of that street, extending from the river back to Penn. Av., and draining, with its branches, the region of about 400 acres between 20th and 25th Avs. N. inclusive.

The next northerly section between 26th and 32d Avs. N. was begun by the 26th Av. N. system in 1900, which also extends at present back to Penn. Av. The next drainage area down 33d Av. N. has only as yet been started by a small section back of Lyndale and temporarily emptying into the adjacent lower system. For the next drainage area a trunk sewer will be built this summer from Wash. Av. down 38th Av. N. to the river, for the immediate purpose of making travel somewhat passable for the enormous and heavy wagon traffic of lumber, bricks and farm produce down Wash. Av. thru Camden Place. A still further north system will be started next year on 42d Av. N. The surface deposit of clay all over North Minneapolis makes these rapid extensions of the sewer systems of the utmost necessity in order to drain the many sloughs formed in every pocket depression of the clay, to make the streets passable in wet weather, and to afford house connections where cess pools have no filtration.

The sewer system for North East Minneapolis was begun in the same year, 1889, and with the same plan as the North Minneapolis tunnel system for discharging below the old pumping stations at the falls. A tunnel was begun under the lime rock at the mill race of the Pillsbury A mill at 4th Av. S. E. It extended up Main St. to Marshall, and thence up Marshall St. to 22d Av. N. E. A branch tunnel was made in 1886 up 3d Av. N. E. nearly to Central Av., with a side branch going up 2d St. N. E. to Broadway.

From the end of this 3d Av. N. E. tunnel a 5½ ft. sewer was continued with two main branches, one across Spring St. and up Fillmore, the other turning up Central Av. to 30th Av. N. E. at present. Likewise from the end of the Marshall St. tunnel a large concrete 6½ ft. sewer has been built up 22d Av. N. E. to Monroe, from whence it is planned to cross Central Av. All North East Mpls. is as yet served by only this one system, with its many sub-branches. With the closing of the lower pumping stations however, an overflow has been provided directly into the river at the foot of 3d Av. N. E.

The extreme South East section of the city, below 16th Av. S. E., was provided for by the Oak St. system, begun in 1888 from the foot of Oak St. and turning both ways on University Av., and by the Hamline Av. system, which was built up that hill from the river in 1904 and winds about among the hills of Prospect Park.

These 13 sewer district systems, whose historical development has here been sketched, have grown to a total length of over 200 miles of sewers at a cost of $5,371,567.— Their total capacity is 2260 cubic feet of 16,942 gals. per second with about 1-3 more when overflows are in use. Some idea of the magnitude of this sewer service can be gained when this capacity is compared with a river. This total sewer capacity equals 45% of the average flow of the Mississippi river; or it would form a river 300 feet wide and 3 feet deep, flowing at a velocity of 2½ feet per second or 1.75 miles per hour.

Some appreciation of the present and future necessities of the city can be realized when it is found that the 53 sq. miles of drainage surface within the present city limits is larger than more populous cities like Paris with its 30 sq. miles.

The original construction material of the sewers was sewer brick, except for the small branches from 9 to 15 inches, where cement pipe was used until 1892. Since then vitrified clay pipe has been used instead of cement pipe and has also been found preferable to brick for sewers up to 2 feet in size. The late use of reinforced concrete construction was applied to our 22d Av. N. E. 6½ foot sewer in 1904, and since then has been found less expensive and more satisfactory than brick construction for all sewers larger than 4 feet. Brick is therefore now used only for sewers between 2½ and 4 feet and in all manholes. For catch basins we have also lately began to use concrete.

In connection with the records of our sewer construction for the past 35 years there has accumulated much interesting and valuable scientific data as to the geological foundation of our city, the stratum of blue lime stone . From many records of the elevation of the lime stone it is seen that it varies on the East Side from 133 ft. above city datum at Central and 15th Avs. N. E. down to 102 ft. at Central and Main St., to 75 ft. at the foot of Oak St. and 83 ft. at the foot of Hamline Av. Likewise on the West Side the elevations descend from 120 ft. at 1st St. and 3d Av. N. to 73 at the foot of 11th Av. S. and the same also further south at the foot of 4th St. S., below the Wash. Av. bridge.

There is thus shown a dip in the lime stone ledge from Northwest to Southeast, and of some 60 ft. difference in altitude within the city limits. The thickness of the ledge also varies from 9 to 20 ft. in the N. E. section to 30 ft. in the S. E. and So. section.

The average level of the surface plain of the city near the river is maintained on this sloping rock by the complementary increase of the soil deposits on top of the rock. For, while the lime stone ledge comes quite to, or within a few feet of, the surface in N. E. Mpls. (where the many quarries are), the sloping rock has been covered in the S. E. section and along the west bank of the river with some 40 ft. of sand and gravel.

ENGLACIAL AND SUPERGLACIAL DRIFT IN MINNESOTA, THE DAKOTAS, AND MANITOBA.

By Warren Upham, D. Sc., St. Paul, Minn.

[Abstract of a paper read before the Minnesota Academy of Sciences, December 7, 1909.]

Modified drift, consisting of stratified gravel and sand, with local deposits of clay, overlies the bed-rocks and the till, and generally forms the surface, on an extensive area stretching from St. Paul and Minneapolis northwestward to the lakes at the sources of the Mississippi, and onward to the Rainy river, the southwest side of the Lake of the Woods, and to the vicinity of the city of Winnipeg. The contour of the greater part of these deposits, through their extent of 400 miles, is flat or moderately undulating, and their surface varies in height from a few feet to 50 feet or rarely more above the adjoining lakes and streams. In central Minnesota these tracts of gravel and sand have an elevation that increases from south to north, being 825 to 950 feet above sea level near the Twin Cities, rising gradually to 1,200 feet in the distance of about 100 miles northwest to Brainerd, and ranging from 1,350 to 1,500 feet between the Leaf hills and Itasca lake. Thence their surface sinks to 1,150 to 1,075 feet in the vicinity of Rainy river and the Lake of the Woods, and is between 750 and 875 feet in the district close northeast of Winnipeg, where a part of these deposits forms a remarkable esker, named Bird's Hill.

On each side this broad belt is bordered by areas of nearly the same general elevation, which have mostly a surface of till; and it is to be remarked that the heights of the tracts of modified drift and till are alike determined by that of the underlying rocks, on which these superficial deposits are spread in a sheet of slight depth in comparison with the gradual change in their elevation. The drift sheet on this belt, including both the sand and gravel and the till, probably varies in its average thickness from 50 to 150 feet, while its central portion rises 400 to 600 feet above its south and north ends.

The distribution of the modified drift thus found upon large tracts along a wide belt from St. Paul to Winnipeg, while it is more scantily developed on a still wider region of Minnesota, South and North Dakota, and Manitoba, southwest of this belt, and likewise is scanty or wanting on its northeast side in northern Minnesota and about Rainy lake and the northeast and north portions of the Lake of the Woods, seems to be attributable to converging slopes of the surface of the ice-sheet and the consequent convergence of its currents, which brought an unusual amount of englacial drift into the ice along this belt, and by which also the streams produced in its melting were caused to flow thither from extensive tracts of the ice on the east and west. The glacial striae of these adjoining areas show that on the east the course of the motion and the descent of the surface of the ice-sheet were from northeast to southwest, but that on the west the glacial currents moved and the ice surface sloped toward the southeast.

My studies of the prominent kame called the Devil's Heart hill,* on the south side of Devil's lake in North Dakota, and of Bird's Hill,† near Winnipeg, convince me that much drift was carried upward into the ice-sheet of this region, to heights of 1,000 to 1,500 feet or more above the ground. The distance from Bird's Hill to the boundary of the glacial drift is about 700 miles to the south and 300 miles to the southwest. It may be estimated, from altitudes of the drift on the White mountains, the Catskills, and the Adirondacks, that the ice-sheet similarly rising over Manitoba attained a maximum thickness of at least one mile, or more probably one and a half miles, about 8,000 feet. The gradients of its surface were similar to the slowly ascending slopes by which the ice-sheets of Greenland and the Antarctic continent rise to altitudes of about two miles above the sea. In the lower quarter or sixth part of the ice covering Manitoba, that is, to a height of probably 1,500 feet, much drift had been carried by its variable and partly rising currents.

Near the border of the ice-sheet during its time of accumulation, little drift could thus be carried into it, and therefore in the melting and recession of that outer part the englacial and finally superglacial drift was generally inconspicuous; but at any considerable distance inside the glaciated area as a score of miles or more, the final melting set free much formerly englacial till and modified drift. The processes of drift transportation and deposition here emphasized were well stated by Prof. N. H. Winchell in 1873,* by Prof. C. H. Hitchcock in 1878,† and by me in 1876 and 1878 and in numerous later papers and reports.‡ At the present day these processes are exemplified by the Malaspina glacier or piedmont ice-sheet in Alaska, which during the last century has been much reduced in area and thickness; but the Greenland and Antarctic ice-sheets, which are now constant or increasing by snowfall, have no superglacial drift.

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* The Glacial Lake Agassiz, U. S. Geol. Survey, Monograph XXV, 1895, pp. 156, 157.

† Ibid., pp. 183-188; also a paper presented to the Geological Society of America, December, 1909, vol. XXI, pp. 407-432.

* The Drift Deposits of the Northwest, Popular Science Monthly, vol. III, pp. 202-210, 286-297 (especially page 294, relating to superglacial drift).

† Geology of New Hampshire, vol. III, pp. 282, 283, 309, 326, 333-8.

‡ Proc. A. A. A. S., vol. XXV, for 1876, p. 218; vol. XXVII, for 1878, pp. 299-310. Geol. of N. H., vol. III, 1878, pp. 9, 10, 175-6, 285-309. Geol. of Minnesota, Final Report, vol. I, 1884, pp. 440, 603-4; vol. II, 1888, pp. 252, 254-6, 409-417. Am. Geologist, vol. X, 1892, pp. 339-362; vol. XII, 1893, pp. 36-43; vol. XIV, 1894, pp. 69-83; vol. XVI, 1895, pp. 100-113; vol. XIX, 1897, pp. 411-417; vol. XX, 1897, pp. 383-7; vol. XXIII, 1899, pp. 369-374; vol. XXV, 1900, pp. 273-299.

HISTORICAL SKETCH OF THE MINNESOTA ACADEMY OF SCIENCE.

Compiled from its records by Secretary Harlow Gale, for the Thirty-third Anniversary Meeting (278th) January 2, 1906.

The father of the 33-year-old Minnesota Academy of Science is Dr. A. E. Johnson, who conceived the idea of forming a group of Nature-lovers for "the cultivation of Natural Science in general, and especialy the sciences of Geology and Archæology." With two of his professional friends, Drs. Charles Simpson and C. E. Rogers, he issued a public invitation to any persons interested in such a purpose to meet in his office in the Wensinger Block, corner of Central Avenue and Main Street, in St. Anthony, on January 4th, 1873. This invitation brought out three other lovers of nature, Dr. A. F. Elliot, E. W. B. Harvey, Superintendent of the St. Anthony Schools, and Professor N. H. Winchell, who had just come to the University of Minnesota as State Geologist. Two days later an organization was effected, with the presence of two additional physicians, Drs. A. E. Ames and W. H. Leonard, under the adopted name of the "Minnesota Academy of Natural Sciences," whose first officers were as follows:

President—A. E. Johnson, East Minneapolis.
Vice-President—S. C. Gale, West Minneapolis.
Secretary—Chas. Simpson, East Minneapolis.
Corresponding Secretary—A. E. Ames, West Minneapolis.
Treasurer—E. W. B. Harvey, East Minneapolis.

Professor Winchell was the guiding spirit in embodying the organization and drafting the constitution and by-laws; while the offer of Dr. Johnson's office as a place of meeting and for the preservation of specimens was accepted. It is significant of the spirit of the Academy that of the dozen original charter members a majority were practical physicians, viz.: Drs. A. E. Johnson, Chas. Simpson, C. E. Rogers, A. E. Ames, W. H. Leonard, A. F. Elliot and Dr. M. D. Stoneman, a dentist; while only three were teachers, viz.: Professor N. H. Winchell, the State Geologist; Principal E. W. B. Harvey, of the St. Anthony schools, and A. W. Williamson, a teacher of mathematics(for many years now a teacher of English at Augustana College, Rock Island, Ill.) Among the first year's added members, who took an active interest in the thirteen meetings of the year, were R. J. Mendenhall and R. J. Baldwin, bankers and naturalists; William Cheney, our pioneer meteorologist; Dr. P. L. Hatch, our pioneer ornithologist; Dr. W. H. Leonard, Archæology and Botany; Dr. B. L. Taylor, George W. Tinsley, mechanic, and Professor S. F. Peckham, the chemist of the State University. Paris Gibson and O. V. Tousley were among the original trustees.

The first formal paper read to the Academy was Dr. Johnson's able presidential address, "Did Life Originate by Law?" at the February meeting, 1873, which was published before the end of the year as the first number of the first volume of bulletins of the Academy.

In this address of 30 pages the author found it "impossible, in one or a hundred discourses, to present all the evidence that impels us to the belief of the law hypothesis, to the belief that the methods of God are secondary in the control of the universe." The first scientific report was an oral one from Professor Winchell "of his observations of the Drift, presenting the various theories on the subject, together with his own views." Two months later "the Drift was again discussed at considerable length by Messrs. Winchell, J. B. Clough, Ames, Gale and Johnson;" when a query by Dr. Stoneman regarding the identity of matter and force elicited considerable discussion, engaged in to a greater or less extent by all present. The fact that "the question was left undecided, no one being able to see clarly the identity of the two agents or substances" evidently led Dr. Johnson to present a paper two meetings later on "Matter and Force." The last meeting of its first year shows a remarkably virorous Academy, judged from the following minutes. "Dr. Ames read a communication from Professor Leidy concerning a vertebra found by Dr. Ames in the Red River country, assigning it to the Bison antiquus. A report on the Mammalia of the state was read by Dr. Ames (printed in the second number of the Bulletin). A report of the Archæology of the state was read by Dr. Leonard. Mr. Cheney referred to some recent experiments on the effect of vapor of water in equalizing the temperature of a room, which was followed by discussion. A report on the Ornithology of the state was partly read by Dr. Hatch (the balance being read at he next meeting and all printed in the second bulletin.) A paper was read by Dr. Simpson on "Prerequisites to a Proper Study of Science," and was published later.

After an extra supplementary meeting, at which the remainder of Dr. Hatch's report was read and Dr. Johnson read a paper on the "Timbers of the State," the second year of the Academy was begun with a remarkable and valuable paped by Dr. Johnson, designed as his retiring address as President, but really proving to be a new inaugural on the "Geological and Archæological Evidences of the Antiquity of Man" and filling forty pages of the second bulletin. The rest of this bulletin is occupied by a most interesting paper by Professor Winchell on "Geological Notes from Early Explorers in the Minnesota Valley," and by an ingenious paper by Geo. W. Tinsley on "Astronomy—Scientific and Unscientific." The unpublished papers and discussions of this second year should also be recorded here as stimulating evidence of the intellectual activity of the original Academy members. Mr. Tinsley had a paper "On the Cooling of the Earth and Its Relation to the Drift," Dr. Johnson a paper on "Evolution," followed two months later by one from Dr. Ames, who founded his principal argument against the theory on the fact of the existence of the lower forms of life at the present day. The paper drew out a great deal of discussion and revealed the fact that each man held views peculiar to himself." This evolution was again followed by Rev. E. C. Mitchell, who "considered that the two important factors in the origin of species were natural birth and extraordinary generation." Dr. Johnson's indefatigable enthusiasm produced three more papers in the fall of this year: one on "Entomology," one "describing some explorations and discoveries at Palmer

Lake Mound," Brooklyn, Minn., and one "on the Anatomy, Physiology and Habits of the Star Fish." Resolutions were also offered by Dr. Johnson in October of this year (1874) in memory of the death of Dr. A. E. Ames, who had himself offered similar resolutions at the beginning of this year on the death of the distinguished honorary member of the Academy, Professor Louis Agassiz.

The meeting of the third year (1875) began with descriptions by Professor Winchell of the order of the rocks which underlie the surface in this vicinity and by Professor Peckham on the iron ore from Duluth, which was similar to a Rhode Island ore containing a large proportion of titanium. The only paper by Dr. Johnson this year was one in March "On the Stoat, with Special Reference to Its Change of Color." Rev. Mr. Mitchell read "An Essay on Hydrophobia, profusely elaborating the symptoms, real as well as imaginary." R. J. Mendenhall had a paper on "Some Insects Injurious to Vegetation in this Climate," which was published in this year's bulletin "with a view to its wide distribution in our state." The rest of this bulletin for 1875 is occupied with supplementary list of the birds of the state, by Dr. Hatch, with acknowledgements of aid to Mr. John Roberts and his son, T. S. Roberts, W. L. Tiffany and G. W. Tinsley; "Notes on a Remarkable Storm," by Geo. B .Wright, in which over thirty inches of water fell during thirty hours about July 18, 1867; the first installment of Meteorological Statistics by William Cheney, beginning with 1864; "Notes on the Deep Well Drilled at East Minneapolis in 1874-5," by Col. J. B. Clough, City Engineer; and the reports of the committee on Conchology by Dr. Elliot, and of the curator, Dr. Simpson. The fall meetings developed a new and fertile subject when Dr. Leonard "made an interesting report on the examinations of the mounds at Lake Minnetonka in August last, and of the bones found therein, which he placed in care of the curator of the museum." The next month he reported "the opening of a new mound at Crystal lake. A few human bones and the vertebrae of a snake were all that was discovered." A month later Mr. Tinsley "stated that he had discovered thirteen large mounds out at Bloomington, giving a description of them; while at the following meeting Dr. Hatch "gave an interesting account of the opening of a mound by Mr. Thurber at Lake Minnetonka. The mound was covered by stones, placed in the form of a roof, and immediately beneath was a layer of wood, under which was an adult skeleton. One foot below this were four others, making the four points of the compass; one appeared to be an adult male, another an adult female, lying with their bodies horizontal, head slightly raised and legs flexed. The other two were children, with legs flexed in a similar manner, but face down."

The end of this third year marked an important event in the history of the Academy and one which will call our attention to the two other functions of the Academy besides its meetings, i. e., its museum and library. A committee of Drs. Elliott, Hatch, and Simpson, appointed "to take into consideration the propriety of moving the museum of the Academy to a more central location" where it "would be visited by a larger number of people than at present and thereby awaken a greater interest in its prosperity, looked for rooms centrally located about Center block, but they were mostly on the third floor and rents were too high to be easily met by the Academy. The room formerly occupied by the Y. M. C. A., No. 214 Nicollet avenue (over the Post Office) can be obtained for $120 a year. It is of fair size and well lighted; will accommodate the wants of the Academy for a few years very well." Colonel Clough offered to solicit money to finish up the museum cases for which Mr. Tinsley offered the hinges; all of which was done. Thus the meeting of November, 1875, was held in the new rooms.

The museum had begun with gifts of specimens at its organization from Drs. Johnson and Elliot, followed soon by gifts or exchanges from similar societies; so that the curator, Dr. Simpson, in his first report after one year's existence wrote: "Since the Academy took possession of its present rooms, cases have been constructed for the accommodation of our geological and mineralogical specimens, copied from similar cases in the museum of the University of Michigan, which are sufficient, not only for our present collection, but for all that we may reasonably expect to accumulate for some time to come. Ten cases of a different character, with glass covers, intended for the exhibiton of specimens of a more delicate nature, such as insects and shells, have also been procured and partly utilized." The collection then comprised several thousand secimens illustrative of the geology and paleontology of Minnesota, 350 specimens of minerals, a few zoology specimens, about 100 specimens of bones or implements in the archæology of the state, some 300 native Lepidoptera, a few native birds and several hundred land and fresh-water shells. What a stimulating evidence this collection is of the scientific spirit and enthusiasm of the genuine nature-loving founders of the Academy!

The library, with its present 12,000 numbers, began similarly from gifts and exchanges. The corresponding secretary, Dr. Ames, reported at the first May meeting "that he had entered into communication with most of the learned societies of the country;" while the first year's contributions to the library came not only from 164 similar academies of science in California, St. Louis, New York, Buffalo and Philadelphia, but even France, Spain and Scandinavia. The exchanges from our own bulletins now come from every continent of the world.

The fourth year of the Academy's life (1876) was memorable for the publication in that year's bulletin of Dr. A. E. Johnson's monumental paper on "The Mycological Flora of Minnesota," filling a hundred pages. In his genuine naturalist's devotion to this specialty Dr. Johnson had gathered and examined over 10,000 specimens in Hennepin, Ramsey, Wright and Anoka counties, resulting in 559 specimens new to the state, two of which were new to science. Besides this splendid product of the Academy's zeal this bulletin contained Mr. R. J. Baldwin's fine presidential address on "Light," Dr. Leonard's report on "Ferns," Dr. Hatch's supplemental report on "Ornithology," a paper on "Tornadoes and Cyclones" by Gen. T. L. Rosser, "Notes on a Hail Storm Occurring August 18, 1858," by Nathan Butler, and Dr. A. F. Elliot's curator report. Other papers read during the year were "A Case of Plants Adapting their Habits to

Circumstances," by Geo. B. Wright; "On the Detection and Extermination of Several Very Troublesome Insects Among Fruit Trees and Shrubery," by R. J. Mendenhall, Dr. Johnson read a paper giving an account of what was found in the Palmer Lake mounds, General Rosser described the phenomena of falling fish in Kentucky on March 8, 1876, Geo. W. Tinsley read a valuable paper on "The birth and Growth of Planets," Dr. Johnson "gave an interesting and detailed account of how he killed numerous plants with chloroform, which was new to him; but nevertheless convinced him that plants will be killed, as well as animals, from an over dose," and Professor Winchell read a paper as "Notes on the Paleontology of the Trenton Limestone in Minnesota."

These winter months of 1876 make an epoch in the Academy's history through the three public lectures on "Astronomy" by Richard A. Procter, which besides their value as a means of scientific culture netted the Academy treasury $356.60.

Though the scientific activity for 1877 waned somewhat, the following records of papers read show a good vitality: "The Muskrat as the Founder of the Baconian Philosophy," by Geo. B. Wright; "On the Purity of the Water of the Mississippi River," by Dr. Johnson; "On the Tube Artesian Wells of Minneapolis," written by C. E. Whelpley, and read by Dr. Elliot; "Report of the Analysis of Some Ashes Taken from a Furnace where Bran was used for Fuel," by Prof. S. F. Peckham; "The History of Milling," by Geo. H. Christian; verbal report of his investigations in Ichthyology by W. L. Tiffany; a description of the effects of the storm of the previous Friday night in Richfield township by Mr. John Roberts; remarks on the geology of Hennepin county by Prof. Winchell, and "an elaborate account of the ancient as well as modern trilobite by Mr. Tiffany.

The records of the two following year (1878 and 1879) show, amid the presentation of many specimens for the museum and exchanges for the library, the following scientific activity:—two supplementary reports by Dr. A. E. Johnson on the "'Fungi of the State,' of which he had collected 229 species new to our state and 22 new to science (both reports and catalogs being printed in the Bulletin for 1877-9); "An Assay of the Effects of Fungous Growths upon Vegetable and Animal Life," by Dr. Johnson; a paper on "Infusoria," by Dr. A. W. Abbott; a discussion on the recent explosion of the Washburn A mill, by R. J. Baldwin, A. C. Rand and W. L. Tiffany; "An Essay on the Black Bass," by W. L. Tiffany; "Progress in the Study of the Mounds of the State," by Nathan Butler; a paper on "Drilling Wells for Water Purposes," by C. E. Whelpley; a paper on "Ornithological Notes," by Thomas S. Roberts, Robert S. Williams and Clarence L. Herrick, and read by Mr. Tiffany; a paper on "Entomology," by R. J. Mendenhall, and one on "The Yeast Plant," by Dr. A. W. Abbott (both these papers appear only in abstract in the bulletin because all the manuscript and printed pages of the 1878 bulletin were destroyed in the Brackett Block fire); a lecture on "Ethnology," by Hon. C. S. Bryant of St. Paul; a lecture on the Mineralogy and General Geographical Features of the Lake Superior District," by Prof. S. F. Peckham; a lecture on "The Eagle

Fish Hawk," by W. L. Tiffany, the secretary; address on the "Uses of the Misroscope," by Wm. Kilgore, and a paper on "Darwinism," by Professor Winchell, who was president for this year (1879.) Although this paper on Darwinism, along with Dr. Johnson's inaugural address of this year was evidently lost in the historic Brackett Block fire. Professor Winchell's retiring address closes the first volume of over 400 pages of the Bulletin and is a most valuable document on the first seven years of the Academy's history on its purposes and benefits. It ought to be quoted in full in the present historical paper. Besides the men whose names which have appeared as partaking in the Academy's programs there should be mentioned the names of three honored clergymen who took much active interest in the Academy, Jas. McGolrick, Henry A. Stimson and E. S. Williams, the first of whom was the first life member of the Academy, R. J. Mendenhall being the second.

The year 1880 shows the following intellectual scientific activity:—an inaugural presidential address by Dr. P. L. Hatch, reviewing with his well-known literary originality the work of the Academy a letter from C. E. Whelpley, reporting the discovery of wood and bone at a depth of 300 feet during the boring of a well at Sheldon, Iowa, from which the specimens themselves were also sent; "an evening was devoted to microscopy, ten instruments being present, several of which were described in detail by their owners," and a box of microscopic slides, recently purchased from Mr. John Walker. were evidently used; Professors Peckham and Winchell described successively the various specimens in the fine collections of minerals presented by Mr. W. A. Morey for the use and benefit of the Academy;" a similar description, with the aid of Professor Hall, of a collection of minerals given by Mr. C. H. DuBois; "A Biographical Notice of a Few of the Fishes of the Falls of St. Anthony," by Mr. Tiffany; a paper on "How the United States Fish Commission Works," by Franklin Benner, who was connected with this work in Maine in 1878; an address by Dr. R. J. Taylor of Galesburg, Ill., on "The Rotary Motion of the Gyroscope," which address was candidly recorded with the characteristic honesty of the secretary, T. S. Roberts, as being of "little force and unscientific;" an article on the "Copper Mines of Lake Superior," by Professor Winchell, who also discussed the mound builders in connection with the ancient copper mines at Isle Royale, and at two later meetings; Mr. Whelpley described the sand and rock layers, which he presented to the Academy, taken from the artesian well at the Washburn A mill; Warren Upham "spoke of the glacial terminal moraine, which he had spent his time the past summer and fall in examining, and an article on "Red Lake Notes" was transmitted to the Academy and printed in its bulletin from Miss Franc E. Babbitt of Little Falls, together with her sending a box of pottery fragments from this region. In connection with this first mention of a woman in the Academy's proceedings it should have been recorded before that Mrs. F. L. Tinsley, wife of Geo. W. Tinsley, had been elected the first woman member in March, 1876. Mrs. Tinsley had presented the Academy a month before with thirteen mounted bird skins, which she had herself prepared and for which she was voted thanks "for the valuable specimens presented, prepared, as they were, with artistic skill."

The year 1881 opened with a paper from Mr. Charles Hallock of Hallock, Minn., former editor of "Forest and Stream," on "The Fauna of Northern Minnesota," read by A. B. Jackson and published in the Bulletin. "Mr. T. S. Roberts read an interesting paper upon "The Orchids of Minnesota," speaking first of the peculiarities of the family in general and the various curious adaptations for cross fertilization, the writer directed his attention to the orchids native to the state, of which thirty-two species have been identified. Taking them up in the order of Gray's Botany, each of these was briefly described, with additional notes upon peculiarities, habits, etc" (From the record of the secretary, C. L. Herrick, as the paper was unfortunately not published.) "President Winchell read a paper entitled "Where did Carver Winter in 1766?" Carver's account was shown to be vague and in some respects unreliable. He was in search of the 'Northwest Passage to Asia.' He says he ascended the 'Minesotay' 200 miles, which is an evident exaggeration. Evidence seems to point to the mouth of the Cottonwood river as the actual site of this disputed locality. The paper elicited questions and remarks. Mr. Upham, in response to question, said that he found several evidences of two glacial epochs in the portions of the state which he had examined: First, vegetable remains in situ between layers of boulder clay, also fresh-water shells under the same circumstances; second, terminal moraines in succession. He also spoke of the evidence that there had been more than two such epochs. The universal prevalence of glaciation indicates the astronomical origin of glacial epochs. In response to a question from Mr. Gale, Professor Winchell restated briefly the method by which he had estimated the time since the last Glacial epoch by the data afforded by the recession of the Falls of St. Anthony." (All from March, 1881.)

Mr. Chas. Hallock then gave a personal lecture upon "Fish and Fishing," illustrating his remarks by exhibiting the various paraphernalia of the sport. On motion of Professor Hall the Academy "requested Professor Weitbrecht of St. Paul, Professor Gray of St. Cloud, Professor Boutelle of Winona and Dr. C. N. Hewitt of Red Wing to collect data in reference to the recent and earlier floods of the Mississippi and Minnesota rivers and other waters of the state, in order to made a permanent record of the floods which periodically devastate the state." (July, 1881.) The last meeting for 1881 was held in the new room to which the Academy had moved, back again in the Wensinger Block, 100 Central avenue, where the rent was $100 per year, and insurance for $500 was placed on the collections.

The year 1882 began with Professor Winchell's retiring presidential paper on "The Geology of Minneapolis," the same being a report on the product of the drilling of an artesian well at the Washburn A mill and comparing it with the various geological formations throughout the state." "From the section of Astronomy Judge N. H. Hemiup, Chairman, read an interesting paper on 'The Other Side,' drawing conclusions from the writings of astronomers concerning the actual physical condition of the moon," calling forth much discussion from Professors Winchell and Downey. "Warren Upham read a very able and elaborate paper on 'The Flora of Minnesota,—Its Trees, Fruits, Flowers and Weeds,' at the March meeting in spite of its adjourning prematurely in consequence of the uncomfortable condition of the hall from cold." "Professor Dodge gave a very full description of some tests of building stones being made in the chemical laboratory" of the University; and "Professor Pearson then read a paper entitled 'Carbonic Acid in the Air.' The paper embodied experiments and results of a series of investigations made by the author a few years ago in and near Boston, Mass." (April meeting.) Both these papers were followed by much discussion on the part of Professor Pike and Dr. W. H. Leonard respectively. The May meeting was memorable for the splendidly able paper by Dr. A. E. Johnson on "Whence came the Differnt Species of Varieties of Man?" published later in the Bulletin and which proved to be the last of the eighteen monumental papers by the "Father of the Academy." His absorbing devotion and study of his fungi, especially his excessive use of his microscope by lamp light by which he nearly lost the sight of one eye, had already begun to break down his health; sciatic rheumatism also began to cripple him. So that from about this time he gave up his practice as a physian and began the long series of invalid years of which he has now almost reached the end. This paper of Dr. Johnson's on the evolution of man was immediately followed by Professor Winchell's fine tribute to Charles Darwin in the shape of resolutions on his death (printed in the Bulletin,) and Judge Hemiup was appointed to prepare a memoir on the life and works of Darwin.

After some discussion at the June meeting "on insects injurious to shade trees, especially the elms of the city," Mr. C. L. Herrick gave the Academy some notes of his stay in Europe during the preceding months, and "Mr. J. Walker called attention to a peculiar infusorium recently observed by him, etc." A special meting was called to extend an invitation, in conjunction with the enlisted aid of the Board of Trade and officials of the city, to the American Association for the Advancement of Science to hold its next yearly meeting in Minneapolis; but this invitation could not be accepted. "Professor Winchell read a paper on 'The Bibliography of the Mineralogy of Minnesota,' with a list of minerals found in the state, with their chief localities." (Published in the Bulletin.) At the November meting "an interesting paper was read by John Walker, chairman of the section of Microscopy, giving a review of the field studied by the section during the past year. The work covered observations on Entomostraca, micro-botany; especially Equisetum spores and outer cells of Utricularia vulgaris, the micro-fungi, fresh-water algae, diatoms, also Infusoria, rizopods and other divisions of the Protozoa, articulates, etc." The last meeting of 1882 found the Academy and its museum again on the West Side, after only one year's second sojourn on the East Side, having rented a room 44x80 on the third floor of Anthony Kelly's Block, 110 Hennepin avenue, at $150 per year. The expense of moving, finishing the room and fitting up of new cases for these quarters was largely met by the activity and generosity of Mr. T. B. Walker, who had been a member of the Academy since February, 1879, had been chairman of the sections of

Geology and Astronomy and had been a trustee, in company with Jas. McGolrick, among others, since January, 1882. There should be recorded with gratitude the fact that this year of 1882 marked the beginning of Dr. A. F. Elliot's eight consecutive years of able leadership as president and of Professor C. W. Hall's fourteen laborious and efficient years as recording secretary. Besides the papers already mentioned as recorded in the meetings for 1880-1882, inclusive, the following papers or abstracts are printed in Vol. III of the Academy's Bulletin covering these three years:

"The State and Higher Education," inaugural address of 1881, by President N. H. Winchell.

"Some Impurities in Drinking Water," by Prof. Geo. Weitbrecht, of the St. Paul Medical College.

"Industrial Educati n," by Prof. W. A. Pike, of the University of Minnesota.

"Influence of Geological Structure on History in the United States," by Prof. A. F. Bechdolt, of the Mankato Normal School.

"Is the Dakota Related to the Indo-European Languages?" by A. W. Williamson, Ad't Professor of Mathematics of Augustana College, Rock Island, Ill.; formerly one of the original charter members of the Academy.

"The Classification of Languages" and "The True Method of Political Economy," both by President W. W. Folwell, of the University of Minnesota.

"The Fixed Stars," by Prof. J. F. Downey, of the University of Minnesota.

"Some Theories of the Origin of Meteorites," by Prof. C. W. Hall.

"The Spectroscope in Astronomy," by Prof. W. W. Payne, of Carlton College.

"The Duty of Scientific Societies to Aid in Practical Sanitary Work," by Dr. C. N. Hewitt, Secretary of the State Board of Health and Professor of Public Health in the University of Minnesota.

"Some Observations of Living Cells," by Prof. S. Calvin, of the State University of Iowa.

"Joseph Priestly," by Prof. James A. Dodge, of the University of Minnesota.

"Natural Sciences in the Public Schools," by Prof. A. F. Bechdolt, of the Mankato Normal School.

"Physiology and Mental Science," by Prof. A. T. Ormond, of the University of Minnesota.

"The Utilization of Sawdust," by Prof. J. A. Dodge.

"Lake Agassiz: A Chapter in Glacial Geology," by Warren Upham.

"The Physical Character of the Sun," by Prof. J. F. Downey.

"A Study of Recent Comets," by Prof. W. W. Payne.

"Some Algae of Minnesota Supposed to be Poisonous" and Descriptions of Iowa Uromyces," both by J. C. Arthur.

"Notes on Some Pieces of Pottery, and Native Alum from White Fish Lake," by C. W. Hall.

"On the Oxidation of Benzine Derivations with Potasium Ferri-Cyanide and Caustic Potash," by W. A. Noyes.

"Meteorologlcai Statistics for Minneapolis from 1865 to 1882," by Wm. Cheney.

There is fortunately no further necessity of continuing this catalog of the papers and discussions of the Academy beyond these first ten years of its existence, for from this time on an outline of the Secretary's record book has been printed as "Proceedings" through the third and fourth volumes of the Bulletin. For this valuable innovation the Academy is indebted to its faithful Secretary and President, Prof. C. W. Hall. As we can therefore trace the personnel and amount and character of the scientific activity of the Academy so easily to the present time through its printed records, there only remains the mention of two important historical events in the Academy's life.

Already in February, 1880, President Hatch had "called the attention of the Academy to a proposition to erect a building which it was proposed to consider at this time, concluding by calling upon Mr. R. E. Grimshaw to present the matter more fully." On Mr. Grimshaw's motion that a committee of five be appointed to consider the whole subject of the erection of a building he was appointed chairman and associated with T. B. Walker, S. C. Gale, A. B. Jackson and N. H. Winchell. Nothing more is said in the records of this plan until November ,1884, when it was resolved through Professor Winchell's motion, "That it is the sense of the Minnesota Academy of Natural Sciences that there should be erected a joint building for the accommodation of the Academy, the Athenaeum and the Art Association, and that this Academy will gladly co-operate with any parties who may inaugurate a general movement to secure this event." This resolution immediately followed mysterious "communication by Judge Hemiup, having reference to a public building to be built for uniting the place of meeting of this Academy and the Athenaeum." Judge Hemiup moved that a committee of three, of whom Dr. Elliot should be one, be appointed to consider the matter in confernce with the trustees of the Athenaeum with a view to solicitation of funds from the public. The matter was further brought forward in a letter read by Judge Hemiup from (name withheld) a friend of the Academy. Dr. Elliot then associated with himself in this committee T. B. Walker and S. C. Gale.

But the "Public Library" plan for the co-ordination of these three public educational functions of literature, art and science was finally executed, and on October 8, 1889, "the Academy met for the first time in its new quarters in the Public Library Building; fifty persons were present." The meetings began there regularly on January 15, 1890, when Dr. Hatch moved that a vote of thanks be extended to the Library Board of the City of Minneapolis "for their prompt and generous action in affording quarters for the Academy and in furnishing cases for the preservation and exhibition of its collections. Mr. Edward Gale, in seconding the motion, spoke in warm and hearty words the appreciation of the institution for the ready and cheerful action of the Library Board towards the Academy. The motion was unanimously carried." But before the Academy could get away from the Kelly Block, Mr. Walker again came to its rescue by contributing $125 toward the $175.81, which Father

McGolrick's peaceful and faithful service as trustee had at last effected as a settlement of the two years' arrears of rent with Mr. Kelly.

The other historical event is the "Menage Scientific Expedition to the Philippine Islands," the inception and history of which is told in the Bulletin "Proceedings" from April 8, 1890, to November, 1894, in the "Preliminary Notes on the Birds and Mammals Collected by the Menage Expedition," which form sixty-four pages of the first issue of "Occasional Papers" of the Academy, and in the "Letters from Dean C. Worcester and Frank S. Bourns, forming the Menage Expedition," in pages 131-172 of Vol. IV. of the Bulletin.

The collections of this expedition have become celebrated. They embrace a beautiful group of stuffed orangs, said to be the best in existence, other Philippine large animals, numerous alcoholic specimens used by the Zoological department of the University of Minnesota, and the finest and largest collection of Philppine bird-skins extant. the last loaned by the Academy to the Honolulu Museum and used by Mr. Bryan in his work on the birds of the Pacific ocean.

The project of this expedition was brought to the attention of the Academy by Mr. H. V. Winchell, a college friend of Messrs. Worcester and Bourns. Mr. Menage was visited by thes three enthusiasts, and on condition that the Academy would house and care for the collection, Mr. Menage contributed ten thousand dollars for expenses.

I cannot close this historical sketch of the Academy of Sciences without recording a couple of practical inferences which have grown out of my leisurely traveling through the Academy's history. The first inference is that the Academy's foundation strength lies in a love for the knowledge of nature right about us, especially of our own state. This love of nature for her own sake, stimulating vigorous physicians, business men and teachers to use their own senses and hungering intelligence to know about the plants, birds, fish, waters, woods, prairies, rocks, bones and pottery,—all this to better understand our own individual relations to the world of nature and man right about us,—such was the strong character of the founders of the Academy thirty-three years ago, and such intellectual interests have made the honorable and useful record of the Academy's first generation of existence. When the Academy has become weakened or desiccated, the cause is evident in the loss of this love of nature and the introduction of the spirit of scientific professionalism. For there is a professionalism of science as well as of bodily exercise. When a student of nature becomes so morbidly developed that his main interest is in displaying his accomplishment or prowess, in collecting an ingenious armor of apparatus for his specialized kind of scientific warfare, and then takes his chief scientific exercise in beating his competitors for good salaried positions,—such a scientific athlete crushes out the modest love of nature—not but that microscopic specialists must exist in the machinery of a true university, or but that much genuine amateur disinterested love of scientific exercise is scattered here and there among the professional positions; and the Academy ought to be deeply grateful for the constancy and efficiency of such well-tried experience as it has had the good fortune to gain. But its second generation of life, judged from its first, must find its main nourishment in the amateur spirit of voluntary intellectual exercise for one's own stronger scientific manhood.

The second inference is as to the most efficient methods of exercising this love of nature. First by each member's bringing into the monthly meetings the finds in nature which have given him personally the greatest satisfaction. Then by exchanging these nature-discoveries the members were mutually educated in the highest way,—better than any cut and dried formal course of study could do. The bringing in of real specimens for the museum, describing them informally and untechnically, was the best stimulus for each member's learning more in his special field of nature. The wider perspectives of the application of all these bits of knowledge to ourselves, as preeminently gathered up in the great world-law of evolution, has often been presented most ably in the presidential addresses. And the most that any guiding officer could do was in aiding or arranging the meetings for discussions and papers; his most strenuous official fidelity is unavailing without a homogeneous body of real lovers of and workers in nature. If the contribution made a fairly complete chapter or even paragraph of knowledge they printed their papers themselves to exchange with similar all over the world. Here again they happily avoided a professionalism which, often under the glamor of artificial light or obscurity, too often extracts money from spectators to pay for publishing their personal victories. The range of the Academy's collected studies thus naturally confined itself to the knowledge of the nature of our own community and state; similar scientific societies in other cities and states making their local studies and exchanging with Minneapolis and Minnesota. The more abstract, technical, or ultra-scientific papers found little expression in the four volumes of the Academy's Bulletins; such articles should go to the few highly specialized scientific journals.

Then, besides being a mutual knowledge-exchange, the Academy made itself helpful to a larger circle through the educational means of its public museum and public lectures. Both these public functions have done much for the intellectual culture of our city. They require more financial support than the publishing function; but, when any necessary or reasonable plans for museum growth or popular scientific lectures were made, there has been a timely and generous support from public-spirited men of intellectual and business force of character. Where there has been scientific ideals and determination the money has never failed. Thousands of children and adults have gotten educational culture from the Academy's collections of the works of nature and of nature's children, or from the Academy's public lectures on astronomy or physiology. Along with the rich opportunities for literary and art culture which our city generously offers to its children and citizens there is also the indispensable need for the complementary side of human culture in knowing nature about us at first hand. And this function the Academy's museum and public lectures can fulfill as none of our other educational means in schools and colleges try or can hope to do.

Thus it is profoundly to be hoped that the spirit of loving to know about nature for her own sake and the executive ability for pursuing this knowledge for its own culture-value to themselves and to the community may be sacredly honored, preserved and extended in the life of the Academy.

LIST OF ACCESSIONS TO THE LIBRARY BY EXCHANGE FOR THE YEARS 1905-1909.

Prepared by O. W. Oestlund, Corresponding Secretary.

Aarau, Switzerland.—Aargauischen naturforschenden Gesellschaft zu Aarau. Mitteilungen: X; XI.

Adelaide, South Australia.—Royal Geographical Society of Australasia, Proceedings: VIII.

Agram, Hungary.—Jugoslavenska Akademija.
Ljetopis: XIX-XXIII. Rad. 158-161, 163, 165, 167, 169, 171, 173, 175, 177.

Albany, N. Y.—State Educational Department: Annual Report, I, II.
State Library: Bulletin, Nos. 86, 87, 91, 93, 97, 99, 100.
State Museum: Annual Report, 56, 57; Bulletin, 77-87, 89, 91, 93-97, 99, 100, 102.
University of N. Y. Annual Report, 1905.

Altenburg, Germany.—Naturforschende Gesellschaft des Osterlande.
Mitteilungen: XI, XII, XIII.

Amiens, France.—Société Linnéenne du Nord de la France.
Bulletin: XV-XVIII; Memoires, XI.

Ann Arbor, Mich.—Academy of Science. Reports: I-VI, IX, X.
University of Michigan. Bulletins, 1905-1909.

Austin, Texas.—Texas Academy of Science. Transactions: IX, X.

Baltimore, Md.—Johns Hopkins University. Circulars: 1905-1909.

Baltimore, Md.—Peabody Institute. Annual Reports: 38, 41.

Bamberg, Germany.—Naturforschende Gesellschaft in Bamberg.
Bericht: XIX, XX.

Barcelona, Spain.—Real Academia de Ciencias y Artes de Barcelona.
Boletin: II: 6-11. Memorias: V, 2-27; VI, 1-33; VII, 1-17; VIII, 1-6. Nomena: 1904-1908.

Basel, Switzerland.—Naturforschende Gesellschaft in Basel.
Verhandlungen: XV, 3; XVI-XIX; XX, 1.

Belfast, Ireland.—Natural History and Philosophical Society.
Report and Proceedings: 1903-1906.

Bergen, Norway.—Bergens Museum. Aarsberetning: 1904-1906. Aarsbog: 1904: 2, 3. 1905; 1906; 1907: 1, 2. Meeresfauna von Bergen; I-III.

Berkeley, Cal.—University of California.
Publication: I: 8; II: 1-2. Chronicle: X, 3, 4.

Berlin, Germany.—R. Friedländer & Sohn.
Naturae novitates: 1904, 19-24; 1905-1908; 1909, 1-6.

Beiers, France.—Société d' Etude des Sciences Naturelles de Beziers.
Bulletin: XXVI-XXIX.

Bogota, Colombia.—Ministerio de Obras Publicas.
Revista: I, 8-12; II; III; IV, 1-9.

Bologna, Italy.—Reale Accademia delle Scienze dell' Instituto di Bologna. Memorie: Ser. 5, X; Ser. 6, I-V. Rendiconto: VII-XII.
Bombay, India.—Royal Asiatic Society. Bombay Branch.
Journal: XXII; XXIII; Centenary Memorial Volume.
Bordeaux, France.—Faculté des Sciences, Laboratoire de Botanique.
La Diatomie Blene.
Boston, Mass.—American Academy of Arts and Sciences.
Proceedings: XL, 11-24; XLI, 1-35; XLII, 1-29; XLIII, 1-21; XLIV, 2, 3, 6-26; XLV, 1.
Boston, Mass.—Boston Society of Natural History.
Proceedings: XXXII, 3-12; XXXIII, 2-9; XXXIV, 2-7.
Boston, Mass.—Massachusetts General Hospital.
Publications: I, 1-3; II, 1. The fruits of medical research, C. W. Eliot. A consideration, etc., W. H. Walsh.
Boston, Mass.—Massachusetts Horticultural Society.
Transactions: 1904, 2; 1905-1907; 1908, 1.
Boulder, Col.—University of Colorado. Dept. Psychology: II, 2, 3; III, 1, 2. Studies: II, 3, 4; III-VI.
Bozeman, Mont.—Montana Agricultural College.
Science Studies: I, 1-3.
Braunschweig, Germany.—Verein für Naturwissenschaft.
Jahresbericht: XIV.
Brisbane, Queensland.—Geological Survey of Queensland.
Publications: Nos. 196-205, 207-212, 214-216, 219.
Brisbane, Queensland.—Royal Society of Queensland.
Proceedings: XIX, XX.
Brooklyn, N. Y.—Brooklyn Institute of Arts and Sciences.
Cold Spring Harbor Monographs: I, 3-7 9, 10.
Science Bulletin: I, 4-8, 11-16.
Brunn, Austria.—Naturforschenden Verein in Brunn.
Verhandlungen: 42. Bericht: 22.
Bruxelles, Belgium.—Société royale de Botanique de Belgique.
Bulletin: XLI-XLV.
Bruxelles, Belgium.—Société belge de Microscopie.
Annales: XXVI, XXVIII.
Bruxelles, Belgium.—Société Royal Zoologique et Malacologique de Belgique. Bulletin: 1903-1906.
Bruxelles, Belgium.—Société Scientifique de Bruxelles.
Tables analytique des Annales et Revue, 1875-1901.
Budapest, Hungary.—Ungarische Ornithologische Centrale.
Aquila: XI-XV.
Buenos Aires, Argentina.—Ministerio de Agricultura de la Republica Argentina. Boletin: VII, 3; VIII, 3, 4; IX, 1, 2.
Buenos Aires, Argentina.—Museo Nacional de Buenos Aires.
Annales: V-X.
Buenos Aires, Argentina.—Sociedad Cientifica Argentina.
Anales: LVIII, 4-6; LIX-LXVI; LXII, 1-5.
Calcutta, India.—Geological Survey of India.
Himalaya Mts. and Tibet: I-IV.
Memoirs: XXXII, 4; XXXIV, 4; XXXV, 3; XXXVI, 1, 2.
Palaeontologia Indica: II, 2-5; III, 3; V, 1-3.
Records: XXXI, 3, 4; XXXII-XXXVII; XXXVIII, 1, 2.

Cambridge, Mass.—Harvard College Observatory.
Annals: XLVII, 1; L; LII, 2; LIII, 5-9; LIV; LV, 1; LVI, 1-4; LVII, 1, 2; LIX, 1, 2; LX, 1-5, 9; LXI, 1; LXII, 1; LXIV, 1-3.
Annual Reports: 1904-1906.
Circulars: 88-142.
Cambridge, Mass.—Museum of Comparative Zoology.
Bulletin: XLVIII, 3.
Cameron, La.—Gulf Biological Station.
Bulletin: 7 and 13.
Cape Town, South Africa.—South African Philosophical Society.
Transactions: XIII, pp 289-546; XV, 3-5; XVI, 1-5; XVII, 1; XVIII, 1-4.
Cassel, Germany.—Verein für Naturkunde.
Abhandlungen und Bericht: XLIX-LI.
Catania, Italy.—Accademià Gioenia di Scienze Naturali.
Bollettino: LXXXIII-LXXXVIII.
Chapel Hill, N. C.—Elisha Mitchell Scientific Society.
Journal: XXI-XXV.
Chatham, N. B., Canada.—Miramichi Natural History Association.
Proceedings: No. 5.
Chicago, Ill.—Chicago Academy of Sciences.
Bulletin: III, 1, 2; IV, 2; VI; VII, 1. Special Bulletin No. 2.
Chicago, Ill.—Field Columbian Museum.
Publications: 94, 98, 101, 104-134.
Chicago, Ill.—John Crerar Library.
Annual Reports: X-XIV.
List of Cyclopedias and Dictionaries. A list of books exhibited. Handbook, 1907. List of books in reading room.
Christiania, Norway.—Videnskabs Selskab i Christiania.
Forhandlinger: 1904-1908.
Skrifter: 1904-1908.
Chur, Switzerland.—Naturforschende Gesellschaft Graubündens.
Jahresbericht: XLVII-LI.
Cincinnati, Ohio.—Cincinnati Society of Natural History.
Journal: XX, 5-7; XXI, 1.
Cincinnati, Ohio.—Lloyd Library of Botany.
Bulletin: VII-XI.
Mycological notes: XV-XXIX.
Colorado Springs, Colo.—Colorado College.
Publications: 24-26; 29-33; 36, 37, 39, 42, 44.
Columbia, Mo.—Laws Observatory.
Bulletin: II-XVI.
Columbia, Mo.—University of Missouri Library.
Bulletin: VIII, 5.
Studies: I, 1, 2; II, 1.
Columbus, Ohio.—Geological Survey of Ohio.
Bulletin: II-VIII.
Concarneau, France.—Laboratoire Maritime de Concarneau.
Travaux scientifiques: I, 1-5.

Davenport, Iowa.—Davenport Academy of Sciences.
Proceedings: IX-XI; XII, pp. 95-222.

Denver, Col.—Colorado Scientific Society.
Proceedings: VII, pp. 341-346; VIII, pp. 1-422; IX, pp. 5-258.

Des Moines, Iowa.—Geological Survey of Iowa.
Annual Report: XV-XVIII.

Des Moines, Iowa.—Iowa Academy of Science.
Proceedings: XII-XV.

Dorpat, Russia.—Naturforscher Gesellschaft bei der Universität Jurjew.
Archiv: XII, 3; XIII, 1.
General Register zu I-XIV. Namenregister, III-XIV.
Schriften: XIII-XIX.
Sitzungsberichte: XIII, 3; XIV-XVII.

Dumfries, Scotland.—Natural history and Antiquarian Society.
Transactions: XVII, 3-5; XVIII-XX.

East Lansing, Mich.—Michigan State Agricultural College.
Bulletin: Nos. 221-255. Special, 36.

Ekaterinburg, Russia.—Société Ouralienne des Amis des Sciences Naturelles. Bulletin: XXII-XXVIII.

Emden, Germany.—Naturforschende Gesellschaft.
Jahresbericht: LXXXVIII-XCII.

Firenze, Italy.—Biblioteca Nazionale Centrale di Firenze.
Bolletino: Nos. 49-107.

Fribourg, Switzerland.—Société Fribourgeoise des Sciences Naturelles.
Bulletin: XII-XVI.
Memoires: Bot. I, 7-9; II, 1-5; III, 1. Chem. II, 2-4; III, 1-2. Geogr. IV, 1-3; Bacter, I, 1.

Genève, Switzerland.—Société de Géographie de Genève.
Le Globe: XLIV-XLVIII.

Glasgow, Scotland.—Natural History Society of Glasgow.
Transactions: VI, 3; VII, 1-3; VIII, 1.

Görlitz, Germany.—Naturforschende Gesellschaft zu Görlitz.
Abhandlungen: XXIV-XXVI.

Granville, Ohio. Scientific Laboratories of Denison University.
Bulletin: XIII, pp. 1-166; XIV, pp. 1-287.

Graz, Austria.—Naturwissenschaftlicher Verein für Steiermark.
Mitteilungen: XLI-XLV.

Greifswald, Germany.—Naturwissenschaftlicher Verein.
Mitteilungen: XXXVI-XL.

Groningen, Netherl.—Naturkundig Genootschap Groningen.
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REVISED CONSTITUTION AND BY-LAWS OF THE MINNESOTA ACADEMY OF SCIENCE.

December, 1910.

Article I. NAME.

This Association shall be known as The Minnesota Academy of Science.

Art. II. OBJECT.

It shall be the object of the Academy to observe and investigate natural phenomena; to make collections of specimens illustrating the various departments of science; to name, classify and preserve the same; also to discuss such questions as shall come within the province of the Academy.

Art. III. PLACE OF MEETING.

The place of meeting of the Academy, and the location of its cabinet and library shall be in the City of Minneapolis.

Art. IV. OFFICERS.

The officers of the Academy shall consist of a President, Vice-President, Secretary, Corresponding Secretary and a Treasurer, who shall be elected annually by ballot by a majority of the members present.

Art. V. TRUSTEES.

There shall be a Board of Trustees, which shall consist of six members, two of whom shall be elected annually, and the President and Vice-President of the Academy.

Art. VI. ELECTION.

The election of officers and trustees shall take place on the first Tuesday after the first Monday of January in each year.

Art. VII. FEES.

All persons residing in the cities of Minneapolis or St. Paul, elected members of the Academy, shall pay an initiation fee of three dollars; and all persons elsewhere in the State such an initiation fee as the Academy may determine.

BY-LAWS.

Article I. MEETINGS.

Section 1. The annual meting of the Academy shall be held on the first Tuesday after the first Monday of January in each year.

The regular monthly metings of the Academy shall be on the first Tuesday after the first Monday of each month. Five members shall constitute a quorum.

Sec. 2. The meetings of hte Board of Trustees shall be quarterly on the days following the corresponding monthly meetings of the Academy; Provided, that the President shall have power, at his discretion, to postpone any quarterly meeting except the first in each year, and to call special meetings at the request of three members of the Board.

Sce. 3. The President, at the written request of five members, may call a special meeting of the Academy, but no business shall be transacted at such meetings, except that for which they were called.

Art. II. SECTIONS OF THE MEMBERSHIP.

Section 1. The entire membership shall be divided into sections corresponding to the branches of science, each section being in charge of a chairman appointed by the President, and all vacancies shall be filled by him, subject to confirmation by the Board of Trustees. Each section shall consist of the chairman and as many members as desire to work in it. The chairman shall divide his section into as many sub-sections as will best subserve the objects of the section.

Sec. 2. The sections shall cover the following sciences:

ANTHROPOLOGY.	MINERALOGY.
ASTRONOMY.	MICROSCOPY.
BIOLOGY.	MECHANICAL PHILOSOPHY.
BOTANY.	PHYSICS.
CHEMISTRY.	ECONOMICS AND SANITARY
GEOLOGY.	SCIENCES.
INVERTEBRATE ZOOLOGY.	VERTEBRATE ZOOLOGY.

Sec. 3. There shall be a Committee on Finance and one on the Museum and Library, to consist of three members each.

Art. III. DUTIES OF OFFICERS.

Section 1. The President shall preside at all meetings of the Academy, and at each annual meeting the retiring President shall deliver an address before the Academy on such subject, covered by the scope of its investigations, as he may select—such address to be preserved in the records of the Academy.

Sec. 2. The Vice-President shall preside at meetings of the Academy and act as president in all respects in the absence of the President.

Sec. 3. The Secretary shall keep correct and accurate minutes of the proceedings of the Academy; receive all moneys, and pay them over to the Treasurer and take his receipt for the same; and enter in the proceedings of the Academy the name of each person paying money to him, the purpose for which the same is paid, and the amount paid, and make out in writing and submit to the Academy a correct and accurate statement, in detail, of his official account with the Academy, which statement shall be submitted at the annual meeting; he shall deliver all books and papers in his possession having any reference to the proceedings of the Academy, to his successor in office.

Sec. 4. The Corresponding Secretary shall conduct the correspondence of the Academy.

Sec. 5. The Treasurer shall receive all moneys from the hand of the Secretary, and give his receipt for the same, and shall pay them out on the order of the President, countersigned by the Secretary; and for the faithful performance of his duties, he shall, every year- before entering upon the duties of his office, give a bond for such amount as the Board of Trustees shall determine, such bond to be signed by himself and two sureties; and shall, also, prepare an accurate statement, in detail, of his accounts, and submit the same to the Academy at its annual meeting and shall deliver all books, papers and vouchers in his possession, having any reference to the financial condition of the Academy, to his successor in office.

Sec. 6. The Curator of the Museum shall be appointed by the Board of Trustees. He shall be one of the Committee on Museum, and shall have the custody of the collections belonging to the Academy; shall receive, label and arrange the specimens that may be added to it from time to time, and present annually a report, stating the number and kind of additions to the Museum, and their source. He may, also, present a memoir on any department illustrated by the collections.

Art. IV. DUTIES OF COMMITTEES.

Sec. 1. The chairmen of the sections shall have charge of the departments to which they are appointed, and shall prosecute such investigations as they may see fit, any member offering to the Academy at its regular meetings such remarks, written or oral, as he may think of interest. They shall also collect and preserve for the Museum, specimens illustrating their several branches.

Sec. 2. The Financial Committee shall audit the accounts of the Secretary and Treasurer at the end of each year, and all other accounts referred to them by the Board of Trustees, or by vote of the Academy.

Art. V. DUTIES OF THE BOARD OF TRUSTEES.

Section 1. The Trustees shall hold in trust all property, real and personal, belonging to the Academy, or which may hereafter be acquired by purchase, gift, or otherwise, except as otherwise directed by the Academy.

Sec. 2. They shall cause to be published such transactions of the Academy as they may see fit.

Sec. 3. They shall secure the delivery of public lectures when, in their opinion, it may be expedient.

Sec. 4. They shall appoint and remove at pleasure, all agents and employees of the Academy, prescribe their compensation and fix their duties.

Sec. 5. They shall fill all vacancies in the Board; and members thus elected shall hold office until the next annual meeting of the Academy.

Art. VI. WRITTEN COMMUNICATIONS.

All memoirs and written communications made to the Academy at its regular meetings, by any of its members, shall be preserved in the records of the Academy.

Art. VII. MEMBERSHIP.

Section 1. Any person may be elected to active membership by a vote by ballot of two-thirds of all the members present at any regular meeting, after the payment of the required initiation fee and on being recommended in writing by three members, and may participate in the meetings, and shall enjoy the privileges of such membership only upon signing the constitution.

Sec. 2. Persons non-resident in the cities of Minneapolis or St. Paul, but resident within the State of Minnesota, may be elected active members on the payment of an initiation fee of one dollar. Members non-resident in Minnesota are exempt from all dues.

Sec. 3. A life-membership shall be conferred on all members of the Minnesota Academy of Science who contribute the sum of one hundred dollars.

Sec. 4. The annual dues of the Academy shall be $3.00, except for non-resident members, whose dues shall be $1.00.

Sec. 5. Any member six months in arrears for dues shall become a suspended member, Provided, the Secretary shall have given two months 'notice by mail or otherwise; and such member shall remain suspended until all dues are paid.

Art. VIII. ORDER OF BUSINESS.

The Order of Business at the regular meetings of the Academy shall be as follows:

1. Reading the minutes of former meeting.
2. Communications.
3. Reports of committees and of chairmen of sections.
4. Miscellaneous business.

Art. IX. AMENDMENTS.

These By-Laws may be amended at any regular meeting of the Academy on one month's notice in writing. Such amendment must be unitedly proposed by three members.

LIST OF MEMBERS, DECEMBER, 1910.

Aiton, Geo. B., 1601 University Av., Minneapolis.
Allen, E. F., Minneapolis.
Andrews, Geo. C., University and 26th, S. E., Minneapolis.
Angle, Dr. E. H., St. Louis, Mo.
Appleby, Dean W. R., University of Minnesota, Minneapolis.
Arndt, Prof. E. L., 1280 St. Anthony Av., St. Paul.
Aurness, Dr. P. A., 420 Syndicate Arcade, Minneapolis.
Avery, L. B., Normal School, St. Cloud, Minneapolis.
Baker, Prof. H. S., St. Paul.
Ballard, C. A., Moorhead.
Bartleson, C. J., 712 N .Y. Life Bldg., Minneapolis.
Batchelder, Prof. L. H., Hamline University, Hamline.
Benner, Franklin, Minneapolis.
Bennett, R. M., Minneapolis.
Berkey, Dr. Chas. P., Columbia University, New York.
Bierbauer, Bruno, Mankato.
Bond, C. E., Minneapolis.
Bourns, Dr. Frank S., Manila, P. I.
Bradford, James E., Minneapolis.
Brown, Dr. E. J., 39 Syndicate Blk., Minneapolis.
Bryant, J. C., 1265 Laurel Ave., St. Paul.
Burchard, H. F., Minneapolis.
Butters, Dr. F. K., University of Minnesota, Minneapolis.
Butler, Nathan, 1619 7th St. S. E., Minneapolis.
Calhoun, J .F., 1611 Dupont Av. S., Minneapolis.
Calvin, Prof. S., Iowa City, Iowa.
Chaney, Prof. L. W., Carlton College, Northfield.
Channell, S. P., Minneapolis.
Child, S. R., 816 Lumber Exchange, Minneapolis.
Christianson, Prof. Peter, University of Minnesota, Minneapolis.
Clifford, Miss Julia B., East High School, Minneapolis.
Cook, John H., 906 N. Y. Life Building, Minneapolis.
Corbett, Dr. J. Frank, 2 Syndicate Blk., Minneapolis.
Countryman, Miss Gratia, Librarian, Public Library, Minneapolis.
Cox, U. S., Mankato.
Decker, W. F., 304 Andrus Bldg., Minneapolis.
Dorsett, C. M., 51 South Eighth St., Minneapolis.
Dunsmoor, Dr. F. A., 100 Andrus Bldg., Minneapolis.
Eddy, Prof. H. T., University of Minnesota, Minneapolis.
Elftman, Dr. A. H., Tonapah, Nev.
Fellows, C. S., 1813 Vine Place, Minneapolis.
Franzen, J. W., Curator Academy of Science, Museum, Public Library Bldg., Minneapolis.
Foss, Miss Elizabeth, North High School, Minneapolis.
Frost, W. D.
Gale, Edward C., 800 Security Bank Bldg., Minneapolis.
Gale, Harlow, 810 Sykes Bldg., Minneapolis.
Gale, Samuel C., 68 So. 11th St., Minneapolis.
Gill, J. H.

Glascoe, Paul M.
Gordon, H. L., Los Angeles, Cal.
Grant, Dr. U. S., Northwestern Univ. Evanston, Ill.
Griffin, L. E.
Hafer, Claud, La Luz Est de Guanajuato, Mexico.
Hall, Prof. C. W., University of Minnesota, Minneapolis.
Halverson, Oscar, Two Harbors.
Hanscom, Dr. Walter C., 901 20th Ave., N. Minneapolis.
Harris, Frank J., La Crescent.
Harmon, F. E.
Harper, Prof. D. N., Agricultural Experiment Station, St. Anthony Park.
Hawley, John B., Minneapolis, Minn.
Holzinger, Prof. John M., Winona.
Hone, Miss Daisy, 1034 15th Ave. S. E., Minneapolis.
Hortvet, Julius, 45 Barton Ave., Minneapolis.
Hosmer, J. K., 101 St. Botolph St., Boston, Mass.
Hoveland, H. B., Duluth, Minn.
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