PROFESSOR WILLIAM H. PETTEE.

SEVENTH REPORT

OF

THE MICHIGAN ACADEMY OF SCIENCE

CONTAINING AN ACCOUNT OF THE ANNUAL MEETING

HELD AT

ANN ARBOR, MARCH 30, 31, AND APRIL 1, 1905.

PREPARED UNDER THE DIRECTION OF THE COUNCIL

BY

CHARLES E. MARSHALL
SECRETARY

AND

WALTER G. SACKETT
ASSISTANT SECRETARY

BY AUTHORTY

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SEVENTH REPORT

OF

THE MICHIGAN ACADEMY OF SCIENCE

LETTER OF TRANSMITTAL

To Honorable Fred M. Warner, *Governor of the State of Michigan:*

Sir—I have the honor to submit herewith the Seventh Annual Report of The Michigan Academy of Science for publication in accordance with Section 14 of Act No. 44 of the Public Acts of the Legislature of 1899.

Respectfully,

Charles E. Marshall,

Secretary of The Michigan Academy of Science.

Agricultural College, May 5, 1905.

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CONSTITUTION

OF

THE MICHIGAN ACADEMY OF SCIENCE.*

ARTICLE I.

This Society shall be known as "THE MICHIGAN ACADEMY OF SCIENCE."

ARTICLE II: OBJECTS.

The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science.

ARTICLE III: MEMBERSHIP.

The Academy shall be composed of *Resident Members, Corresponding Members, Honorary Members and Patrons.*

1. Resident Members shall be persons who are interested in scientific work and resident in the State of Michigan.
2. Corresponding Members shall be persons interested in science, and not resident in the State of Michigan.
3. Honorary Members shall be persons distinguished for their attainments in science, and not resident in the State of Michigan, and shall not exceed twenty-five in number.
4. Patrons shall be persons who have bestowed important favors upon the Academy, as defined in Chapter I, Paragraph 4 of the By-Laws.
5. Resident Members alone shall be entitled to vote and hold office in the Academy.

ARTICLE IV: OFFICERS.

1. The officers of the Academy shall consist of a President, a Vice President of each Section that may be organized, a Secretary, and a Treasurer.

These officers and all past presidents shall constitute an Executive Committee, which shall be called the *Council.*

2. The PRESIDENT shall discharge the usual duties of a presiding officer at all meetings of the Academy, and of the Council. He shall take cognizance of the acts of the Academy and of its officers, and cause the provisions of the Constitution and By-Laws to be faithfully carried into effect. He shall also give an address to the Academy at the closing meeting of the year for which he is elected.
3. The duties of the President in case of his absence or disability shall be assumed by one of the Vice-Presidents who shall be designated by the Council.

The VICE-PRESIDENTS shall be chairmen of their respective Sections. They shall encourage and direct research in the special branches of science included within the Sections over which they preside.

4. The SECRETARY shall keep the records of the proceedings of the Academy, and a complete list of the members, with the dates of their election and disconnection with the Academy. He shall also be the Secretary of the Council.

The SECRETARY shall co-operate with the President in attending to the ordinary affairs

*The history of the Academy will be found in full in the First Annual Report.

of the Society. He shall attend to the preparations, printing and mailing of circulars, blanks, and notifications of elections and meetings. He shall superintend other printing ordered by the Academy, or by the President, and shall have charge of its distribution under the direction of the Council.

The SECRETARY, unless other provision be made, shall also act as *Editor* of the publications of the Academy and as *Librarian* and *Custodian* of property.

5. The TREASURER shall have the custody of all funds of the Academy. He shall keep an account of receipts and disbursements in detail, and this account shall be audited as hereinafter provided.

6. The Academy may elect an *Editor* to supervise all matters connected with the publication of the transactions of the Academy, under the direction of the Council, and to perform the duties of Librarian until such time as the Academy shall make that an independent office.

7. The COUNCIL is clothed with executive authority, and with the legislative powers of the Academy in the intervals between the latter's meetings; but no extraordinary act of the Council shall remain in force beyond the next following stated meeting, without ratification by the Academy. The Council shall have control of the publications of the Academy, under the provisions of the By-Laws and of the resolutions from time to time adopted. It shall receive nominations for members, and on approval, shall submit such nominations to the Academy for action. It shall have power to fill vacancies *ad interim*, in any of the offices of the Academy.

8. TERMS OF OFFICE. The *President* and *Treasurer* shall be elected annually, and shall not be eligible to re-election for an interval of three years after retiring from office. The *Vice Presidents*, *Secretary*, and the *Editor* shall be elected annually and be eligible to re-election without limitation. [Section 8 was amended April 1, 1898, to read as follows: The President, Vice Presidents, Secretary, Treasurer, and Editor shall be elected annually, and be eligible to re-election without limitation.]

ARTICLE V: VOTING AND ELECTIONS.

1. All *elections* shall be by ballot. To elect a Resident Member, Corresponding Member, Honorary Member, or Patron or impose any special tax shall require the assent of three-fourths of all Resident Members voting.

2. Any member may be expelled by a vote of nine-tenths of all members voting, provided notice that such a movement is contemplated be given at a meeting of the Academy three months previous to such action.

3. ELECTION OF MEMBERS. Nominations for Resident membership shall be made by two Resident Members, according to a form to be provided by the Council. One of these Resident Members must be personally acquainted with the nominee and his qualifications for membership. The Council shall submit the nominations received by them, if approved, to a vote of the Academy at a regular meeting.

4. ELECTION OF OFFICERS. Nominations for office shall be made by the Council as provided in the By-Laws. The nominations shall be submitted to a vote of the Academy at its winter [Annual] meeting. The officers thus elected shall enter upon duty at the adjournment of the meeting.

5. At the meeting in which this Constitution is adopted the officers for the ensuing year shall be elected in such manner as the Academy may determine.

ARTICLE VI: MEETINGS.

1. The Academy shall hold at least two stated meetings a year—a *Summer* [*or Field*] *Meeting*, and a *Winter* [*or Annual*] *Meeting*. The date and place of each meeting shall be fixed by the Council, and announced by circular at least three months before the meeting. The programme of each meeting shall be determined by the Council, and announced beforehand, in its general features. The details of the daily sessions shall also be arranged by the Council.

2. All members must forward to the Secretary, if possible, before the convening of the Academy, full title of all papers which they propose to present during the meeting, with a statement of the time that each will occupy in delivery and a brief abstract of their contents. From the abstracts thus presented, the Council will determine the fitness of the paper for the programme.

3. This section stricken out April 1, 1898.

4. SPECIAL MEETING of the Academy may be called by the Council, and must be called upon the written request of twenty Resident Members.

5. STATED MEETINGS OF THE COUNCIL, shall be held coincidently with the stated meetings of the Academy. Special meetings of the Council may be called by the President at such times as he may deem necessary.

6. QUORUM. At meetings of the Academy a majority of those registered in attendance shall constitute a quorum. Four members shall constitute a quorum of the Council.

ARTICLE VII: PUBLICATIONS.

The publications of the Academy shall be under the immediate control of the Council, but the Council shall accord to each author the right, under proper restrictions, to publish through whatever channel he may choose.

ARTICLE VIII: SECTIONS.

1. Members not less than eight in number may by special permission of the Academy unite to form a Section for the investigation of any branch of science. Each Section shall bear the name of the science which it represents, thus: The Section of (Agriculture) of The Michigan Academy of Science.

2. Each Section is empowered to perfect its own organization as limited by the Constitution and By-Laws of the Academy.

ARTICLE IX. AMENDMENTS.

This Constitution may be amended at any Winter [Annual] meeting by a three-fourths vote of all the Resident Members present.

BY-LAWS.

CHAPTER I: MEMBERSHIP.

1. No person shall be accepted as a Resident Member unless he pay the dues for the year, within three months after notification of his election. The annual dues shall be one (1) dollar, payable on or before the annual meeting in advance; but a single pre-payment of twenty-five (25) dollars shall be accepted as commutation for life.

2. The sums paid in commutation of dues shall be invested, and the interest used for the ordinary purposes of the Academy during the payer's life, but after his death the sum shall be covered into the Research Fund.

3. An arrearage in payment of annual dues shall deprive a Resident Member of the privilege of taking part in the management of the Academy and of receiving the publications of the Academy. An arrearage continuing over two (2) years shall be construed as notification of withdrawal.

4. Any person eligible under Article III of the Constitution, may be elected Patron upon the payment of one hundred (100) dollars to the Research Fund of the Academy.

CHAPTER II: OFFICIALS.

1. The PRESIDENT shall countersign, if he approves, all duly authorized accounts and orders drawn on the Treasurer for the disbursement of money.

2. The SECRETARY, until otherwise ordered by the Academy, shall perform the duties of Editor, Librarian, and Custodian of the property of the Society.

3. The Academy may elect an ASSISTANT SECRETARY.

4. The TREASURER shall give bonds, with two good sureties approved by the Council, in the sum of five hundred dollars, for the faithful and honest performance of his duties, and the safe-keeping of the funds of the Academy. He may deposit the funds in bank at his discretion, but shall not invest them without the authority of the Council. His accounts shall be balanced on the first day of the Annual Meeting of each year.

5. The minutes of the proceedings of the Council shall be subject to call by the Academy.

CHAPTER III: Election of Members.

1. Nominations for Resident Membership may be proposed at any time on blanks to be supplied by the Secretary.

2. The *form* for the nomination of Resident Members shall be as follows:

In accordance with his desire, we respectfully nominate for Resident Member of The Michigan Academy of Science.

(Full name)

(Address)

(Occupation)

(Branch of Science interested in, work already done, and publications if any)

(Signed by at least two Resident Members)

The form when filled is to be transmitted to the Secretary.

3. The Secretary shall bring all nominations before the Council at either the winter [Annual] or summer [Field] meeting of the Academy, and the Council shall signify its approval or disapproval of each.

4. At the same or next stated meeting of the Academy, the Secretary shall present the list of candidates to the Academy for election.

5. Corresponding Members, Honorary Members, and Patrons shall be nominated by the Council, and shall be elected in the same manner as Resident Members.

CHAPTER IV: Election of Officers.

Section 1. At the Annual Meeting the election of officers shall take place, and the officers elected shall enter on their duties at the end of the meeting.

Section 2. The Council shall nominate a candidate for each office, but each Section may recommend to the Council a candidate for its Vice-President. Additional nominations may be made by any member of the Academy. All elections shall be made by ballot.

CHAPTER V: Financial Methods.

1. No pecuniary obligation shall be contracted without express sanction of the Academy or the Council. But it is to be understood that all ordinary, incidental and running expenses have the permanent sanction of the Academy, without special action.

2. The creditor of the Academy must present to the Treasurer a fully *itemized* bill, *certified* by the official ordering it, and *approved* by the President. The Treasurer shall then pay the amount out of any funds not otherwise appropriated, and the receipted bill shall be held as his voucher.

3. At each annual meeting, the President shall call upon the Academy to choose two members, not members of the Council, to whom shall be referred the books of the Treasurer, duly posted and balanced to the first day of the Annual Meeting as specified in the By-Laws, Chapter II, Paragraph 4. These Auditors shall examine the accounts and vouchers of the Treasurer, and any member or members of the Council may be present during the examination. The report of the Auditors shall be rendered to the Academy before the adjournment of the meeting and the Academy shall take appropriate action.

CHAPTER VI: Publications.

1. The publications are in charge of the Council and under their control, limited only as given by Article VII, of the Constitution.

2. One copy of each publication shall be sent to each Resident Member, Corresponding Member, Honorary Member, and Patron, and each author shall receive fifty copies of his memoir. This provision shall not be understood as including publications in journals not controlled by the Academy. [By recent ruling, authors receive no reprints free. If reprints are wanted the Academy will pay two-thirds if the author pays one-third the cost of printing not to exceed two hundred fifty copies.] (Minutes of 1903.)

CHAPTER VII: The Research Fund.

1. The Research Fund shall consist of moneys paid by the general public for publications of the Academy, of donations made in aid of research, and of the sums paid in commutation of dues according to the By-Laws, Chapter I, Paragraphs 2 and 4.

2. Donors to this fund not Members of the Academy, in the sum of twenty-five dollars, shall be entitled without charge, to the publications subsequently appearing.

CHAPTER VIII: Order of Business.

1. The order of business at the Winter [Annual] Meetings shall be as follows:
(1) Call to order by the Presiding Officer.
(2) Introductory ceremonies.
(3) Statements by the President.
(4) Report by the Council.
(5) Report of the Treasurer, and appointment of the Auditing Committee.
(6) Election of officers of the next ensuing Administration.
(7) Election of Members.
(8) Announcement of the hour and place for the Address of the retiring President.
(9) Necrological notices.
(10) Miscellaneous announcements.
(11) Business motions and resolutions, and disposal thereof.
(12) Reports of Committees and disposal thereof.
(13) Miscellaneous motions and resolutions.
(14) Presentation of memoirs.

2. At an *adjourned session*, the order shall be resumed at the place reached on the previous adjournment, but new announcements, motions and resolutions, will be in order before the resumption of the business pending at the adjournment of the last preceding session.

3. At the Summer [Field] Meeting the items of business under numbers (5), (6), (8), (9), shall be omitted.

4. At any Special Meeting the Order of Business shall be (1), (2), (3), (7), (10), followed by the special business for which the meeting was called.

CHAPTER IX: Amendments.

These By-Laws may be amended by a majority vote of the members present at any regular meeting.

OFFICERS 1905–1906.

President, Prof. W. B. Barrows, Agricultural College.
Secretary-Treasurer, Prof. Charles E. Marshall, Agricultural College.
Assistant Secretary, Walter G. Sackett, Agricultural College.
Librarian, Dr. G. P. Burns, Ann Arbor.
Editor of Bulletin, Dr. Charles E. Marshall, Agricultural College.

Vice-Presidents.

Agriculture, Dr. W. J. Beal, Agricultural College.
Botany, Dr. J. B. Dandeno, Agricultural College.
Geography and Geology, Frank Leverett, U. S. Geological Survey, Ann Arbor.
Sanitary Science, Dr. V. C. Vaughan, Jr., Ann Arbor.
Science Teaching, Dr. E. N. Transeau, Alma.
Zoology, Dr. J. E. Duerden, Ann Arbor.

Council.

The Council is composed of the above named officers and all Past-Presidents, who are as follows:
Prof. W. J. Beal, Agricultural College.
Prof. W. H. Sherzer, Ypsilanti.
Bryant Walker, Esq., Detroit.
Prof. V. M. Spalding, Witch Creek, Cal.
Dr. Henry B. Baker, Lansing.
Prof. Jacob E. Reighard, Ann Arbor.
Prof. Charles E. Barr, Albion.
Prof. V. C. Vaughan, Ann Arbor.
Prof. I. C. Russell, Ann Arbor.
Prof. F. C. Newcombe, Ann Arbor.
Dr. A. C. Lane, State Geologist, Lansing.

ACTIVE MEMBERS OF THE MICHIGAN ACADEMY OF SCIENCE.

April 1, 1905.

(Charter members are marked with an asterisk.)

Resident Members.

Adams, Charles C., Ann Arbor.
Alexander, Samuel, 822 Oakland avenue, Ann Arbor.
Anderson, A. Crosby, Agricultural College.
Bach, Ellen Botsford, Agricultural College.
*Baker, Henry B., A. M., M. D., Lansing.
*Barr, Charles E., 111 Oswego street, Albion.
*Barrows, Walter B., Agricultural College.
*Beal, W. J., Ph. D., Agricultural College.
Bennett, C. W., Coldwater.
Bigelow, S. L., Ann Arbor.
Bissell, John H., Bank Chambers, Detroit.
Blain, A. W., 131 Elmsood avenue, Detroit.
Bogue, E. E., Agricultural College.
Brenton, Samuel, V. S., 121 Alexandrine avenue, Detroit.
Bretz, J. H. Albion.
Brown, F. B., 814 Congress street, Ypsilanti.
Brotherton, Wilfred A., Rochester.
Burnham, Ernest, 509 S. Rose street, Kalamazoo.
Burns, G. P., Ph. D., Ann Arbor.
Calkins, L. D., Central Normal School, Mount Pleasant.
Carhart, W. G., 525 Forest avenue, Ann Arbor.
Carpenter, Janette C., Agricultural College.
Carrow, Flemming, M. D., "The Balms," Detroit.
Carlton, Orlando C., Kalamazoo.
Clark, Herbert L., Ph. D., Olivet.
Clark, L. T., Agricultural College.
Clawson, A. D., Ann Arbor.
Collin, Rev. Henry Park, Coldwater.
*Connor, Leartus, M. D., 91 Lafayette avenue, Detroit.
Cooley, T. B., M. D., Ann Arbor.
Cooper, Wm. F., Box 244, Lansing.
Cooper, Wm. S., 1015 Jefferson avenue, Detroit.
*Courtis, W. M., 449 Fourth avenue, Detroit.
Crane, Augustus W., M. D., Kalamazoo.
Crane, Rev. Caroline Bartlett, Kalamazoo.
Dachnowski, Alfred, 643 S. Thayer street, Ann Arbor.
Dandeno, J. B., Ph. D., Agricultural College.
Davies, Meurig L., Bay City.
*Davis, Charles A., Ann Arbor.
Dawson, Jean, 209 S. Ingalls street, Ann Arbor.
*Dodge, Charles K., Port Huron.
Duerden, James E., Ph. D., Ann Arbor.
Dunbar, Frances J., 322 S. Fifth avenue, Ann Arbor.
Dunphy, George W., V. S., Quincy.
Edwards, S. F., M. S., Ann Arbor.
*Farwell, O. A., 784 Congress street, east, Detroit.
Fuller, W. N., 212 east Williams street, Ann Arbor.
Gelston, Lewis M., Ph. D., 411 E. Washington street, Ann Arbor.
Gilmore, Gertrude A., 27 Charlotte avenue, Detroit.
Goddard, Mary A., 516 Adams street, Ypsilanti.
Golm, H. M., V. S., St. Johns.
Grove, J. M., Hillsdale.
Hagle, Florence, 618 Packard street, Ann Arbor.
*Hall, Asaph, Ph. D., Ann Arbor.
Hang, Bernice L., 1130 Third avenue, Detroit.
Harper, E. H., Alma.
Harter, John C., Jackson.
Harvey, Caroline, 51 Winder street, Detroit.
Harvey, Nathan A., Ypsilanti.
Hibbard, R. P., Ann Arbor.
Hinsdale, W. B., M. D., Ann Arbor.
Holmes, S. J., Ph. D., 523 Packard street, Ann Arbor.
Hornbeck, H. N., Traverse City.
Hubbard, Lucius L., Ph. D., Painesdale.
Hunt, Wm. F., Ann Arbor.
Jamieson, Clara O., Ann Arbor.
Jefferson, M. S. W., A. M., 14 Normal street, Ypsilanti.
Jeffery, J. A. Agricultural College.
Johnson, Ira O., 126 Miami avenue, Detroit.
Jopling, Wm, V. S., Owosso.
Kauffman, C. H., Ann Arbor.
Kiefer, Guy L., M. D., City Board of Health, Detroit.
Kraus, Edward H., Ph. D., 548 Thompson street, Ann Arbor.
*Lane, Alfred C., Ph. D., Lansing.
Leverett, Frank, Ann Arbor.
Loew, Fred A., Agricultural College.
Lombard, Warren P., M. D., Ann Arbor.

Lyons, Albert B., 72 Brainard street, Detroit.
Magee, M. J., Sault Ste. Marie.
Magers, S. D., Ypsilanti.
*Manton, W. P., M. D., 32 Adams street, Detroit.
Marshall, Charles E., Ph. D., Agricultural College.
Marston, Hon. T. F., Bay City.
Mast, Samuel O., Holland.
Murbach, Louis, 950 Cass avenue, Detroit.
Myers, Jesse J., Agricultural College.
*Newcombe, F. C., Ph. D., Ann Arbor.
Notestein, Frank N., Ph. D., Alma.
Novy, F. G., Sc. D. M. D., Ann Arbor.
Pearl, Raymond, Ph. D., Ann Arbor.
Pettee, Edith E., 83 Harper avenue, Detroit.
Pettit, Rufus H., Agricultural College.
Phelps, Jessie, 429 N. Adams street, Ypsilanti.
*Reighard, Jacob, Ann Arbor.
Robison, Floyd W., Agricultural College.
*Russell, Israel C., Ph. D., Ann Arbor.
Ruthven, A. G., 821 E. Ann Street, Ann Arbor.
Sackett, W. G., S. B., Agricultural College.
Sargent, Herbert E., Grand Rapids.
Seaman, A. E., Houghton.
Shaw, R. S., Agricultural College.
*Sherzer, Wm. H., Ph. D., Ypsilanti.
Smith, Charles E., 108 N. Saginaw street, Pontiac.
Sperr, Fred W., Houghton.
*Stearns, Francis L., Adrian.
Streng, Louis H., 335 N. Prospect street, Grand Rapids.
*Strong, E. A., Ph. D., Ypsilanti.
Tanis, J. E.
Thompson, Harriet W., Port Sanilac.
Transeau, A. N., Alma.
Trapwell, A. P.
Vaughan, V. C., Ph. D., M. D., LL. D., Ann Arbor.
Vaughan, V. C., Jr., M. D., Ann Arbor.
Walker, Bryant, 18 Moffat Building, Detroit.
Wallace, Wm. T. Hastings.
Warren, Lewis, E. St. Johns.
*Watkins, Hon. L. Whitney, Manchester.
Wetmore, Mary, M. D., Agricultural College.
*Wheeler, E. S., Jones Building, Detroit.
Wilbur, Cressy L., M. D., Lansing.
*Willson, Mortimer, M. D., Port Huron.
Wood, L. H., Ann Arbor.
Wood, Norman, A., Ann Arbor.
Wright, Hon. L. L., Ironwood.
Wright, Winifred, R., Agricultural College.
Zahorski, Boleslau, Bay City.

Corresponding Members.

Barlow, Bronson, Guelph, Canada.
Bastin, E. S., Chicago, Ill.
Bullock, D. S., Casilla 75, Mishion Aureania, Temuco, Chile, South America.
Cole, Leon J., Cambridge, Mass.
Cowgille, Paul A., Michigan City, Ind.
Hankinson, T. L., Charleston, Illinois.
Horton, Robert E., Utica, N. Y.
Holt, W. P., Toledo, Ohio.
Johnston, J. B., Morgantown, West Virginia.
Lander, Clarence H., Cleveland, Ohio.
Lillie Frank, R.
Longyear, B., Fort Collins, Colorado.
Munson, Wm., R. Winona, Minnesota.
Reed, R. S., Columbia, Missouri.
Smith, Harlan I., New York City.
Worcester, C.
Ward, Henry B., Lincoln, Nebraska.
Wheeler, Charles F., Washington, D. C.
Wolcott, Robert H., Lincoln, Nebraska.

Honorary Members.

Spalding, Prof. V. M., Witch Creek, California.

SUMMARY OF TREASURER'S REPORT.

Year's receipts	\$385 60
Year's expenses	377 47
Balance on hand	\$8 13

WILLIAM HENRY PETTEE.

In preparing a memorial of William Henry Pettee, for so many years a leading member of the faculty of the University of Michigan, I shall have to draw largely upon the memorials prepared by those older than I who had seen more of him.[1] My own acquaintance with him dates only from 15 years ago, when I met him (during the course of one of his tours examining high schools) in Houghton. We talked over the College of Mines in Houghton, which was then less than five years old, and his unselfish point of view struck me very strongly at the time.

In these days when temptation to originality even in error is so strong and ambition for fame as dominant among scientific men as in other walks of life and perhaps more so, it is well that we should commemorate in a way that will make his example tell upon us and upon others the life of one who valued accuracy and correctness above originality and duty above fame and who illustrated the value of broad general culture as well as special knowledge.

He was born January 13, 1838, at Newton Upper Falls, near Boston, Mass., the son of Otis and Matilda (Sherman) Pettee, his father being a cotton manufacturer. He was not very robust and entered college at 19 years of age. He took high rank in the course which was at that time mainly made up of required work and largely classical. He delivered a Latin oration in his junior year and was graduated in 1861. He continued in connection with the University, studying in the engineering subjects in the Lawrence Scientific School, and in the college, where he was also assistant in chemistry. He took his A. M. in 1864. He was chemical assistant from 1863-65, the subject which he had elected in his junior year. He studied in Europe, mainly in Freiberg, from 1865-68, and returned to Harvard, being appointed instructor in mining in 1869 and assistant professor in 1871. He married July 8, 1874, a fellow townswoman, Sybil Anna Clarke. In 1875 he was appointed professor of mineralogy, economic geology and mining engineering at the University of Michigan, and he continued to hold this chair until his death, although the growth of the College of Mines had relieved him of some part of the duty which would naturally fall to the incumbent of this chair, and he had become editor of the University publications, confidential advisor of the Regents, secretary of the University senate, and leading member of the faculty in all University problems.

His first professional field work seems to have been in 1869 in the south part of Colorado, and from 1871 to '80 he was engaged in connection with the California State Geological Survey under J. D. Whitney. From this work came two publications, "Contributions to Barometric Hypsometry," with tables for use in California (1874—a supplement of additions was added in 1878), and the investigations of auriferous gravels, which is published as an appendix to Whitney's report. These publi-

[1] Science July 8, 1904, p. 58. Transactions American Institute of Mining Engineers, Biographical Notice by R. W. Raymond, 1904.

cations are said "to show that careful examination of phenomena, weighing of evidence, and painstaking accuracy, which those best acquainted with Professor Pettee always expect in papers prepared by his hand." He edited the mining and metallurgical terms for the Standard Dictionary.

It may be that the disease of the heart, which has finally brought his earthly career to a close, checked his activity in the field, for he told me of it years ago, had been very painfully conscious of it for many years, and knew that any hour might be his last. The patient and cheerful courage with which he kept on the round of duty under these circumstances is an example to us all. He was prominent in many societies and did some of his most valuable work in that connection. He was a member of the Phi Beta Kappa, American Institute of Mining Engineers, American Association of Advancement of Science, Geological Society of America, American Philosophical Society of Philadelphia, and Michigan Academy of Science, and had held offices in many of these. In particular his association has been intimate with the Mining Engineers of whose transactions he has read the final proof critically for many years. The qualifications for a good proof reader are very high. I often feel my deficiency in this respect. They include a good memory, sound judgment, a very wide range of exact information, patience, a zeal for accuracy, and yet the kind of a mind which will not, in looking out for commas pass unnoticed blunders of sense. It has been said that it takes a poet of the first order to translate a poet of the first order. So to read proof well requires a reader who knows more than the author of the article. In this department, Raymond writes, "He would detect a broken or inverted letter, a column of figures that did not 'add' right, a mistake in a chemical formula or algebraic equation, an incorrect reference or quotation, a blunder in a foreign tongue, or a logical absurdity, obscurity or contradiction—all with equal certainty and precision. Backed by the great library of the University of Michigan, he was absolutely indefatigable in following the trail of the smallest question involving reference, quotation, or statement by one author of the views of another. It was, indeed, a startling revelation to me that, of the passages marked by authors as quotations, he found so many which gave the quoter's notion of the meaning, instead of the exact words of the original. In this, as in all other particulars of the ethics of authorship and scholarship, Prof. Pettee was an unerring and uncompromising authority."

He was a loyal supporter of the church of his choice, and his fidelity to truth was a characteristic that impressed his colleagues. Overstatement, exaggeration, and disproportionate display would be as unfit for him dead as they were to him living, but the societies who have owned him as a member have reason to regret his departure, and when Rossiter W. Raymond speaks of his "unimpaired reason, manifold knowledge, balanced judgment, dauntless perseverance and loyal affection," he was using chosen words weighty with meaning.

A. C. LANE,
Lansing, Michigan.

LIST OF PAPERS PRESENTED AT THE ELEVENTH ANNUAL MEETING OF THE MICHIGAN ACADEMY OF SCIENCE.

Presidential Address—Natural Resources, their Conservation and Compensation, for Necessary Consumption, One Feature of which is a Scientific Search for Substitutes. A. C. Lane, State Geologist.

Annual Address—Old and New Hypotheses of the Earth's Origin. Prof . T. C. Chamberlin, University of Chicago.

1. Outline of a Course in Rural Sociology. Kenyon L. Butterfield, President of State Agricultural College, Rhode Island.
2. Syllabus for an Elementary Course in Economics. W. O. Hedrick, Agricultural College.
3. Syllabus for a Four-year Course in Live Stock Husbandry. R. S. Shaw, Agricultural College.
4. Syllabus for a Four-year Course in Horticulture. U. P. Hedrick, Agricultural College.
5. Social Phases of Agricultural Education. J. L. Snyder, President of Agricultural College.
6. Outline of Topics in Horticulture for some Grades of Common Schools. U. P. Hedrick, Agricultural College.
7. The Place of Agriculture in the Rural Schools. Clarence E. Holmes, Superintendent of State School for Blind, Lansing.
8. School Gardens. F. L. Keeler, Mt. Pleasant.
9. Some Experience in the Management of School Gardens. J. B. Dandeno, Agricultural College.
10. The Preparation of Teachers for the Rural Common Schools. Ernest Burnham, Kalamazoo.
11. The Rural School Museum. C. W. Garfield, Grand Rapids.
12. Planning Courses for Rural Schools. L. H. Bailey, Dean of Agricultural School, Cornell University.
13. Some Lessons Concerning Soils for the Common School. Joseph A. Jeffery, Agricultural College.
14. Geotropic Response of Stems and Roots at Various Angles of Inclination, (10 minutes). F. C. Newcombe, Ann Arbor.
15. Color Stimuli and Plant Functions, (10 minutes). J. B. Dandeno, Agricultural College.
16. A Canker of the Yellow Birch Accompanied by a Nectria, (10 minutes). J. B. Pollock, Ann Arbor.
17. A study of the effect of dilute solutions of Hydrochloric Acid upon the Radicles of Corn Seedlings, (5 minutes). F. A. Loew, Agricultural College.
18. The Toxic Action of Copper Sulphate upon Certain Algae, in the Presence of Foreign Substances, (5 minutes). Ellen B. Bach, Agricultural College.
19. The Relation of Bacteria to Plant Food, (15 minutes). Walter G. Sackett, Agricultural College.
20. Michigan Fungi Not Previously Listed in the Reports of the Michigan Academy of Science, (15 minutes). J. B. Pollock and C. H. Kauffman, Ann Arbor.
21. Sexual Reproduction in a Red Alga, (Calithamnion Baileyi), (15 minutes). R. P. Hibbard, Ann Arbor.
22. Vitality of Seeds after Twenty-five Years, (5 minutes). W. J. Beal, Agricultural College.
23. Polystictus Hirsutus as a Parasite on Mountain Ash, Maple and Carpinus, (10 minutes). J. B. Pollock, Ann Arbor.
24. Notes on Ganoderma (Fomes) Sessile, Murrill, its Variation from the Original Description and Possible Parasitism (10 minutes). J. B. Pollock, Ann Arbor.
25. Preparations for Dissecting Pans (5 minutes). S. O. Mast, Holland, Mich.
26. Relation of Peat Development to Depth of the Water in Post-Glacial Lakes (15 minutes). G. P. Burns, Ann Arbor.

27. A Study of Plants in Ravines near Adrian (15 minutes). Frances Stearns, Adrian.
28. Plant Distribution in a Small Bog (15 minutes). Edith Pettee, Detroit.
29. Ravines in the Vicinity of Ann Arbor. (An Abstract) (10 minutes). Alfred Dachnowski, Ann Arbor.
30. History of Ecological Work (30 minutes). H. S. Reed, University of Missouri, Columbia, Mo.
31. A Remarkable Floral Reversion Caused by Bud-Grafting and A Southern Plant New to the Hitherto Known Flora of Michigan, Found Growing at Ann Arbor (20 minutes). S. Alexander, Ann Arbor.
32. A Series of Hormodendrum Parasitic on the Arenaria (10 minutes). J. B. Pollock, Ann Arbor.
33. Changes of Level at the West End of Lake Erie, (30 minutes). E. L. Moseley, Sandusky, O.
34. Relation of Lake Whittlesey to the Arkona Beaches, (20 minutes). Frank B. Taylor, Fort Wayne, O.
35. Occurrence and Distribution of Celestite-bearing Rocks, (15 minutes). Edward H. Kraus, Ann Arbor.
36. Glaciers of British Columbia, slides, (20 minutes). W. H. Sherzer, Ypsilanti.
37. Drumlin Areas in Northern Michigan, slides, (20 minutes). I. C. Russell, Ann Arbor.
38. Interglacial Lake Clays of the Grand Traverse Region, (15 minutes), Frank Leverett, Ann Arbor.
39. Beach Cusps, slides, (15 minutes). M. S. W. Jefferson, Ypsilanti.
40. Origin of the Sulphur Deposits at Woolmith Quarry, Monroe Co., Mich., (15 minutes.) Edward H. Kraus, Ann Arbor.
41. The War Against Tuberculosis. V. C. Vaughan, Dean of the Medical School, Ann Arbor.
42. Bird Hematozoa. F. G. Novy, Ann Arbor.
43. Subject to be announced later. E. E. Butterfield, Ann Arbor.
44. Am I My Brother's Keeper? Henry B. Baker, Lansing.
45. The Scientific Necessity of Complete Registration of Vital Statistics. Cressy L. Wilbur, Lansing.
46. Tryptophan Media. S. F. Edwards, Ann Arbor.
47. Technical Cultural Manipulation of Rhizobium. L. T. Clark, Agricultural College.
48. Staining by the Romanowsky Method. H. N. Torrey, Ann Arbor.
49. The Steam Still. Bronson Barlow, Guelph, Ont.
50. The Relation of the Bacterial Content to the Ripening of Michigan Cheese. W. R. Wright, Agricultural College.
51. Some Bacterial Hemolysins. T. B. Cooley, Ann Arbor.
52. The Action of the Intra-Cellular Poison of the Colon Bacillus. V. C. Vaughan, Jr., Ann Arbor.
53. The Extraction of the Intra-Cellular Poison of the Colon Bacillus. Sybil May Wheeler, Ann Arbor.
54. The Germicidal Action of Fruit Juices upon Certain Pathogenic and Non-Pathogenic Bacteria. Mary Wetmore, Agricultural College.
55. Disinfection by means of Formalin and Potassium Permanganate. James C. Cumming, Ann Arbor.
56. Bacterial Products in Milk and Their Relation to Germ Growth. Charles E. Marshall, Agricultural College.
57. Anthrax-Like Bacilli. D. J. Levey, Ann Arbor.
58. The Action of the Intra-Cellular Poison of the Pneumococcus. Fred Munson, Ann Arbor.
59. Elementary Field Work,—Aims and Methods (40 minutes). I. B. Meyers, School of Eductaion, University of Chicago.
60. Discussion (20 minutes). Opened by L. H. Bailey, Cornell University.
61. Aims and Methods of Physiography Field Work in Secondary Schools (20 minutes). M. S. W. Jefferson, State Normal College.
62. Discussion (15 minutes). Opened by R. D. Calkins, Central Normal School.
63. Aims and Methods of Zoological Field Work in Secondary Schools. (30 minutes). C. E. Adams, University of Michigan.
64. Discussion (15 miuntes). Opened by Miss Jessie Phelps, State Normal College.
65. Aims and Methods of Botanical Field Work in Secondary Schools (45 minutes). Illustrated with lantern. H. C. Cowles, University of Chicago.
66. Discussion (15 minutes). Opened by E. L. Moseley, Sandusky High School.
67. Field Work in Botany for the Winter Season (10 minutes). J. Harlan Bretz, Albion College.

68. Natural History Notes from the Hawaiian Islands.
   (a) Role of Mucus in Corals
   (b) Commensalism of Crab and Actinian } J. E. Duerden, Ann Arbor.
69. The Value of the Pedicellariæ in the Taxonomy of Sea-urchins. Hubert Lyman Clark, Olivet College.
70. The Static Function in Some Crustacea, (15 minutes). L. Murbach, Detroit.
71. An Ecological Study of Physa. Miss Jean Dawson, Ann Arbor.
72. Light Reactions of Stentor, (30 minutes). S. O. Mast, Hope College.
73. The Reflex Theory of Phototaxis. S. J. Holmes, Ann Arbor.
74. Variation in the Blue Racer, (15 minutes). C. C. Whittaker, Olivet College.
75. The Nervous System of Coenopsammia. Miss S. A. Ayres, Ann Arbor.
76. Some Results of a Study of Variation in Paramecium. Raymond Pearl and Frances J. Dunbar, Ann Arbor.
77. Some Results of a Study of Correlation in the Crayfish. A. B. Clawson, Ann Arbor.
78. Demonstration of Hawaiian Corals. J. E. Duerden, Ann Arbor.
79. The University Museum Expedition to Northern Michigan.
   a. Introductory Remarks. Charles C. Adams, Ann Arbor.
   b. An Ecological Survey in the Porcupine Mountains and Isle Royale. A. G. Ruthven, Ann Arbor.
   c. Ecological Distribution of the Birds of the Porcupine Mountains. Otto McCreary, Ann Arbor.
   d. Annotated List of the Mollusca of the Porcupine Mountains and Isle Royale. Bryant Walker and A. G. Ruthven, Detroit and Ann Arbor.
   e. Annotated List of the Birds of the Porcupine Mountains.
      N. A. Wood, M. M. Peet, and O. McCreary, Ann Arbor and Ypsilanti.
   f. Annotated List of the Birds of Isle Royale.
      N. A. Wood, M. M. Peet, and O. McCreary, Ann Arbor and Ypsilanti.
80. The distribution of Polygyra in Michigan.
   Bryant Walker, Detroit.
81. The Ophidia of Michigan. Frank N. Notestein, Alma College.
82. A Summary of the Work hitherto done on Michigan Herpetology.
   Morris Gibbs, Olivet College.
83. The Distribution of the Blue Racer and Rattlesnake in Michigan. (With maps. 10 minutes.)
   Hubert Lyman Clark, Olivet College.
84. A Provisional List of the Amphibia and Reptilia of Michigan. (15 minutes).
   Morris Gibbs, H. L. Clark, and Frank N. Notestein, Olivet College and Alma College.
85. The Status of Entaenia Brachystoma.
   C. C. Whittaker, Olivet College.
86. Variation of Land and Water Temperatures. W. F. Cooper, Lansing, Mich.
87. Climatic Centers and Centers of Plant Distribution. E. N. Transeau, Alma, Mich.

NATURAL RESOURCES, THEIR CONSUMPTION AND CONSERVATION.

A. C. LANE.

In these days of evolutionary theories and dominance of biology it has become fashionable to apply the analogies and language of biology in other fields,—for the geographer to speak of mature rivers, and youthful drainage; and the sociologist and historian to speak of society and nations as organisms. So, without going so far as to assume that there are units of consciousness apart from brains, and that there is an American or Michigan consciousness (standing in somewhat the same relation to your consciousness and my consciousness as ours, it may be supposed, to the sensitiveness which may belong to each individual cell of our body), we may still accept the comparison of the nation or state to that of an organism so far as it may help us to remember and collate real facts.

The youth of a people is in reality like that of a man, full of hope, extravagant, feeling boundless resources, and inclined recklessly to squander them in attaining the objects of desire. If it is wisely guided age may bring mature judgment, more careful and conservative expenditure, and riches which are not merely in prospect but in possession, which are the fruits of useful industry and the relics and mementoes of a noble ancestry. Unwisely guided, age may bring the exhaustion of the resources thought to be boundless, with nothing worth while to show for them; and as the individual man may be found bankrupt in purse and pride, so the nation or community may suddenly find its supposedly inexhaustible supplies exhausted, the fabulous fertility of its fields failing, its hills once clad in forests naked and seamed and gashed by gullies until they remind one of the beggar's clothes whose spendthrift habits have dragged him down to like depths of destitution.

Mill[1] says that "looking on the world as not only the home of man, but as subservient in all its phenomena to the welfare of the human race, we may consider the development of any region to mean such treatment of its natural resources as will enable the land to continue to support an increasing number of inhabitants," and ventures the suggestion that "fortune hunting is inimical to development in its true sense. A fortune acquired through production or speculation can usually be made by only a few individuals and almost always entails the exhaustion of natural resources or the lowering of wages; a prosperous livelihood, on the other hand, can often be secured to a multitude without permanent impoverishment of the land."

The former statement we may consider a very fair definition of development of a country. The latter is one of those general statements which are hard to disprove, being both vague and qualified. But it suggests that there may be such a thing as improper development. Much talk and

[1] Hugh R. Mill, New Lands, p. 7.

writing seems based on the theory that development is always and only good—is a good in itself. This we may fairly question. Legislation has too often been but the application of formidable locks, bolts and bars to the door of an empty stable.

It is fit, then, to consider what is the path of wisdom, what is that true development of our natural resources which scattereth and yet increaseth, and what is that development which may better be called devastation, whose scattering is not that of the seed corn which returns many fold, but that of the whirlwind and tornado? How may we best conserve our resources and how secure adequate compensation for that consumption which is necessary? These are questions in which we have an interest, as scientists studying either the face of nature or the course of history, as patriots desiring the welfare of our country, and as parents desiring to pass on unimpaired the patrimony that has come down to us.

In the first place let us note that the development of national resources does not in all cases imply consumption. It is true that you cannot eat your cake and have it, too, but it is also true that you can use your house, that you can see your picture, and gaze at your statue, and they be none the worse for it.

Italy and Greece are wealthier today than they would have been had the marble of their statues remained in the quarries of Paros or Carrara, for the marble still in the quarry has not the value that it has piled up in the Parthenon. Every Milton who dies mute, inglorious, but who might have sung immortal verse is a loss and waste, most of course to the higher and spiritual interests of the nation, but also to the commercial interests as well. I do not know how much cash loss of trade it would be to Stratford-on-Avon had Shakespeare lived and died there without knowing letters, but I do know that the American pilgrims to the footsteps of great men gone before us leave in Italy every year hundreds of thousands of dollars.[1]

So the fact that the Republican party was born in Jackson meant many dollars to many Jackson people about a year ago. Thus a development of our natural resources which means merely turning material into more valuable, artistic shape, or surrounding it with inspiring associations—such development is pure gain and no loss, so long at least as we do not bury living prophets under the tombs of their forerunners or shackle the present with reverence for the past.

Schools and professional feeling which help the workman to become the artizan, to put individuality into his work and feel a pride in it, are thus directly helping the prosperity of the commonwealth and money spent in the production and education of men who serve mankind and whose footsteps will be gazed upon with reverence by coming generations is money well spent. Again, insofar as work of artistic value is expended upon material which is retained in the State, there is a definite increase in the wealth of the State. This accumulation of wealth may be either by the importation of art from abroad or by turning our own material into art forms. Particularly is this true of architecture and of furniture which is worthy to descend as heirlooms from father to son.[2] The accumulation within the State of Art treas-

[1] "Last year was a record breaker, and Americans paid $35,379,050 for ocean steamship fares from New York alone. It is claimed that Americans spent four times as much as their fares while abroad, and that makes a total of $131,516,000 spent in Europe and other parts of the old world last year, by people who sailed from New York."

[2] The money spent in making dollar chairs is no permanent gain to the community. A Chippendale sofa on the other hand is worth more than ever.

ures, that is to say of fine work in fitting material, is therefore a means of increasing the wealth of the State.

In the second place I would call attention to the resources of which there is a continuous and transitory supply in contrast to those of which there is a stock in the use of which we are drawing on an original supply or the accumulation of generations. The farmer's windmill in using wind power is using a resource of the former class, while the use of coal is drawing on a reserve.

Farm products so far as they are due to air, water, sunshine and hard work and but mint the golden sunshine into golden grain, which is converted into golden coin, are a development of resources continuously supplied. But there is also a little ash or mineral matter which if not replaced by manure or fertilizer is a draft upon the capital of the commonwealth.

Most important perhaps of these resources in this state is the water power, which is indeed largely used, but of which there are thousands of horse power going to waste in our streams. Any permanent, substantial dams which may help us to utilize this, as it is proposed that the power of the Huron shall be utilized, will be a permanent gain to the resources of the state. So again topographic maps which may help us to recognize this, or the work which Mr. Horton is superintending in gaining accurate knowledge of the wealth of water power, so much of which is as yet unutilized, is a direct provision for the day of exhausted coal.

Thirdly and of most interest to our theme are the resources which are wasting away in the use. As we gaze on a piece of soft coal across the cleavage we shall see dozens of alternating bright and dull bands in an inch. Each of these may represent an annual or semi-annual change of climate and a ton of coal may represent 60 tons of wood. Thus in using coal we are dissipating in a few years the accumulations of generations heaped up millions of years ago.

Now of these reserve accumulations, there is, and I cannot emphasize the fact too strongly, there is never an inexhaustible supply. People a scant half century ago used to talk of the inexhaustible supplies of pine in the Saginaw. There is now hardly a stick standing. Men prate of inexhaustible mines. The bottom of perhaps the greatest mine in the world, the Calumet & Hecla, on its conglomerate is much too visible. Of course sometimes the supplies are in a way practically inexhaustible. The salt of Michigan, if the present rate of production of two billion pounds a year is not too greatly exceeded, probably might last some two million years. Yet the consumption will increase, we know not how much, and a much less time and amount would threaten the collapse of Detroit beneath Lake Erie.

They talked only a few decades ago of inexhaustible supplies of iron ore, and yet now a pretty well posted man says there is in sight but 30 or 40 years supply of ore—that is now merchantable I presume he means. I would double that and say that at the present rate of consumption of some 23,000,000 tons a year there is probably enough (for, in fact, I think the steel trust alone owns over a billion tons of ore in Michigan and Minnesota) for 80 years' consumption. Still that is not a very long time, in the life of a nation.

One thing must be noted in regard to this matter of exhaustion. It is rare that a resource supposed to be inexhaustible comes so sharply and entirely to an end as the pine of the Saginaw valley (the American Lumberman says that pine is on the toboggan), or the countless herds of Buffalo of the western plains, which were sharply wiped out between 1877 and 1887, so that the buffalo coats which the street car men wore when I was a sub-freshman were a luxury of the rich when I was graduated. Usually as the cost increases it tends to cut down the consumption until a certain balance, depending upon available substitutes, is attained, and so the price slowly rises and consumption keeps on decreasing. That is the way in which our anthracite coal fields, and the British coal and iron ores are becoming exhausted. Moreover in many cases there may be both an accumulated stock and a continuous supply. For instance, it is so to a certain extent with our forests. The magnificent growth the pioneers found here was an accumulated stock. But in many countries forests, like the farmer's wood lot here, are looked to for a continuous supply. We must soon be in that case. Originally the great white pine belt extended over 400,000 square miles and there may have been 700 billion feet of it at the beginning, say in 1851. By 1901 there was but 110 billion feet, which was going at the rate of 7 billion a year. So within 10 years there will be no more white pine—it will be hemlock, jack-pine, anything. As the annual consumption in the United States is some 25 billion cubic feet, and the total forest area of the United States is some 500 million acres, from which American lumbering practice will only get 420 board feet per acre a year, it is obvious that even though we improve to the standard of the German practice of 660 board feet per annum we must still either reforest large areas or find substitutes. It is difficult to see the national economy of rushing through our timber pell-mell at a low price and then buying that of our neighbor, Canada, at a high price.

Beside stored up treasures of wood and coal the loss by extermination of any animal or plant is one which may indeed be small, but may easily be irreparable. The last survivor of those flocks of wild pigeons which once darkened the sun seems to have winged his solitary way to that bourne whence no traveller returns, which the fowler's eye may vainly strain to discern. The same thing is almost true of the wood-duck. Logging operations have absolutely cleared many a stream of trout, and it might easily be that grayling, whitefish and sturgeon would become as unknown as the wolverine in the Wolverine State. The gain or loss of all this or of preventing these exterminations I am not prepared to state. I presume in some exterminations like those of the rattlesnake and the wolf there is a distinct gain. But it is not well that we should let these exterminations of our animal neighbors go on in sheer heedlessness, but take some pains to preserve and propagate those most valuable. A great body of laws on game preservation and fish culture show that we realize something of this. Yet I venture to say that we still know far less than we might of what animals should be preserved and especially how best to do it, or which of our animal friends are being exterminated and how best to stop it. Many a well meaning action fails in its object because based on imperfect knowledge.

First, then, as regards these exhaustible resources we should know what is happening. Again we should try to make the consumption as little wasteful as possible, so that we may get the full benefit of all that is used. As we shall see, unwise action may almost force extravagance.

Thirdly, we should put the produce to such good use that we may have something to show for the exhausted resources. In particular, then, we should see that so far as possible substitutes are devised and developed.

Now to illustrate the kind of knowledge we should have.

Our marl or boglime beds, which have been used as the base for cement factories have been produced in the past few thousand years, but the lake algae and shells are still busy abstracting lime from the hard water. One thing which it would be interesting to know is how fast our marl beds are growing and how many acres of pond and bog and cubic yards of boglime a company should have, so that when they got around they could begin over again. The state might well encourage such an investigation and also see how fast it could be accumulated by the fittest plants. In the same way with our peat bogs. If peat comes to be a popular fuel, and I believe it will, it will at first be mainly on accumulated peat that we shall draw, but it will also be worth while to know how fast a bog can be made to grow and whether its growth can be stimulated by changes in water level or encouraging appropriate plants. I believe the layers showing the annual rate of increase of depth are in some bogs from an inch in depth near the top to one-twentieth of an inch at the bottom, or say 182 to 3630 cubic feet per acre per year, or between 25 and 50 tons of fuel value per acre. In this case and probably also that of the marl or boglime, it may be only the accumulated stock that can practically be counted as wealth. I would suggest it as a good reason for the commonwealth's economic policy that scientific research be endowed on just these grounds, that when our present coal mines are exhausted we may know where most readily to find new, and when these in turn are but hollow voids some inventor shall have found a storage battery that will turn Ariel from a tricksy sprite to a mighty genius of work and make the windmill as much a source of power as the water wheel.

A Frenchman has recently suggested setting a coal mine on fire and pumping down just enough air to make water gas and then burning this gas as it comes to the surface. If this idea proves feasible it would add untold millions to the wealth of this state in seams which it would not now pay to burn. But in any case by the time our earlier sources of power, lumber waste and coal, are exhausted, we may discover oil and gas, or use our water powers to develop electric heat or grow our own fuel either as four-foot wood or as peat, whichever shall be proven by scientific experiment to be the most economical and be ready with our streams already dammed and copper cables covering the land to furnish more power from water than we now use from coal.

So, again, little by little the unfertilized farm will become less fertile, for in spite of all the care and skill of the Michigan farmer the wheat product per acre of the lower four tiers of counties of Michigan does not bear the same ratio to that of the state that it once did.[1] It is well worth

[1]Average Yield per Acre of Wheat in Michigan.

Year.	State.	Southern four tiers of counties.	Excess.
1876–1880	15.4	17.7	2.3
1881–1885	16.6	16.9	0.3
1886–1890	15.6	15.9	0.3
1891–1895	16.0	16.2	0.2
1895–1900	13.4	13.2	— 0.2

while, therefore, to see, as they do at the Agricultural College, that we are getting our money's worth in buying fertilizer to replace the fertility. It should be worth while to see that we do not squander valuable potash salts in making table salt, or burning lumber waste, etc.

Again, as our forests depart, not only should we cherish what is left, but with the proceeds, before we are left naked, poor and desolate, we should plan to develop substitutes: tile and slate for shingle; cement, sand-brick and stone for building; stone cement and steel bridges for wooden; and paving brick and macadam for cedar block and corduroy. The Bureau of Chemistry of the Department of Agriculture at Washington is hard at work seeking for fibres which may replace the wood pulp.

We may hope that by the time our present iron ores are becoming exhausted our scientific chemists will have found some economic method of smelting leaner ores, or, better yet, of handling that vast bulk of iron ore, of which we now know, that is made refractory by only a few per cent of titanium. Our geologists may have found for us new ranges or extensions of the old ones under the Paleozoic mantle.[1] So, for instance, we might appropriately tax a foreign corporation like the fish trust, catching or buying Michigan fish, for the purpose of supporting our fish commission, which studies our fish and stocks our rivers and lakes, which are not producing a tithe of the fish food they might.

Moreover, as we have said, we should see that the necessary consumption is as little wasteful as possible. Legislation which is such that "we skin through as fast as we can and then throw the land back on the state" is not wise legislation. I am well aware that there are two parties in politics and in economics as to whether the state should hold for itself these natural resources. But if it be granted that the state should put these in the hands of individuals to exploit it is certainly short sighted to then so legislate in the hope of getting back again "unearned increments" by taxation that the individual is tempted or even forced to rush through the development, squandering a large proportion of the resources in order to get the utmost possible returns to himself. It is very easy by legislation to accomplish just this result by taxing not according to the income or return, but according to some fixed valuation, especially if excessive, so that the problem for the individual is to get the utmost income in the shortest time and avoid the most taxes.

In the same way the policy of taxation which leads those with accumulated property to leave the State and transfer the money which they may have made from its resources to some other clime, and their interests to other institutions, will not correct any error which may be supposed to have been made in allowing them to accumulate that wealth in the first place.

It is often proposed to correct and control the excessive accumulation of wealth and the power of wealth by competition but it must be remembered that competition is a most potent source of waste. The different iron ores are used together to produce a maximum amount of iron from a minimum amount of iron ore, because they are all owned by the same parties, regardless of the fact that some of the ores can be produced much more cheaply than others. But if the ore belonged to different parties and there were free and unrestricted competition

[1]Lines of magnetic attraction show that the iron ranges extend down to Green Bay under a thickness of not over 1 000 feet of Paleozoic mantle.

the most cheaply produced ore would crowd the others for a time entirely from the market and would cause a decay of the town supported by their development. I do not think that anyone would consider this desirable, and certainly from the point of view of the geologist there would be a waste of resources.

It is lucky for Michigan that the iron ore of Lake Superior is held by a comparatively few strong corporations, the U. S. Steel Co. having say a billion tons of the Mesabi range and many million tons of the older range. The Mesabi ore is a mere mass of varicolored dirt. I saw five forties last summer said to contain 200,000,000 tons of ore. All that has to be done is to run in trains of ore cars and load it on by steam shovels, after once the layer of clay till, etc., overhead is removed. The huge, yawning, red chasms thus left, when wreathed in the smoke of puffing locomotives and laboring steam shovels, present a volcanic and truly infernal picture. In time some of them will be 400 feet deep and over. The ore, too, is largely of the highest grade. What could any ordinary iron mines do in competition with such, especially those of Michigan where the miners have now all disappeared under ground?

Fortunately, however, it has been found that in the draft of the blast furnace in which these ores are reduced to iron, a good part of this light powdery ore is liable to be blown out if not held down by something more substantial. Moreover a certain amount of some flux must be added to aid the flow of iron, and the silica of some of our Michigan harder ores poorer in iron is admirably adapted to that end. And as the same interests own properties in both States they prefer rather than to let their Michigan properties go to rack and ruin to use a moderate amount of that ore and save wasting their Mesabi ore, even if thereby it is not produced quite as cheaply at the moment. They fix the price and in the long run it will be doubtless better for the community and corporation. More iron will be made with less work, by mining the high grade and low grade ores together, than there would were the high grade ore first run and wasted and then the low grade ore developed. The same thing is true regarding coal. In an era of unrestricted competition only the choicest portions of the best seams would be put on the market provided, as is true, there is a possibility of producing more coal than can be consumed. Customs such as that of paying royalty only on the coal mined may favor wastefulness. If the royalty were per acre foot, it would pay to mine more closely, as I have said in my report on coal. Thus it is for the State's interest that coal royalties should be per ton on coal in the ground, not per ton of coal hoisted. This is practicable and done in some coal fields. In the case of iron ore, too, much property has changed hands on the basis of the ore in the ground as shown by drilling. In the same way in Indiana it has been found necessary to pass laws restricting the waste of gas or oil because in so many cases it was cheaper for the individual to save the one and waste the other regardless of the effect upon the resources of the State or his neighbor's wells. It would seem therefore that in relying upon competition as a cure for the ills of the body politic or in attempting taxation of the "unearned increment" we should not fail to consider carefully the effect of these remedies upon the development or conservation of the natural resources of the State which, once squandered, no financial or political ledgerdemain can restore.

I know that the questions here raised are difficult ones and I know no panacea for all the wastes of the body politic. I might indeed suggest that it seems to me that municipal or State ownership is too often treated as of necessity synonymous with municipal and State operation and exploration. The Boston subway is a good illustration of public ownership and private operation, which apparently works better there than would any other plan just now. I may perhaps remind you, too, that in Mexico all mining is under a system of State leases, and in Canada lumbering. In this commonwealth the policy has in general been for the State to divest itself of the title to its lands, with their resources, even though they could be sold only for a song, and were mainly useful to be cut up into lots to be given away with "free chickens," thus to make work and fees in the process of title registering and tax collecting. Even our State institutions of learning have largely divested themselves of their landed wealth. Would not in many cases a lease for fifty years or longer have been exactly as well? It is a fair question, how far it is wise for a community to let its wealth go permanently out of its own hands, and in particular into the hands of non-residents. Non-resident property owners have been a source of friction ever since the days of the nobleman who let out his vineyard to husbandman and went into a far country. Harvard University years ago, instead of selling Boston real estate outright, had a policy of letting it on a 99 year lease. And of late every now and then a piece of property, like the Adams house, worth a couple of hundred thousand reverts, and is a very welcome addition to their unrestricted funds. It seems to me well worth while to consider whether it would not have been, and even now be, a wise policy for the State and its land owning institutions in regard to land not best suited for homesteads, to have leased the lands for a term of years rather than deeded the property outright. Certainly a lot of land would have come back to them, and kept off that maelstrom of useless expense,—the delinquent tax list. While this I would merely suggest, what I would urge is more careful and intelligent consideration of our waning natural resources, so that before they are gone we may develop substitute products and replacing industries, and that their proceeds may go in part into permanent improvements, and additions to the wealth of the State, stone roads replacing plank roads, stone or cement bridges wooden bridges, stone or cement dams wooden dams.

But of all the wealth that Michigan has possessed I ask anyone to find any that has been better spent for the permanent wealth of the community than that which has been spent on educational institutions. They produce intelligent citizens. They draw into the State an intelligent public which spend much money at the time. Many of them stay here to help build up the State. Their buildings and equipment will be more and more Meccas and permanent objects of interest and attraction and resort. Their scientific researches will help to develop, to save, and to replace our natural resources.

I can picture in my mind two fortunes, and they will be but composite photographs drawn from life. The one is built upon a reckless cutting out of the choicest of lumber, none but the best taken, the brush left around, and fired either purposely or fraudulently to conceal theft. In the path of the first fires is left either a tangled mass of worthless trash, overgrown with bushes and fireweed, ready fuel for a series of conflagrations that sweep through from time to time, or a sandy plain covered with sweet fern and goldenrod, used by Chicago speculators to defraud the settlers who from time to time try to make a livelihood from it.

There are here three wastes, the half crop of timber later burned, the land left in a useless condition, and labor wasted in trying to make it useful.

The logs thus gathered are driven to the mill by a crew of loose livers whose hard earned wages are largely scattered to the dive and brothel in a few weeks. The saw mills devour them and circular saws rip a wide swath of saw dust waste at each cut; piles of slabs, saw dust, and waste of every description are transported in a continuous stream to an ever burning fire whose pillar of cloud by day and fire by night betokens the presence not of Jehovah but of the demon of destruction. The timber itself is shipped east to build up the fame of Michigan pine and the money thus acquired by one who keeps on making money because he does not know what else to do, is squandered by his heirs who by themselves or by those whom they purchase as husbands, scatter it to scandalize two continents.

The forest, the accumulation of generations, and of ages of sunshine, rain and dew, is gone, and there is less than nothing to show for it. This is criminal waste.

Now let us paint a brighter picture. Into the forest go a lot of sturdy pioneers, such as Ralph Connor loves to picture, bent on caring for themselves and their children. The instructions are to cut every green top, and every thing is gathered up, even old half burned logs. Whatever is not otherwise used is used for fuel in making salt, but all that can be used down to stuff that will only make lath or matches or toothpicks is saved and pains are taken to make even the narrow band saw cut as narrow as may be. The land is left ready, if it is good enough, for one of those same sturdy pioneers to take hold of and make a farm that will be the stay of his old age, and the homestead of his children. That best fitted to remain forest returns once more to the State to be reforested.

The lumber goes where it is most needed, but part of it into buildings within the State, of permanent artistic value—a permanent pride and landmark, like the capitol. The fortune thus acquired is expended perhaps in part in reforesting those parts of the tract that are better suited for forest growth than for anything else, and in their fire protection, but those lands hardly worth paying taxes on are deeded to some State institution to which after some years they will be of great value, while in the meantime they are kept off delinquent tax rolls.

Another part of this fortune is employed in permanent improvements, roads and railroads, and in buildings which are a permanent addition to the beauty of the State as well as a memorial of the man who reared them. Another part goes on starting industries and providing education which will open fields of valuable employment and keep alive the town where the fortune is made when lumbering ceases to be the all sustaining occupation.

A part may be employed in exploring for coal, developing peat or water power, drilling for oil, mineral water or other resources to replace those that are vanishing.

The forest then is not wholly gone, and in the place of the part taken are fertile farms, with happy homes, noble buildings, intelligent people and varied industries, and the State is wealthier than ever.

The one picture is as true as the other (Mr. Hackley's fortune illustrates many of the brighter items) though they are put together like one of Thompson Seton's stories, but I hope and think that the brighter picture is the one becoming more true. For this let us all strive as citizens not merely of the kingdom of science and the republic of letters but of the commonwealth of Michigan.

ON THE ORIGIN OF THE SULPHUR DEPOSITS AT THE WOOLMITH QUARRY, MONROE COUNTY, MICH.

EDWARD H. KRAUS.

From the mineralogical standpoint, the Woolmith quarry, half way between Scofield and Maybee, Monroe County, is very interesting on account of the occurrence of a very considerable amount of native sulphur, accompanied by its usual associates, celestite, calcite and sometimes gypsum. It is not necessary to discuss at this time at any great length the geological conditions at this locality, for they are admirably set forth by Sherzer in his "Geological Report on Monroe County."[1]

The rocks at this quarry are for the most part dolomites, sometimes, however, quite siliceous, and have been assigned to the Monroe series. Many of the strata contain a relatively large percentage of bituminous matter. It is also important to state that the strata at or near the surface are usually quite compact and vary much in color—from gray to brown—and are more or less blotched or streaked. These compact layers are characterized by an unusually high specific gravity. Inasmuch as the rock is not homogeneous, different values were obtained. They varied from 2.80 to 3.45. The specific gravity of a normal dolomite ought to be 2.80 to 2.90. This high specific gravity must hence, be considered as indicative of the presence of some mineral, possessing quite a high specific gravity, disseminated throughout the rock.

As we descend into the quarry the rocks become more porous and cavernous. It is in these layers with cavities, ranging from a few inches up to a foot or more in diameter, that the native sulphur with the associates, indicated above, is found. The occurrence of these minerals is clearly one of secondary formation.

The rocks near the surface, although compact where they have been protected, show, when exposed, the characteristic structure of leached celestite-bearing rocks which are quite common in the rocks of this series or its equivalent.[2] This, together with the high specific gravity, already referred to, would suggest the presence of celestite. In order to determine the presence of celestite and also its probable percentage, an analysis of the uppermost layer, characterized by Sherzer as Bed A, was made by Mr. W. F. Hunt, assistant in mineralogy in the University of Michigan.

As already indicated, the rock is by no means homogeneous, and hence, in order to obtain as near as possible the average composition of the same, many chips were taken from a specimen of approximately the following dimensions, 4x5x6 inches. The specific gravity of most of the chips was determined and the following are some of the values obtained: 2.80, 2.87, 2.98, 3.17, 3.33, 3.45.

[1] W. H. Sherzer, "Geological Report on Monroe county," Geological Survey of Michigan, 1900, 75.

[2] E. H. Kraus, "The occurrence of celestite near Syracuse, N. Y., etc.," American Journal of Science, xviii, 30-39, 1904. Also "Occurrence and Distribution of celestite-bearing rocks," ibid, xix, 286-293, 1905.

The methods pursued in this and the following analysis were those recommended by Hillebrand[1] in his treatises on rock analyses. Knowing that much would depend upon the separation of the earth alkalies, the utmost care was exercised in their determination. Their precipitates were in every instance tested spectroscopically and, if necessary, the extraction repeated until in each case they could be considered free from contamination. We may, therefore, regard the results obtained as very accurate. They are as follows:

	Per cent.	Molecular ratio.
SiO_2	0.58	
Al_2O_3 / Fe_2O_3	0.37	
CaO	25.18	.448840
MgO	18.11	.448710
BaO	0.13	.000848
SrO	7.86	.075870
Na_2O	0.11	
K_2O	0.05	
P_2O_5	0.02	
Cl	0.04	
CO_2	39.55	.89886
SO_3	6.33	.079067
Organic Matter	0.92	
H_2S	Trace	
	99.25	

The percentages of the oxides of calcium, magnesium, strontium and barium, together with the carbon dioxide and sulphur trioxide, are important. It is at once noticeable that the amounts of strontium oxide and sulphur trioxide are relatively high. A comparison of the combined molecular ratios of the oxides of calcium and magnesium with that of the carbon dioxide,

$$\left\{ \begin{matrix} CaO & (.44884) \\ MgO & (.44871) \end{matrix} \right\} : CO_2\,(.89886) = 1:1.0014,$$

shows that the rock is a dolomite, and in fact a normal dolomite. We, thus, have quite conclusive evidence that all of the calcium oxide is, doubtlessly, present as a carbonate and not in part as a sulphate.

The unusually large amounts of strontium oxide and sulphur trioxide are extremely interesting. If we consider the small amount of barium oxide present as isomorphous with the srtontium oxide, we obtain the following proportion:

$$\left\{ \begin{matrix} SrO & (.075870) \\ BaO & (.000848) \end{matrix} \right\} : SO_3\,(.079067) = 1:1.0306.$$

These values indicate that the sulphur trioxide is combined with the oxides of strontium and barium, and hence, evidence is at hand that the mineral celestite is present in this uppermost stratum to the extent of 14.32 per cent. The results of the analysis are, therefore, in harmony with what has already been said concerning the structure, specific gravity and so forth, thus indicating that the celestite is present in a disseminated condition, doubtlessly, of primary origin. The very small amount of the combined oxides of aluminium and iron, namely 0.37 per cent, would preclude any appreciable quantity of pyrite or marcasite being present. It is also significant, as will be seen later, that organic matter and a trace of hydrogen sulphide were noted.

In the lower strata as already said, the celestite is found lining the cracks and cavities, and is, of course, of secondary origin.[2] It is with these secondary occurrences of celestite that the native sulphur is found.

Sherzer[3] in discussing the origin of the sulphur at this locality rightly refers the same to the hydrogen sulphide, which is to be observed in considerable quantities not only in the water at this quarry but also in the majority of the wells of that section of the county. Sherzer thought that the hydrogen sulphide might be due to the decomposition of pyrite and marcasite, which are supposed to be present in considerable quantities.

[1]W. F. Hillebrand, Bulletins 148, and 176, U. S. Geological Survey.
[2]E. H. Kraus, "Occurrence and Distribution of Celestite-bearing Rocks," American Journal of Science, XIX, 290, 1905.
[3]W. H. Sherzer, "Geological Report on Monroe County," 212, 213, 1900. Also, American Journal of Science 3rd series, L. 246-248, 1895.

The analysis of the rock from Bed A, however, shows clearly that if the sulphides of iron are present in the uppermost layers, they must be present in amounts which are almost insignificant when compared with that of the celestite. It is also of vast importance to call attention to the fact that, when the rocks of the various layers in this quarry are treated with dilute acid, or even boiled with water, hydrogen sulphide is liberated. To be sure, in some instances the amount is very small but, nevertheless, even a trace is of great import, indicating that a soluble sulphide, no doubt, strontium sulphide, is present. We must, therefore, consider the theory that the decomposition of pyrite or marcasite by the formation and subsequent oxidation of hydrogen sulphide has given rise to the native sulphur at this quarry as untenable.

However, when we consider, first, that the uppermost strata contain about 14 per cent of strontium sulphate, which is quite soluble in water and hence easily transported to the lower layers by the descending waters, and second, that these and the lower strata contain considerable organic matter, and third, that there is only a negligible amount of iron present, and fourth, that hydrogen sulphide is liberated when the rock is treated with acid, it seems evident that the celestite, present in a disseminated condition and which has by the action of the organic matter become partially reduced to the sulphide, must be considered as the source of the hydrogen sulphide.

Hence, if the foregoing statements be true, an analysis of the rock from the more porous and cavernous layers, the cavities of which contain celestite and sulphur, ought to show not only the presence of strontium as a sulphate but also as a sulphide, which would be indicated in the analysis as sulphur trioxide and hydrogen sulphide, respectively.

The following analysis was also made by W. F. Hunt.

	Per cent.	Molecular ratio.
SiO_2	20.14	
Fe_2O_3 Al_2O_3	0.86	
CaO	19.56	.3493
MgO	15.32	.3795
SrO	0.66	.0063706
BaO	0.07	.0004565
H_2S	0.02	.000587
SO_3	0.56	.006994
CO_2	31.94	.7259
Na_2O	0.09	
K_2O	0.07	
Cl	0.03	
Organic[1] matter	10.68	
	100.00	

The sulphur trioxide represents the total amount of sulphur. The hydrogen sulphide was determined directly by liberation with hydrochloric acid, absorbed in potassium hydroxide, acidified and titrated with N-100 iodine.

The silica is present, no doubt, as free silica. The value of the molecular ratios of the oxides of calcium and magnesium, as also that of the carbon dioxide, give rise to the following proportion:

$$\left.\begin{matrix} CaO\ (.3493) \\ MgO\ (.3795) \end{matrix}\right\} : CO_2\ (.7259) = 1.004:1.$$

Hence, this rock may be considered a siliceous dolomite. The sulphur trioxide and hydrogen sulphide indicate that the strontium is present both as the sulphate and sulphide. In this connection, we note that if the hydrogen sulphide be considered as having been derived from strontium sulphide, and further, if that amount of strontium, which is necessary to unite with the sulphur—equivalent of 0.02 per cent hdyrogen sulphide[2]—to form strontium sulphide, be deducted from the value of strontium oxide, given in the analysis the following relationship between the molecular ratios of the strontium oxide and sulphur, trioxide, actually present, is revealed.

$$\left.\begin{matrix} SrO \\ BaO \end{matrix}\right\} : (.0061741) : SO_3\ (.005616) = 1.099:1.$$

These values are so close that we must consider this evidence in support of the above theory as very conclusive, namely, that the celestite, as a source of the sulphur, is parti-

[1]By difference.

[2]Determinations from other portions of this same layer showed as much as 0.12 per cent hydrogen sulphide. The analysis was, however, not complete and, hence, is not given.

ally reduced to strontium sulphide, which, when acted upon by an acid and even by water under some conditions will liberate hydrogen sulphide. Oxidation of the hydrogen sulphide will, of course, then give rise to the sulphur. That the sulphur should be associated with celestite is, hence, self evident.

The enormous deposits of sulphur at Girgenti and vicinity on the Island of Sicily have been explained by some in a manner analogous to the above, namely, by the reduction of gypsum ($CaSO_4$, $2 H_2O$) to the sulphide, and the liberation and subsequent oxidation of hydrogen [1 2] sulphide.

Although the evidence at hand, thus far, seems ample to support the theory advanced, this paper must be considered as merely a preliminary report. The investigations are being continued.

Mineralogical Laboratory,
University of Michigan.

ON THE OCCURRENCE AND DISTRIBUTION OF CELESTITE BEARING ROCKS.

EDWARD H. KRAUS.

[Abstract]

The study of the rocks—shales and dolomitic limestones—of the upper portion of the Salina epoch in Central New York shows that celestite occurs quite widely disseminated throughout them (1) in the form of well developed crystals and (2) in small circular spots. The celestite was no doubt deposited simultaneously with the rock material. The rocks on the Island of Put-In-Bay, Lake Erie, and in southern Michigan, especially those at the Maybee quarry, Monroe Co., show a similar occurrence of celestite. When celestite-bearing rocks are leached by the action of circulating water the celestite passes quite readily into solution and the rock then assumes a porous character; in this manner the so-called "vermicular limestones" of New York and also the "gashed" and "acicular" dolomites of Michigan may be explained. Such celestite rocks are also the source of the large deposits of celestite which are so abundant in the islands of Lake Erie—especially Put-In-Bay—and at the Maybee quarry, Monroe Co., Mich.

The paper has been printed in full in the American Journal of Science xviii, 1904, 30-39; xix, 1905, 286-293.—Mineralogical Laboratory, University of Michigan.

RELATION OF LAKE WHITTLESEY TO THE ARKONA BEACHES.*

BY F. B. TAYLOR.

The studies of 1904 on the glacial drift and lake deposits of southeastern Michigan have shown that the history of the glacial lakes has been more complex than supposed. It has been the belief hitherto that all the principal changes of the glacial waters in the Erie and Huron basins were changes to lower levels, produced in each case by the uncovering of a new and lower point of discharge by the retreating ice sheet. It has been found that in one case, at least, the order of change

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[1]Compare Bischof, Chemische Geology.

[2]R. Brauns, Chemische Mineralogie, 1896, 384, 389, also, J. F. Kemp. The Mineral Industry, 1893, 585.

* Published by permission of Professor T. C. Chamberlin. A more extended account will appear in the Journal of Geology.

was reversed. The ice re-advanced, closing an outlet which had served for a considerable time, and raised the level of the lake so as to submerge beaches which had been made at lower levels. Indeed, significant evidence was found for three such episodes, and there may have been more. One of these episodes is established by evidence so abundant and clear that its reality seems a matter of entire certainty. It is of this one especially that the present paper gives an account.

Lake Maumee was the earliest and highest of the glacial lakes in the Erie-Huron basin. Thus far, two stages have been recognized for this lake. They stood at different levels and had different outlets. During its first stage the lake lay mostly in northwestern Ohio, with an arm running up to Adrian, Michigan, and its western point projecting into Indiana. Its outlet was through the city of Fort Wayne to the Wabash and Mississippi rivers. At the second stage the lake was much the same, except that it reached considerably farther east and northeast. It also stood ten to twenty-five feet lower and had its outlet near Imlay, Michigan, and thence westward by way of the Flint and Grand River valleys. The beaches marking the two stages are known as the Upper and Lower Maumee beaches. They are both of such character as makes it appear quite certain that neither of them has been modified by submergence since it was made. In its last phase the outlet of Lower Lake Maumee emptied at Flushing into Early Lake Saginaw, which in turn discharged through the Grand River channel and Lake Chicago to the Mississippi river.

After Lower Lake Maumee had endured for a considerable time there came a change which caused the waters to fall with relative suddenness to a lower level. It is with this event that the present account begins. It has been supposed hitherto that at this time the waters fell to the level of the Belmore beach of Lake Whittlesey, which is the first strongly developed shore line below the Lower Maumee. But it has been found that the waters fell first to the Arkona beaches, which are below the Belmore, and then after pausing for a considerable time at each of the three or four Arkona beaches in descending order, the waters were then quickly raised from the lowest Arkona to the Belmore level. In this change the lake level was raised 44 to 45 feet, and in this new position the waters stood for a relatively long time with only slight changes of level. The Belmore is one of the most prominent of the old beaches of the lake region, and during all the time that it was being formed—an interval which covered the whole period of Lake Whittlesey's existence—the Arkona beach ridges were submerged under its waters.

Lake Whittlesey was a very large lake. The expanse of its surface was about twice that of present Lake Erie. It reached from the Indiana-Ohio state line on the Maumee river to Marilla in western New York, twenty miles east of Buffalo, and from near Port Huron, Michigan, to Ottawa and Norwalk, Ohio, and to Komoko and Brantford in Ontario. Storm waves on a lake of this size would be expected to do effective work and to disturb the water to a considerable depth. It would be expected that beach ridges of gravel submerged under such waters twenty-five to forty-five feet would be much modified. And such is the fact. The shores of Lake Whittlesey which were exposed to a wide sweep of water, affording opportunity for powerful wave action, extended, within the boundaries of Michigan, from Spring Hill, a small hamlet fourteen miles northwest of Port Huron, to the Ohio line in the southeast corner of Lenawee county. An arm of this lake also extended north from Spring Hill fifty miles to Ubly, which is at the head of its outlet. But this extension was only a long, shallow, narrow bay, less than three and a half miles wide at its mouth east of Spring Hill. The site of this bay is the present valley of Black river.

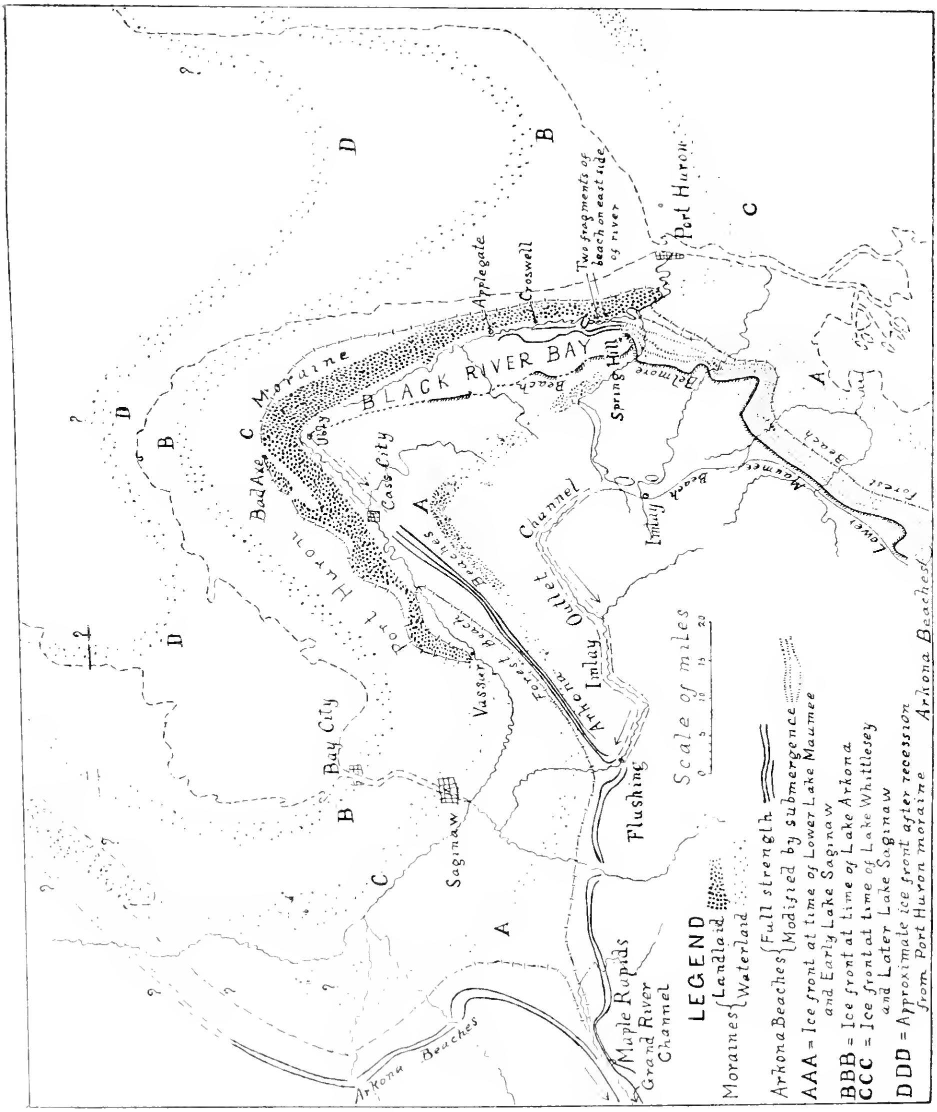
During the time of Lake Whittlesey the front of the ice sheet rested on the Port Huron moraine which was then being built. This moraine is a great ridge of clay hills extending from the north bank of Black river six miles west of Port Huron northward and northwestward along the east side of the river into Huron county, where it turns to the southwest past Cass City and Caro to Vassar. Between these points it is landlaid and is a rugged, prominent feature. South of Port Huron it is waterlaid and is low and flat. It crosses the St. Clair river into Canada one mile above the village of St. Clair. From Vassar westward it is also waterlaid and passes through the city of Saginaw. While Lake Whittlesey filled the Erie-Huron basin in front of the Huron ice lobe the Saginaw valley in front of the Saginaw ice lobe was also filled with another glacial lake known as Later Lake Saginaw. The outlet of this last lake was westward through the Grand River valley. These two lakes existed at the same time and the overflow from Lake Whittlesey entered Later Lake Saginaw and made a large channel about eighteen miles long running southwest from Ubly to Cass City, descending in this distance, as levels are now, about fifty feet. But the land has been tilted up at the north a little since then, so that the descent at that time was probably about one-third less.

The existence of Lake Whittlesey was wholly dependent upon the presence of the ice sheet as a retaining barrier or dam. The ice sheet was a solid, rock-like mass filling the whole bed of Lake Huron and part of the Saginaw valley, its front resting all along on the Port Huron moraine. About five miles north of Ubly the surface of the thumb begins to fall away northward to Lake Huron, descending about two hundred feet in eighteen miles. If the ice sheet had not existed as supposed, or if its front had stood a few miles farther north, there would have been nothing to keep Lake Whittlesey up to its level. Its waters would have found free passage around the end of the thumb at the level of Later Lake Saginaw, forming a strait between the waters on its two sides. These facts and relations were clearly made out in 1896.*

The studies of 1904 brought out further facts bearing on the history of Lake Whittlesey. Since it was discovered and named by Spencer about eighteen years ago, the next beach below the Belmore has been known as the Arkona beach. It has generally been described as a faint and broken shore line. More recently Prof. W. H. Sherzer of Ypsilanti found it in Monroe and Wayne counties with the same characters, but represented by two ridges. It was found last season that in a certain favorable locality this beach presents three well formed ridges with a fourth fainter one above, possibly belonging to the same series. The interval between the three strong ones is fifteen to eighteen feet, the middle one lying a little above the mean.

The Arkona beaches were found to sustain a remarkable relation to

*"Correlation of Erie-Huron beaches with outlets and moraines in Southeastern Michigan." Bulletin Geological Society of America, Vol. 8, 1896. See also, "The great ice-dams of Lakes Maumee, Whittlesey and Warren." American Geologist, Vol. XXIV. July, 1899.


BLACK RIVER BAY
Port Huron
Applegate
Croswell
Two fragments of beach on east side of river
Spring Hill
Belmore
Imlay
Bad Axe
Ubly
Cass City
Bay City
Saginaw
Vassar
Flushing
Maple Rapids
Grand River Channel
Imlay Outlet Channel
Port Huron Moraine
Arkona Beaches
Forest Beach
Lower Maumee Beach
Scale of miles
0 5 10 15 20
LEGEND
Moraines { Landlaid / Waterlaid
Arkona Beaches { Full strength / Modified by submergence
AAA = Ice front at time of Lower Lake Maumee and Early Lake Saginaw
BBB = Ice front at time of Lake Arkona
CCC = Ice front at time of Lake Whittlesey and Later Lake Saginaw
DDD = Approximate ice front after recession from Port Huron moraine

Lake Whittlesey, to the Port Huron moraine and to the Saginaw valley. Briefly, the evidences and relations are as follows:

(1) From Spring Hill southwest to the Ohio line, where they were exposed to the full sweep of waves across the broadest part of Lake Whittlesey, the Arkona beaches are very faint and fragmentary. They are nearly always gravelly, but their relief is so slight that in many parts they can scarcely be called ridges, but are merely gravel belts running across the country. Usually they are not more than two to three feet high.

But besides their low relief, these beaches show another significant peculiarity. The soils which they make are not the loose, light soils which are generally found on beach ridges. They contain a considerable amount of clay which acts as an agent of cementation, and makes them stiffer and more firm than ordinary beach soils. There are several deltas associated with the Arkona beaches, that of the Huron river below Ypsilanti being one of the largest. These show the same effect of stiffening of the soil by infiltration of clay. Both of these characters indicate modification by submergence. The beach ridges were almost washed away by the heavy seas that passed over them; their crests were lowered and the hollows between them and along their sides were partly filled. On the other hand, in times of quiet after storms the clay in the muddy water settled into the interstices of the gravel, making soils of the quality described.

Explanation of Map.

The accompanying map is largely diagramatic, many details being omitted. The lakes, with their shore lines and outlets, were different for each position of the ice front. The map may be best understood by noting the lake conditions associated with each of the several resting places of the ice front in the order of their occurrence.

(1) When the ice front rested on AAA, it held two lakes in front of it. In the Erie-Huron basin was Lower Lake Maumee with the Lower Maumee beach as its shore line. Only the northern extremity of this lake is shown on the map. Its outlet was west through the Imlay channel to Early Lake Saginaw at Flushing, the outlet of the latter lake being southwest through the Grand River channel to Lake Chicago and the Mississippi river. Faint, fragmentary beaches of this lake were found between Flushing and Maple Rapids a little above the level of the Arkona beaches.

(2) From AAA the ice front retreated to BBB. This position marks the approximate place of the western ice boundary of Lake Arkona, its eastern ice boundary being in western New York and probably across the west end of Lake Ontario. The Arkona beaches modified by submergence are shown on the map, extending from the lower edge up to Spring Hill and thence in full strength northward to Croswell and Applegate. Farther towards the northwest they are overridden by the Port Huron moraine, passing probably a little south of Ubly and thence southwest to Cass City. A few miles southwest of the latter place they reappear in full strength running southwest to Flushing, west to Maple Rapids and thence north and northwest to an intersection with the Port Huron moraine. A strait several miles wide connected the waters on the east side of the thumb with those west of it, where the outlet was westward through the Grand River channel.

(3) From BBB the ice front re-advanced to CCC (the Port Huron moraine). By this advance the ice closed the strait around the thumb and raised the level of the waters on the east side about 45 feet. The lower right hand corner of the map shows a part of Lake Whittlesey. This lake lay south of CCC with the Belmore beach as its land shore to the west and Black River bay extending northward to Ubly, where the outlet river passed southwest to Cass City. At this place the outlet entered Later Lake Saginaw which was also held in front of the Port Huron moraine and had its outlet west through the Grand River channel. The water of this lake appears to have stood at the level of the lowest Arkona ridge, for no shore line representing it independently has been found.

(4) From CCC the ice front retreated to a position not observed within the area of the map, but shown conjecturally at DDD. With this movement another similar oscillation of lake level was inaugurated, but it is not described in this paper.

(2) Spring Hill is on a spit of the Belmore beach at the entrance to Black River valley. East from Spring Hill to the crest of the moraine east of Black river is a distance of about three and a half miles. The long bay which lay to the north at that time may be called Black River bay. The Arkona beaches show their modified, low relief up to the mouth of this bay. But to the north, where they lay on the floor of the bay, they grow rapidly stronger with full relief and lighter soils, like other beach ridges which have not been modified by submergence. In the bay area they average ten to twelve feet in height. The lower ridge may be traced six and a half miles north from the road running east from Spring Hill. In the last two miles this ridge is cut away by the river in four places. Two fragments of it occur on the east side of Black river, the first one being about forty rods long and the second about twice this long. A third short fragment farther up the valley is on the west side of the river. Both of the fragments on the east side are in actual contact with the front of the Port Huron moraine. Its foot rests directly against the east side or face of the beach ridge in both cases. Within ten paces one may step from the loose gravelly soil of the beach ridge to the hard, stony clay soil of the moraine. These fragments of the beach are developed in full strength and, contrary to reasonable expectation, bear no appreciable amount of outwash, although the moraine is so close and rises to the height of sixty feet or more in less than half a mile to the east.

The middle ridge runs fourteen and a half miles north from the Spring Hill road and the upper ridge seventeen and a half miles. Both keep their full strength to the end and show no modification due to submergence. Both are finally lost by being buried under sandy outwash from the moraine, the middle ridge at a point one mile northwest of Croswell and the upper ridge one and a half miles south of Applegate.

The occurrence of strong beaches in the bottom of a valley facing a great morainic ridge so close to them, one of them being in actual contact with it, is a very unusual arrangement. In their present relations there is no open lowland or basin in front in which waves could have gathered to form beaches, for the moraine rises to higher levels than they do.

There appears to be but one explanation. Neither the moraine nor the ice which made it were there when the beaches were being built. Instead, there must have been a wide expanse of open water in front, the ice front at that time being many miles away to the north and northeast. The remarkable preservation of the beaches north of Spring Hill appears to be due to the fact that they were submerged in a shallow bay which had a narrow mouth and which on this account protected them from the heavy seas which effected the same ridges so greatly in the open lake area south of Spring Hill. It was a re-advance of the ice after the Arkona beaches had been made that brought the moraine into the place where we now find it, close in front of the beaches, and the same re-advance brought Lake Whittlesey into existence after the Arkona beaches had been formed. The result was that the Arkona beaches were submerged under Lake Whittlesey, and while they were almost destroyed in the area south of Spring Hill, they were protected and preserved in the Black River valley.

(3) In the Saginaw valley certain strong, gravelly beach ridges, usually two or three close together, have long been a puzzle as to their identity. Spencer thought they belonged to his Ridgeway beach which is now called the Belmore. Later, they were thought to belong to the Forest beach, and still later they were called the Saginaw beaches, and were supposed to belong to Later Lake Saginaw alone. But last year's work shows that they are in reality the Arkona beaches in an area where they have not been submerged or modified in any way. Their position next above the Forest beach confirms this identification. These ridges in the Saginaw valley are composed of gravel, are strongly developed and are in every way fully comparable with the unmodified Arkona ridges in the Black River valley. The Port Huron moraine from Vassar to Cass City makes the valley of Cass river a long, pointed bay at the Arkona level, shallow and narrow at its head. Yet the

Arkona beaches extend nearly to Cass City as gravel ridges almost as strong as they are farther west where they would be much more exposed. Towards Cass City these ridges become buried under sandy delta deposits near the mouth of the Ubly outlet channel. The situation is somewhat like that in Black River valley. With the Port Huron moraine where it is now these beaches could not have attained such strength as they show near Cass City. They were made before the moraine was built, and this moraine is the same one that stands in front of the Arkona beaches in the Black River valley.

(4) From their strength near Applegate and Cass City it seems certain that the Arkona ridges once extended northward around the thumb, crossing its crest a little south of Bad Axe. Between Cass City and Applegate, therefore, the Arkona ridges appear to have been overridden and destroyed by the ice when it re-advanced to the place of the Port Huron moraine. It is plain that the same re-advance that raised the waters on the east side of the thumb to the Belmore level would have no effect on the level of the water on the west or Saginaw side, because the outlet for the lake in the Saginaw valley was westward through the Grand River channel and the re-advance of the ice did not touch this channel or even come near to it.

In southeastern Michigan the Arkona beaches may therefore be divided with respect to their history into four provinces or areas. First, in the Saginaw valley they have not been modified in any way, either by overriding or submergence; second, on the thumb between Cass City and Applegate they have been overridden and destroyed; third, in the Black River valley they were submerged, but were, at the same time, so protected as to be preserved without suffering discoverable modification, and fourth, in the interval from Spring Hill southwest to the Ohio line they were submerged and greatly modified, their relief being much reduced—in some parts destroyed—and their composition changed by the infiltration of clay.

Evidences showing slight movements of re-advance on the part of the ice front were found in a number of places some years ago. But, with perhaps one exception, they show nothing definite as to the amount of re-advance. The relations on the thumb seem to show very clearly a re-advance of at least fifteen to twenty miles.

In that case, the re-entrant angle between the Huron and Saginaw ice lobes during the time of Lake Arkona was somewhere near Port Austin on the end of the thumb. This would leave a strait across the outer part of the thumb at the Arkona level connecting the waters on the two sides. In its re-advance the re-entrant angle of the ice pushed up the slope of the thumb to Ubly which is about two hundred feet higher than Port Austin. In the last part of its re-advance the ice carried the water level on the east side of the thumb up with it from the lowest Arkona beach to the Belmore beach, but did not effect the level of the waters in the Saginaw valley. Thus, Lake Whittlesey was an incident of a glacial re-advance following a movement of retreat during which Lake Arkona had its entire period of existence and made all of the Arkona beaches. Besides showing that there was a re-advance of fifteen to twenty miles, the Arkona beaches show that the time during which the ice front rested after its retreat and before its re-advance to the Port Huron moraine was fully as long as the time during which it rested on that moraine. While the ice front was resting near Port Austin before its re-advance it must have been building a moraine comparable to the Port Huron moraine. But this was probably overridden and destroyed during the re-advance. This overridden moraine was being built while the Arkona beaches were being made, and the time which they required for their making was time enough for the building of that moraine, just as the time required for the making of the Belmore beach was enough for the making of the Port Huron moraine.*

There are many evidences of re-advance of the ice front in other intervals of the general glacial retreat. If, as seems to be the case, every so-called "recessional" moraine marks the climax of a re-advance and if there was in each case so long a pause before the re-advance it seems plain that the rate of the general glacial retreat was slower and the time it occupied longer than some authors have supposed.

Fort Wayne, Ind.

DRUMLIN AREAS IN NORTHERN MICHIGAN.

ISRAEL C. RUSSELL.

There are at least two regions in the Northern Peninsula of Michigan, in which drumlins form the most conspicuous features of the topography. One of these areas includes Les Cheneaux Islands and a part of the adjacent mainland, on the north shore of Lake Huron; and the other area is situated principally in Menominee County, to the west of Green Bay.

Les Cheneaux Islands area embraces about 70 square miles, the numerous drumlins within it are of the elongate, ridge like type, are in general about 40 feet high, and trend N. W. and S. E. The direction of ice movement to which the drumlins are due, as recorded by striæ, etc., on rock surfaces, was from the N. W. towards the S. E. Many of the drumlins are partially submerged in the water of Lake Huron and form Les Cheneaux Islands and the capes on the border of the adjacent mainland; the conspicuous parallelism of the longer axes of the islands and of the neighboring capes, is due to this cause. The drumlins are for the most part below the horizon of the Nipissing beach, and have been washed by lake waters so as to remove the greater part of the fine material formerly present on their surfaces, and concentrate the stones and boulders.

The Menominee area occupies at least 150 square miles, and contains many hundred and probably several thousand drumlins. The drumlins are mostly of the ridge like type, are usually about 40 feet high, and their longer axes trend N. E. and S. W. The till of which they are composed is reddish, sandy, without laminaton, and contains many flat slabs of limestone which are without orderly arrangement. Boulders of native copper and of specular iron ore found in the till, indicate that it was deposited by a glacier moving from the N. W. toward the S. E. Striae, etc., on rock surfaces in the midst of the drumlins, record an ice movement from the N. E. toward the S. W. The longer axes of the drumlins are not strictly parallel, but vary in trend from N. 32° E. to N. 55° E. The rocks on which the drumlins rest is Trenton limestone, and has a conspicuously even surface; no knobs or crags are present, such as might serve as nuclei for till accumulation. The larger drumlins rise

*All these phases of the glacial retreat have been discussed in a previous paper. "Moraines of Recession and their significance in glacial theory," Journal of Geology, Vol. V, No. 5, 1897.

to a uniform height and if the valleys and channels between them were filled a nearly horzontal plain would be produced. The depressions separating the drumlins are in many instances, smooth-surfaced, concave troughs; and in one example there is a well defined trench of this character, about 12 feet deep and from 20 to 30 feet wide, about the N. E. end of a small drumlin and extending along its sides. The surfaces of the drumlins to a depth of some 12 to 18 inches, are composed of exceedingly fine, dust like loamy sand, which contains loose stones and boulders.

The drumlins are for the most part smooth-surfaced, half cigar-shaped hills of the normal type, but in a few instances instructive irregularities are present. Among these are: A flattening of a portion of the normally elliptical ground-plan, as if a marginal portion of a well-shaped drumlin had been removed by erosion, leaving an abnormally steep slope; deep transverse trenches at right angles to their longer axes; straight or curved trenches extending from their summits down their sides; irregular pits in their normally smooth surfaces; and in one instance a terrace-like shelf with a convex longitudinal profile, parallel with the crest line of the drumlin on the side of which it occurs.

In the valleys between the drumlins there ae several eskers which as a rule are in a general way parallel with their longer axes, but in a few instances cross their trend nearly at right angles. In one example an esker extends each way from a transverse trench in a drumlin; and in a few instances eskers occur on the tops of drumlins.

From the evidence just summarized, the conclusion is drawn that the drumlins of the Menominee area were produced by ice erosion from a previously deposited till sheet. This explanation is essentially in harmony with the theory of the origin of drumlins advanced several years since by Professor Shaler.

Attention will also be invited to the importance of ice erosion in shaping the topography of glacial deposits in other regions.

Ann Arbor, Mich.

CHANGE OF LEVEL AT THE WEST END OF LAKE ERIE.

E. L. MOSELEY.

Abstract.

When the retreat of the glacier northward opened an outlet to the east for Lake Warren, the water was so lowered that it occupied only the eastern portion of the Erie basin. Subsequent tilting of the land depressed the western portion of the basin relative to the outlet at Niagara so that Lake Erie has gradually attained its present dimensions. The tilting still continues and the lake is enlarging. The effect of the deepening and spreading of the water is shown in many ways.

The streams entering the lake have slack water extending quite a distance from their mouths, in case of the larger ones several miles. Near the mouth of each is a marsh. Streams have been examined in the vicinity of Cleveland, Sandusky, Toledo and on the Canadian side. When the lake was at a lower level the streams cut their valleys deeper than would be possible under present conditions. A number of these valleys extend more than twenty-five feet below the present lake level.

Under Sandusky Bay the stream valleys extend miles beyond the present mouths of the streams. They have been filled with soft mud which can be distinguished from the glacial clay by examining the bottom with an auger. Submerged valleys of all the streams within five miles of Sandusky have been traced in this way. The valley of Pipe Creek has been traced not only under the bay but under the sand bar that separates the bay from Lake Erie and into the lake. The mud accumulated in the submerged valley of Sandusky River south of Johnson's Island is now thirty feet deep.

Submerged Indian graves have been discovered on Squaw Island at the present mouth of the Sandusky River. Submerged forests have been found at Put-in-Bay and in different parts of Sandusky Bay, in one place extending out half a mile from the present shore. Submerged stalactites or stalagmites have been found in four caves of Put-in- Bay; in Daussa's cave, five feet below mean lake level.

About Sandusky Bay several square miles of what in 1820 was forest or prairie land is now marsh. The entire enlargement of the bay and connected marshes since 1820, due partly to subsidence, partly to erosion, is something like twelve square miles. The shores of Lake Erie have receded. This is true of Erie, Cuyahoga and Lake counties, Ohio, and of the vicinity of Port Stanley, Ontario, in fact wherever investigation has been made except short portions of the shore in a few places. At various places about the lake roads have been changed because of the encroachment of the water and orchards and houses have been undermined. The average recession of the shore west of the Pennsylvania line is probably not less than twenty-five rods in the past century on both the south and north sides of the lake but the data at hand are not sufficient for a good estimate.

The flora of the islands of the Put-in-Bay group and Kelley's Island

indicates that they formed part of the mainland in post-glacial times. If all of the uncultivated plants growing upon them had in one way or another reached them by crossing the intervening water, we would expect to find on some of the islands plants well distributed which on others were wanting because the seeds had never reached them and we would expect to find that some of the plants well distributed in similar soil on the mainland were altogether wanting on the islands. But what we find is the reverse of this. (See Sandusky Flora, Ohio Academy of Science, Special Papers No. 1.)

In 1838 trees centuries old were killed by the water standing over their roots and many others in 1858. This occurred about Sandusky Bay, on Kelley's Island, Put-in-Bay, Middle Bass and along the shore between Port Clinton and Toledo. The early settlers could recall many observations that showed the water in the first part of the nineteenth century was not so deep as it became later.

The terminal portion of the Cedar Point peninsula at the entrance to Sandusky Bay is formed of parallel sand and gravel ridges that have been thrown up by great northeast gales occurring at times when the lake was above its normal level. The ridge nearest the bay is the oldest and that nearest the lake the youngest. By studying the vegetation it has been possible to determine the approximate age of each of the principal ridges. Beneath the wind-blown sand the ridges contain stratified sand or gravel or shells of molluscs showing the height to which the materials were thrown by the waves. Each of the principal ridges was dug into in many places in order to ascertain the maximum height of the aqueous deposits in it. These deposits are at a higher level in the recent ridges than in the earlier ones. Dividing the number of feet showing the difference in level between any two of them by the difference in time of their formation in centuries gives the number of feet per century that the lake has risen. It is about 2.14. (For a detailed description of these ridges see "Formation of Sandusky Bay and Cedar Point," published by the Ohio Academy of Science.)

Sandusky, Ohio.

THE VARIATION OF LAND AND WATER TEMPERATURES.

BY W. F. COOPER.

An examination of the yearly mean isothermal lines for lower Michigan as given in the Michigan Section of the Climate and Crop Service of the U. S. Weather Bureau in co-operation with the Michigan State Weather Service, affords some suggestive comparisons. We have for instance the yearly mean isotherm of 46°, during the year 1903, 108 miles farther north on the east side of Lake Michigan than where the same line passes through the central part of St. Clair county, north of Detroit. The isotherm of 44° for the same year passes just north of the line between Arenac and Iosco counties near the entrance of Saginaw Bay, while on the other side of the lower peninsula the equivalent temperature is 66 miles farther north in the region of Grand Traverse Bay. An examination of the yearly mean isothermal chart for the ensuing year, 1904, shows that the isotherm for 44° is 54 miles more northward on the western side of the lower peninsula than in Macomb county adjacent to Lake St. Clair. It will be observed that this annual mean for 1904 is 12 miles less in latitude than for the preceding year. Also the isotherm for 43° is 30 miles higher in latitude on the east side of the Lake Michigan shore. Similar comparisons of the isotherms for 42° and 41° show a difference of 42 and 78 miles respectively farther north on the east shore of Lake Michigan as compared with the west shore of Lake Huron.

As an exception to this general rule of higher isothermal lines on the western shore of lower Michigan, the isotherm of 48° for 1903 is 8 miles farther north in Macomb county adjacent to Lake St. Clair than where Van Buren county is washed by the waves of Lake Michigan. Likewise during 1904 the line for 45° is 16 miles farther south in Berrien county than in Macomb. Both these isothermals, however, show some deflection to the northward on approaching the Lake Michigan shore.

Comparing the isothermals on the east and west sides of Lake Michigan as given by Alexander Winchell in Wallings atlas, we find that the mean isotherm for 47° swings, from Grand Haven southwestward to Chicago, a distance of 78 miles of latitude. Similarly the isotherm for 45° trends from about 20 miles south of the mouth of the Manistee to Milwaukee or 60 miles to the southward. The isotherm for 44° runs from near Manitowoc to Northport in Leelanau county, 72 miles farther north. Generally speaking isotherms have about the same latitude on the west side of Lakes Michigan and Huron, rising to the northward in crossing those bodies of water. The object of this paper is to present some data showing the cause of this atmospheric variation. In obtaining this information I used an H. J. Green thermometer number 7529. The readings were taken on the west side of Saginaw Bay and east of Tobico Bay, northwest of Bay City. Less than five minutes elapsed between the readings on the land and in the water. During the daytime the thermometer was read during August 12, 13, 15, 16, 17, and 18, 1904, at 5:30, 7:30, 8:30, 9:30, 10:30, and 11:15 a. m. and hourly from 1:00 to 7:00 p. m. August 22 and 23 readings were taken consectutively from 1:00 p. m. to 11:15 a. m. August 25 and 26 the thermometer was read from 5:30 a. m. to 5:30 a. m. the following morning being consecutive for 24 hours, ending on the morning of August 26. Judging from these last two series of observations the maximum and minimum temperatures were very nearly obtained by the readings taken from 5:30 a. m. to 7:00 p. m. We will now briefly summarize the results of these observations.

On August 12 the variation of land temperature amounted to 28°; that of the water very nearly 5.5° or 19 per cent of that of the land. From observations sent me by Mr. C. F. Schneider, Director of the Weather Bureau, the amount of variation at West Saginaw and Bay City was 32° and at Midland 22° or 6° less than our land temperatures show. The average of our land temperatures on the day in question was 71°, that of the water 72°. The maximum readings on the land near the bay was 1° less than for West Saginaw, Bay City and Midland, that of the water 6.5° less. Minima readings on the land are 3° higher than at Bay City and Saginaw and 7° lower than for Midland. Similarly the water observation is 21° higher than maximum observations at Saginaw and Bay City and 11° higher than for Midland.

August 13, the day was cloudy until 9:30 a. m. From 5:30 to 11:15 a. m. the land temperature increased 14.5°; that of the water 3° or 20.7 per cent. The average of 6 readings taken during the forenoon was 71.6° for the land and 68.9° for the water.

August 15, the day was clear. From 5:30 a. m. to 2:00 p. m. our land temperature increased 22°, water temperature 7° or 31.8 per cent. Unfortunately I have no data showing the direction of the wind. At Saginaw, W. S. and Bay City the amount of variation was 23°, and at Midland 24°. Our maximum observation on land is 5° less than for Saginaw, 2° less than at Bay City, while Midland is 8° lower. The maximum land observation is 4° less than at West Saginaw, 1° less than at Bay City and 10° higher than at Midland, showing somewhat more stable conditions. Likewise the minimum water temperature is 1° more than at Saginaw, 4° greater than at Bay City and 12° greater than for Midland. Maximum water temperature is 15° less than at West Saginaw, 12° less than at Bay City, and 2° less than at Midland. It is apparent, as we shall see further on, that this would very considerably modify the temperature near the adjacent shore with the wind from off the water.

It rained during the night of August 15 and 16, clearing up by noon time, the wind being from the northeast during the period of fair weather. Our land temperature increased 17.7°, water temperature 8° or 45 per cent. This very considerably higher ratio of the water is very likely due to the action of the wind sweeping down the bay exposing relatively a larger water surface to the wind within a unit of area, and to the action of the waves in entrapping particles of air. Not having the temperature of the rain water which fell during the night it is impossible to state how this would modify that of the water in the bay. The increase of the water temperature during the day dropped only 3° from 7:00 p. m. to 5:30 a. m. the next morning, while that of the land fell 9° in the same interval. It is apparent that under such water conditions, and with the breeze on shore, we would have the climate somewhat modified, the main tendency being to check sudden variations of land temperature and to increase the same. While the maximum amount of land temperature increased 17.7° that at Midland varied 20°, at Bay City 21°, and at West Saginaw 22°, showing a slightly modified temperature variation when compared with the preceding day as well as for the day under discussion. On land our minimum temperature was 12° higher than for Midland, 2° higher than for Bay City and 1° higher than at Saginaw, indicating a considerable amelioration of conditions near the bay. On the other hand maximum observations were 9.7° lower for Midland 1.3° higher for Bay City, and 3.3° greater for West Saginaw. Comparing the maximum and minimum water temperatures with those at the three cities inland we find that the lowest minimum at Midland was 19°, at Bay City 9° and at Saginaw 8° less. Reversely the maximum at Midland was 7° lower than the bay, at Bay City 4° higher and at Saginaw 6° higher.

August 17, the day was clear with the wind from the west during a greater part of the forenoon, and shifting to the north by 1:00 p. m. The land temperature increased 18°; that of the water 6° or 33 per cent, being somewhat intermediate between periods when the wind is off and on shore. The main trend of the bay is northeast. At Bay City the total amount of variation was 15°, at Saginaw 22° and at Midland 24°. It is apparent that this northerly wind was quite pronounced in ameliorating the climate of Bay City which is situated directly south of the bay about 1.5 miles. It is also apparent that Saginaw is benefited to a considerable lesser extent, being some 14 miles farther south, the result is much less noticeable. Apparently these on shore winds are only pronounced in modifying climatic conditions within relatively circumscribed areas. This deduction is also borne out by an examination of the isothermal charts of lower Michigan for 1903 and 1904 to which we have already had occasion to refer. An average of 12 readings on land and water gives 72.8° for the former and 73.9° for the latter, at our station near Tobico bay. The minimum land temperature there was 2° greater than for Bay City and Saginaw, and 12° greater than for Midland to the westward. On the other hand the maximum land temperature at Midland was 6° lower, at Bay City 5° lower, and at Saginaw 2° higher. I believe that insular climates are more pronouncedly influenced in preventing minima temperatures than the reverse. As we shall see farther on this is due to the very considerable capacity water has of absorbing heat during the day and retaining the same to a greater capacity at night. Comparing the minimum water temperature our readings near Tobico show the water 9° warmer than the land there, at Midland 21° warmer, at Saginaw and Bay City 11° warmer. With the maximum water temperature the thermometer at Midland was 3° colder and at Saginaw 5° warmer.

During August 18 the sky was clear with an easterly wind blowing on shore. The land temperature only increased 18° while that of the water increased 9° or 50 per cent. Comparing this with those previously discussed it was noted that with a north wind blowing diagonally across the bay, that the ratio of water to land temperature was 33 per cent, with a northeasterly wind blowing down the bay of 45 per cent, while that from the east as just given is 50 per cent. While theoretically we might expect the greater increase of water temperature with a full breeze coming from the northeast down the main trend of the bay, this result is very probably modified by the shallow waters of the lower reaches of Saginaw bay, giving greater play to wave action. This on shore action, as noted above, is not only pronounced in increasing relatively the greater warmth of the water, but also *pari passu*, in modifying that of the adjacent land to the west. It is also true that the modification of temperature would be greater during the night. Comparing the land minimum with that of the water near Tobico we find the water 9° warmer at 5:30 a. m. and 3° warmer at 6:45 p. m. At Midland the temperature was 14° colder; at Bay City and Saginaw 10° colder. Relatively, however, Midland was much warmer than the usual ratio of temperatures with Bay City and Saginaw, very likely due to this easterly wind. The maximum land temperature at Tobico was 5.2° greater than at Bay City, .8° less than at Saginaw, 2.8° less than Midland, and .1° less than the bay, showing quite stable climatic conditions under these circumstances. Reversely our water minimum was 9° greater than the land near Tobico, 23° greater than at Midland and 19° greater than at Bay City and Saginaw. The water maximum was 5.3° greater than at Bay City, .7° less than at Saginaw, and 2.7° less than Midland, indicating a constantly increasing divergence going away from the bay.

During August 22 and 23 observations were taken consecutively from 1 p. m. to 11:15 a. m. The weather was clear, wind from the northwest, shifting to the west during the morning of the 23rd. During that time the land temperature fell from 76° at 3 p. m. to 50° at 5:30 a. m., or 26°, the maximum change of water temperature during approximately the same time being 8.5° or 32.6 per cent. of the change on land. During the forenoon of the 23rd the land temperature rose 24° by 11:15 a. m. and the water temperature increased 5.7° within the same time, or 23.75 per cent. While during the afternoon the maximum land temperature was 1.8° greater than the water at 5.30 a. m. the next morning the lowest land temperature was 16° less than the minimum water temperature, showing the very considerable capacity of the water to retain heat during the night. Our maximum land temperature near Tobico is 1° greater than at Bay City and 2° less than at Midland and West Saginaw. On the other hand our minimum land temperature was apparently 8° less than at Bay City, 9° less than that of Saginaw, and 10° less than Midland. Maximum and minimum land temperatures on the other side of the bay, and in the path of the wind, would be of value in this connection. Comparing our water maximum of the 22nd with that of the land, we find Bay City .5° greater, Midland and Saginaw 3.5° greater. The wind, however, being from the northwest and west, we would expect greater modifications of land temperatures over in the "Thumb," rather than in the places above mentioned. The minimum water temperature on the 23rd is 22° greater than for Midland, 21° more than at Saginaw and 8° greater than at Bay City, showing to what extent the temperature of Bay City was benefited by its proximity to the bay. An average of our land and water temperatures near Tobico are respectively 64.5° and 69.9° during the entire period of about 24 hours.

During the 24 hours ending at 5:30 a. m., August 26, 1904, we have a continuous series of land and water temperatures. The weather was fair with quite a strong westerly wind blowing throughout that time. The average of 18 readings give a land temperature of 67.07°, that of the water being 69.9° for the same time. During the 25th the land and water temperature increased 13° and 7.5° respectively, the ratio being 57.6 per cent, followed by a minimum drop of 39° and 12.2° of the land and water at 5:00 a. m. on the 26th of the following morning, or only 31 per cent of change of the water relative to the land. Land and water temperatures taken simultaneously on the other side of the bay would be desirable for comparison here. These readings, however, clearly show the property water has of absorbing and retaining heat. During the 25th our maximum land temperature was 85° with 80° for Midland, 82° for West Saginaw and 83° for Bay City. Reversely our minimum land temperature on the morning of the 26th is 46° near Tobico, 43° for Saginaw, 44° for Bay City and 60° for Midland. To show clearly the cause of insular climate it would be well to have maximum and minimum land observations on the east side of the bay in the "Thumb" for comparison with those at Midland to the westward. During the same time our maximum and minimum water temperatures were 75.5° and 63.3° as compared with those given above.

The average of all these observations gives an average water temperature of 72.11°, that of the land being 72.38°. It is more probable, however, as shown by our readings for 24 hours, that the average water temperature is about 4° greater during the latter part of August than that of the land. The ratio of change of water temperature relative to that of the land is less than 34.4 per cent. In this factor, taking into account the prevailing southwesterly winds, is at least a partial explanation of the insular climate of lower Michigan. Moreover the temperature of the water, as a rule, being greater than that of the land from about 7 o'clock in the evening until about 9 o'clock the following day, the tendency would be to increase the temperature of the adjacent shores. On the other hand, the land temperature being greater during the remainder of the day, the water would tend to establish an equilibrium negatively, the two means of variation probably approaching that of the average of the two factors, land and water. The more prolonged periods of greater water temperature and radiation is doubtless the greater factor in this question.

The following tables are appended showing the maximum and minimum temperatures of West Saginaw, Bay City and Midland as furnished by C. F. Schneider of the State Weather Bureau, with our own observations near Tobico.

Geological Survey, Lansing, Michigan, March 20, 1905.

1904.	Aug. 12		Aug. 13		Aug. 15		Aug. 16		Aug. 17		Aug. 18		Aug. 22		Aug. 23		Aug. 25		Aug. 26	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
W. Saginaw..	80	48	87	63	89	66	83	61	82	60	76	47	78	59	78	44	82	64	75	43
Bay City....	80	48	77	47	86	63	81	60	75	60	70	47	75	58	77	45	83	67	75	44
Midland.....	80	58	78	58	76	52	70	50	74	50	78	43	78	60	76	58	80	60	80	60
Tobico, land.	79	51	....	66	83	62	79.7	62	80	62	75.2	57	76	....	....	50	85	50.5	....	46
Tobico, water	73.5	68	....	68	74	67	77	69	77	71	75.3	66	74.5	....	....	66	75.5	66	....	63.3

1904.	Aug. 12		Aug. 13		Aug. 15		Aug. 16		Aug. 17		Aug. 18		Aug. 22		Aug. 23		Aug. 25	
	Tobico, land.	Saginaw bay.	Tobico, land.	Saginaw bay.	Tobico, land.	Saginaw bay.	Tobico, land.	Saginaw bay.	Tobico, land.	Saginaw bay.	Tobico, land.	Saginaw bay.	Tobico, land.	Saginaw bay.	Tobico, land.	Saginaw bay.	Tobico, land.	Saginaw bay.
5:30—A. M............	51	68	66	68	62	67	62	69	62	71	57	66	....	....	50	66	72	68
7:30..................	64.5	69	69.3	68.3	66.2	68.6	65	69	67.4	71.3	65.4	68	....	....	61	67	76	70
8:30..................	....	....	69	68.5	71	71	62	69.3	72.5	72.5	65.5	68.6	....	....	69	68	79	71.5
9:30..................	72.5	71	71.4	69.0	73.5	73	66.3	70.3	76.2	73.6	70.5	69.8	....	....	69.5	69	79	72.5
10:30..................	....	....	73.5	....	73.5	73	68.2	71	78.0	75	69.3	72.2	....	....	72.5	70.4	79	72.5
11:15..................	74.0	73.5	80.5	71.0	73.3	73.3	72.7	72	80	76	75.2	74	....	....	74	71.7	80.5	73.4
1:00..................	78.0	73.6	....	....	83.0	74	79.7	75.6	79	77	73.3	74.8	73	73.2	....	....	85	75.3
2:00..................	78.0	73.3	....	....	81.6	74	76.2	76.5	78.6	76	73.4	75.3	75.5	74.5	....	....	79	75.1
3:00..................	79	73.5	....	....	....	....	76.3	77	74.8	75.5	73	75	76	74.2	....	....	78.2	75.5
4:00..................	78	73.5	....	....	79.0	74	76.6	76.5	72.0	74.3	73	74.1	74.2	73.6	....	....	74.1	74.5
5:00..................	76	73.5	....	....	84	73.3	79	76.5	68.2	73.2	72	73	72.6	72.6	....	....	70.5	73.5
7:00..................	71	71.6	....	....	71.5	73.0	71	74.1	65	71.1	68	71	62.6	71	....	....	63	69
9:00..................	....	....	....	....	....	....	....	....	....	....	....	....	59	69	....	....	55	66.5
11:00..................	....	....	....	....	....	....	....	....	....	....	....	....	55	68	....	....	50.5	66
													Aug. 23				Aug. 26	
1:00..................	....	....	....	....	....	....	....	....	....	....	....	....	53	67.3	....	....	48	65
3:00..................	....	....	....	....	....	....	....	....	....	....	....	....	51	66.5	....	....	46	64
5:00..................	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	46	63.3
5:30..................	....	....	....	....	....	....	....	....	....	....	....	....	50	66	....	....	46.5	64.0

THE VITALITY OF SEEDS.

W. J. BEAL.

(Professor of Botany, Agricultural College.)

This paper will be published in full in the Proceedings of the American Society for the Promotion of Agriculture for 1905, and also in the Botanical Gazette.

"COLOR" STIMULUS AND VITAL FUNCTIONS OF PLANTS.

J. B. DANDENO.

Sunlight affects the vital functions of both plants and animals. What people are in the habit of calling *sunlight* is, however, composed of several separable and distant elements. These individual portions (colors) of the solar spectrum also exert specific influences over the vital activities of plants or parts of plants, in a fairly constant and definite manner. It has been so customary to use the term *light* as though it were a single inseparable stimulus, that most physiological experiments have been made with regard to light as a unit. Hence, we have the term heliotropism, photosynthesis, and the like, conveying the idea that light acts as a single stimulus, instead of the resultant of a number of separable stimuli.

As has already been pointed out (Science, Nov. 6, 1903, p. 604), no very decisive investigations have been made to determine the effects of the individual portions of the spectrum. Moreover, the statements concerning what has been done, seem to be somewhat contradictory and indefinite. Pfeffer (Ewart's trans. p. 104) states: "The relative activity of the different rays of the spectrum has not been precisely determined, and hence it is impossible to say whether the curves for the retarding, phototonic, and formative action exactly coincide or not. In general, however, it may be said that these curves, like that showing heliotropic effect, attain a maximum in the more refrangible rays, fall nearly or quite to zero in the green or yellow part of the spectrum, and frequently, though not always, again rise to a second smaller maximum in the red end of the spectrum." Pfeffer states further (p. 104): "On the other hand it is the less refrangible rays which are most active in photosynthesis, and to a less degree in the development of chlorophyll." But Belzung states (Anat. & Physiol. Veg., p. 77): "Le verdissement acquiert toujours son maximum d'intensité dans la lumiere jaune." In Belzung's figure showing curve for development of chlorophyll, the colors appear in the following order: yellow, green, blue, red, violet. This is different from the latter part of Pfeffer's statement given above, because he places *red* as the part having greatest effect. Even in Pfeffer's own work, as quoted by Sachs (Text-book of Botany, p. 745, 746), there seem to be two different results relating to what Sachs called assimilation (photosynthesis). He arranges them in one place, in the following order: yellow, red, green, blue; and also (p. 746); yellow, orange, green, red, blue, violet. Pfeffer (Physiol. of Plants) seems to have abandoned the figures already given by him, and quoted by Sachs, and makes more general statements concerning the function. There is no doubt, as Pfeffer states, that the relative activity has not been precisely determined. It is not difficult to believe this, when one considers the character of the apparatus used by Sachs, Pfeffer and others to investigate the problem.

For the following investigations to determine the effects of the different portions of the solar spectrum, colored glass plates were secured: red, yellow, green, blue, violet. These plates of glass were approximations towards a pure color. The plotted curve indicating the relative purity of these colors, is given in Science, Nov. 6, 1903, p. 605. Although they are not strictly speaking pure colors, yet they are, so far as they go, definite, because the relative amount of other parts of the spectrum, which passes through, are given, making it possible to decide fairly in regard to the separate color-stimulus. The results obtained from these particular glass plates, are, therefore, definite, and, for the color combination, as indicated in the plotted curve, reliable, for the functions mentioned.

In giving the results of these investigations, the colors are arranged in order, commencing with that producing greatest effect, and ending with that producing least. The results for Phototropism and for decoloring of alcoholic solutions of chlorophyll, have already been published (Sci., Nov. 6, 1903, p. 601) but, for convenience, they are here given.

The results in regard to production of chlorophyll are taken from Belzung, p. 77; and for assimilation of carbon dioxide, from Pfeffer, p. 101, and Sachs, p. 476. The colors used by Belzung and Pfeffer may not be exactly those here given. It is difficult to tell just the exact color they used, because little or no description is given beyond that contained in the mere term,—red, blue, etc. Therefore, a correlation of results is not always possible. The double bell-jar method is a rather crude one for several reasons, but particularly because it is impossible to control the temperature and the ventilation. The colors here used are, of course, not the only ones in the spectrum, but they are chosen as being sufficiently distinct and well-known to convey a clear idea as to what is meant.

PHOTOTROPISM:
    Blue, white, violet, green, yellow, red, opaque.

DECOLORING OF CHLOROPHYLL, (alcholic solution):
    White, yellow, blue, red, violet, green, opaque.

PRODUCTION OF OXYGEN:
    White, yellow, green, red, violet, blue, opaque.

GROWTH:
    Opaque, red yellow, green, violet, white, blue.

PRODUCTION OF GREEN COLORING MATTER:
    White, yellow, green, blue, red, violet, opaque. (Gelzung)

ASSIMILATION OF CO_2:
    *White, yellow, green, red, blue, violet, opaque.
    *White, yellow, red-orange, green, blue, violet, opaque.

PHOTOTONIC AND FORMATIVE:
    White (?), violet, blue, green, yellow, red. (Pfeffer)

PHOTOTACTIC: STEAMING OF PROTOPLASM: MOVEMENT OF CHLOROPLASTS:
    Same as heliotropic, according to Pfeffer.
    These are: Violet, blue, red; none others having effect.
    The results given above under *phototropism* show that Pfeffer's results are erroneous.

*Both of these are given because they arise from different experiments, (Pfeffer.)

These investigation, as far as they go, point towards the conclusion that the stimulative influences upon plants, produced by the several parts of the solar spectrum, can not be predicted. Experimental evidence is required in each function, and with each part of the spectrum. The published conclusions of almost all investigators on this particular question, seem to have been influenced, more or less, by the purely chemical effects of the several parts of the spectrum. The rays of greatest refrangibility have, almost without exception, the greatest chemical activity; but in physiological functions there is a great variety. This alone would seem to indicate that vital activities are not purely chemical actions; or, that there are numbers of chemical actions, differing from those at present known, yet undiscovered.

Plants have by nature been accustomed to sunlight, and it would seem as though they have been subjected to this stimulus, not divided up into its parts as they are in the solar spectrum, but as white light. Therefore, it seems also apparent that the ecological effects of the individual colors would be of little importance. Such, however, in a vast number of cases, is not the condition, when we consider that it is the nucleus and the cytoplasm within the cell, that have fundamentally to do with vital activity of all kinds. To reach this nucleus and cytoplasm, the light has to pass through, in most cases, cell-walls and other refractive bodies, and therefore would be, more or less, a spectrum when acting upon the protoplasm (cytoplasm and nucleus). In the case of such plants as have collenchyma tissue within the stems, it is quite easy to see that these prisms of cellulose would be perfectly adapted to produce a spectrum within the tissue. Take the case of crystals, oil globules, starch grains, and a host of other refractive bodies; it is quite clear, therefore, that spectra would be produced within the living cells in a large number of instances.

And, if it be considered that the light has to pass through a considerable amount of matter before reaching the protoplasm, we can see that some parts of the light may be absorbed in the process of penetration. The light stimulus would be, in such cases, not that of white light, but that of some one color, or a combination of colors with one or more lacking. All aquatic plants are subjected to light which has not the full spectrum of sunlight, owing to the fact that the light has to pass through water, and this more or less impure, to reach the plant. And further, this modified light will again be affected in passing through the cell-walls and cell-contents in its course towards the protoplasm.

Another special instance should be mentioned. In all aerial (land) plants, there are intercellular spaces which are filled with air. These spaces are of a multitude of forms and sizes; and they are usually located—especially in the leaves—adjoining, or near, the living active cells. These intercellular spaces, then, are so many air bubbles among the cells, and it needs no argument to convince any one who has used a microscope, that these air bubbles have a high refractive power for light. In fact the tender white stem of a young seedling owes its whiteness to the fact that it has a large number of prismatic intercellular spaces all filled with air. Even the unicellular plant would be influenced by the refraction produced by its wall and cell content; the mycelium of fungi are so many transparent cylindrical prisms of high refractive power, as compared with air. So that when we speak of the stimulus produced by white light we can not be sure that it is produced by white light at all. It is very probably not. Moreover, the coloring matter in the red and the brown algae are said to serve the function of modifying the light rays so that the portion of the spectrum which reaches the protoplasm may be tempered to the protoplasm upon which it acts. The brown coloring matter is suited to a considerable depth of water. The red coloring matter of the red algae, makes it possible for these plants to live at a greater depth than the brown algae live. At great depths of water the prevailing light is bluish, and the red coloring matter in the algae have probably to do with modifying this blue light to suit the needs of these plants. It has been observed that the maximum assimilation of carbon dioxide occurs in a different part of the spectrum in sea-weeds from that of ordinary green plants. This apparent difference is probably again due to the fact that different conditions are required to produce a given luminous effect upon the protoplasm, although it is quite probable that a certain portion of the spectral light produces a similar effect upon all plants. The difficulty is that we do not as yet know just what portion of the white light reaches the protoplasm, even when we apply certain portions of the spectrum to the plant. So that the whole matter resolves itself into this: Although white light, or direct sunlight, is the kind of light which is received by the external parts of the plant, yet the light which is ultimately applied to the protoplasm, is, in all probability, only some portion of white light, i. e., some color. And, it is only reasonable to suppose that, in the course of development of the race of plants, if a certain color provoke a stimulus useful to plant functions, such would be retained and developed in the course of evolution. This could be brought about by developing tissue, or cell contents, or both, of certain refractive values.

The economic aspect of these deductions, is not without some significance. Light has, without doubt, an important formative influence upon plant structures. If a portion of a branch of a potato plant be kept in darkness, a tuber, or tubers, will be formed. If in the light, leaves and branches are formed. It has also been shown that certain portions of the spectrum have a formative influence. This has been observed in some of the Mucors. Sporangia will form under certain colors, and not under others. Then again, it has been noted that, abnormal growths occur under the influence of certain colors. This affords a suggestion fruitful of results, because man might improve to his advantage such abnormal growths as would prove useful.

As has already been shown, certain colors stimulate in one direction, and other colors, where other functions are under consideration, in other directions. This gives rise to great possibilities. Red stimulates growth more than yellow; while yellow is more active in photosynthesis, i. e., starch production. Blue and violet have greater formative influences. Intelligent regulation of these stimuli might give man a chance to augment his food and fibre supply. Glass houses of colored glass could be made, therefore, important pieces of apparatus to develop this idea. The larger the houses, the more nearly natural the conditions would be; and houses, not bell-jars, are very desirable, so that plants could be cultivated through the whole course of their lives under nearly natural conditions,—a thing much to be desired.

Agricultural College.

THE TOXIC ACTION OF COPPER SULPHATE UPON CERTAIN ALGAE IN THE PRESENCE OF FOREIGN SUBSTANCES.

ELLEN B. BACH.

The toxic action of copper sulphate upon certain of the algae is presented at some length by Moore and Kellerman in a paper entitled "A Method of Destroying or Preventing the Growth of Algae and Certain Pathogenic Bacteria in Water Supplies" (U. S. Department of Agriculture Bulletin No. 64, 1904). It is there stated that a dilution of one to one million in all cases would be sufficient to prevent the growth of a polluting algal form in a body of water. Such a dilution would be about n-125000, where "n" stands for the gram equivalent per liter of solution, and the denominator represents the concentration of the solution. If this strength would kill filamentous algae and leave unharmed higher algae (as Chara), or other aquatic plants, it would be a useful method of keeping aquaria clear.

An aquarium jar of about six liters capacity contained a luxuriant growth of Chara, which had recently become almost completely covered with filamentous algal forms. Strings of the algae also hung from the surface of the water and the sides of the jar. On the bottom of the jar was a thin layer of ordinary garden soil. A normal solution of copper sulphate was made, and sufficient of it added to the water in the jar to make the resulting solution nearly n-100000. This strength would be greater than that given by Moore and Kellerman, yet the algae, as well as the Chara, lived and flourished. Evidently something was present that absorbed some of the copper, and so rendered the solution less toxic. Dandeno proves (Am. Journ. of Sc., Vol. XVII, June, 1904, p. 437) that "non-chemical bodies retard very materially the activity of the solute in bringing about death to the radicle of seedlings." Sand was used as one of the non-chemicals. In the same paper he also shows that "the quantity of the solution has an important bearing upon its power to affect the radicles." If these two points are true in the case of seedlings, why would they not hold for algae in toxic solutions? Experiments were set up for investigation along these two lines.

At first both Chara and filamentous algae were used, separately and together. It was found that a Chara stem 20 cm. or more in length would live in a definite quantity of copper sulphate solution in which a stem half as long would die in twenty-four hours or less. The same was true of the smaller algae. A large mass of filaments would live where a smaller number would die within a short time. When Chara and the lower forms were put together into a solution strong enough to kill Chara alone within a known time, the algae would die and the Chara live. Varying the quantity of the solution had a similar effect. A known amount of the plant tissue that would live in 20 cc. of the copper sulphate solution, would die in a short time in 200 cc. of the same strength. As yet no very accurate data has been obtained upon this point, as the experiments tried were only preliminary, and that phase of the problem has been left until the death-point for certain definite amounts of plant material in a limited volume of the copper sulphate solution shall have been determined.

Small masses of some filamentous forms of algae were placed in glass dishes in the clear solution of copper sulphate, and some in the same volume of the poison in dishes whose bottoms were partially covered with a thin layer of fine quartz sand, or with garden soil. It was found that the algae lived longer, or lived the same length of time in a much more concentrated solution, in the presence of garden soil than in the clear solution. Sand also tended to lower the death-point, though it was not nearly so effective as the soil. It is a fact of common observation that these low forms are often held at the surface, or even a little above the surface of the water in which they are growing by bubbles of the oxygen they give off; the gas being held among the filaments. Masses containing these bubbles were put in solutions of sufficient quantity and concentration to kill them ordinarily in less than twenty-four hours; but, being held up above the liquid in a measure, only the cells around the edge of the mass were killed, while the rest lived, and performed their normal functions when returned to pure water. The same was found to be true of Chara. A tip of a branch projecting out of the solution was always found to be alive.

For convenience, and to have some definite basis upon which to work, portions of Chara plants 10 cm. to 12 cm. in length were used, and these were immersed in 20 cc. of copper sulphate solution of various strengths. In some cases the clear solution was used; in some fine quartz sand was placed on the bottom of the dish; in others a little ordinary garden soil. As yet the effect of varying the quantity of foreign substance present has not been determined. Apparently the amount makes no difference with solutions of the dilutions and small quantities used. Distilled water, tap (hard) water, and river water were tried. The death point was lowest (solution strongest) in all cases in the presence of soil, and highest (died in most dilute solution) in the clear solutions. A curious fact, and as yet unaccounted for, is that the plants lived in a solution of greatest concentration where distilled water was used in making up the solution. One would expect quite the opposite to be true. The plants were always rinsed in some of the solution to be tested before placing them in the 20 cc. A time limit of twenty-four hours was set. If, at the end of that time, protoplasm was found to be moving in any part of the plant it was said to be alive. In many instances the plants were removed at the end of twenty-four hours and placed in clear water, and found to live and grow. The problem, then, for this part of the work, might be stated thus: To find out at what dilution 20 cc. of copper sulphate solution will kill 10 cm. to 12 cm. of Chara plant in twenty-four hours, when foreign substances are present, and also when they are not. The following table will show the strength of the solutions necessary as they stand at the present writing. A larger average of results may change it some:

Clear $CuSO_4$ Solution, Distilled water, dies in about n–12480.
Sand in dish " " " in about n–10240.
Soil in dish " " " between n–3200 & n–2800.
Clear $CuSO_4$ Solution, Tap water, dies in about n–12800.
Sand in dish " " " between n–12674 & n–12544.
Soil in dish " " " in less than n–3200.
Clear Solution, River water, dies in less than n–10880.
Soil in dish " " " in less than n–3200.

Not much has yet been done with the river water; but it would seem from the few results obtained, that copper sulphate is less toxic in river water, clear solutions being compared. At this time of the year the river water is not very clear, and it may be that the small particles floating in it act as non-chemicals and absorb part of the copper, thus lowering the death-point.

In looking over the limited data here given, it appears that the strength of the copper sulphate solution necessary to free an aquarium, or body of water, from algae must depend upon the per cent of plant life present, the amount of foreign substance (non-chemical) in the water, and the kind of water. In view of these facts, might it not be, that, if copper sulphate were introduced at the surface of a body of water of some depth, the plants at the surface would be killed and absorb sufficient of the copper to render the solution too dilute to be toxic at a greater depth? And so the algae at the bottom would remain unharmed. There seems still to be much room for investigation.

Michigan Agricultural College.

A STUDY OF THE EFFECT OF DILUTE SOLUTIONS OF HYDROCHLORIC ACID UPON THE RADICLES OF CORN SEEDLINGS.[1]

F. A. LOEW.

The research work done so far along the line of toxicity of dilute solutions of acids and salts upon radicles of seedlings can be loosely placed in four classes. True and Healed and some others did considerable work with dilute solutions and seedlings, evidently with the idea of finding biological evidence for the support of the dissociation theory of acid solutions. The work of Kearney and Cameron seemed to be mostly in connection with soil problems. Moore, who worked with $CuSO_4$, sought to find methods for controlling the amount of algea in reservoirs and water systems. Dandeno and others studied the behavior of seedlings in solutions when placed under different circumstances. In Europe work on similar problems has been carried on by both the Germans and the French. As far as I have been able to find, no attempt has been made to explain the cause of death of the radicle in such extremely dilute solutions. Dandeno[2] suggests that death is probably caused by chemical action upon the radicles. Upon this suggestion I began my study of the effect of Hydrochloric acid upon radicles of corn seedlings.

[1]This work is incomplete and should be duplicated.
[2]American Journal of Science Vol. XVII, June 1904

The work so far is very incomplete. It was found that corn seedlings would live and grow in a dilution of n-2560 HCl. To find whether there was any chemical action in the killing of the radicles, I put 25 cc. of n-640 HCl into an esmark dish of 50 cc. capacity. In this solution I put 48 seedlings of corn, with radicles 3 to 6 cm. long; after 24 hours 75% of the seedlings were alive. N-640 HCl is four times as concentrated as the dilution at which a seedling will just live.

In 40 cc. of n-2560 HCl, I put four corn seedlings, and allowed them to grow for 24 hours, then they were removed and followed by four lupine seedlings. After 24 hours the lupines had grown 10 mm. The lupine dies at a dilution of n-6400 HCl. These experiments show that there is a loss of acid. Since the radicles were free from all mineral matter on the outside, the acid must have united with the mineral substances from within. This loss of acidity suggested that the acid of the solution acted upon some mineral elements of the radicle, hence it was supposed that the mineral content of corn seedlings killed in HCl solution would be less than that of normal radicles, and also that some element or elements would be more abundant in the one than in the other.

Two lots of radicles were collected. The one was taken from seedlings killed in a solution of HCl about n-256; the other was taken from normal seedlings as they came from the germinator.

The corn was germinated in sphagnum. When the radicles became about 2 to 6 cm. long, a quantity of them were put into a large, shallow esmark dish, holding 500 cc. of the solution. The grain was supported by perforated cardboard, allowing the radicles to reach into the solution. They remained in the solution twelve hours, after which they were removed and rinsed off with distilled water. They were then clipped off about 5 cm. from the tip, on an average, and dried. The solution in which they were killed was changed every other day.

The control lot was taken from the germinator, clipped and dried. About the same length of radicles was taken in both cases. The radicles of approximately 3000 seedlings were collected for each lot, making 4.08 grams of killed radicles and 5.33 grams of natural ones. The solution in which about 2000 seedlings were killed, was evaporated to dryness, then burned to ash, and the ash analyzed for calcium and potash. 1.235 g. of dry material was obtained.

As a check on the last test, two hundred seedlings were put into an esmark dish as used for killing the seedlings, but containing distilled water. They were allowed to remain as many hours per 100 seedlings as were taken to kill the 2000 seedlings which were burned. Then the water was evaporated and tested for alkalinity. No fungi grew in this solution, as did in the killing solution. The results of the chemical analysis of the mineral content are as follows:

	Killed Radicles.	Normal Radicals.	Difference.
Ash	3.952%	7.415%	3.46%
Insoluble ash	13.98	16.59	2.61
Soluble ash	86.02	83.41	−2.61
Cl. in ash	2.41	8.96	6.55
K_2O	34.17	38.76	4.59

	Killing Solution.	Check.	Difference.
Dry material	1.235 grams.	.07 grams.	−1.165 grams.
Ash	31.9%	57.12%	25.22%
K_2O	46.2	.36 (?)	

From my study of this subject, the following conclusions were reached:

1. The amount of acid in dilute solutions of HCl is reduced by growing corn seedlings in them.

2. The mineral content of radicles killed in n-256 HCl was nearly one-half that of normal radicles. The Potassium and Chlorine were less.

3. Bacteria and fungi thrived in the solution in which the seedlings were killed. None were perceptable when the seedlings were kept in distilled water for one week.

4. The seedlings which were killed in n-256 HCl excreted much material rich in potassium.

5. Seedlings of corn grown in distilled water excrete potash, or some other alkali.

The following are suggestions received from my work:

1. The fact that the amount of acid in solutions in which seedlings are grown becomes reduced, suggests that the death is caused by a chemical action.

2. The fact that the killed radicles contain less potassium than normal ones, and that the solution in which they were killed is rich in potassium, suggests that death is caused by a chemical action between the acid of the solution and the potassium of the radicle.

3. The fact that fungi and bacteria grow so vigorously in the solution in which the seedlings were killed, and did not thrive in the distilled water in which seedlings were growing, suggests that the excretions or extractions caused by the acid solution might be some organic compound especially nutritious to these lower forms of plant life.

I am indebted to Professor F. S. Kedzie for most of the chemical analysis involved in this problem.

Agricultural College, Mich.

NOTES ON GANODERMA SESSILE MURRILL.—ITS VARIATION FROM THE ORIGINAL DESCRIPTION AND POSSIBLE PARASITISM.

JAS. B. POLLOCK.

Murrill has recently described a new species of a genus of the Polyporaceæ under the name of *Ganoderma sessile* (Bull. Torr. Bot. Club, 29: 604–5, 1902), a fungus of which specimens had been collected in Indiana, Ohio, New York, New Jersey, Alabama and Louisiana, and which had been referred to *Ganoderma pseudoboletus* (Polyporus lucidus Fries).

The writer collected specimens of this fungus in two localities in the summer and autumn of 1904, on the University campus at Ann Arbor, and in Allen's woods, eleven miles west of Ann Arbor. Some of the specimens differed from the description given by Murrill to such a degree as to make it desirable to record these differences, and one of the collections was made in a situation which suggested that this fungus might be a parasite.

In July, 1904, a man trimming up trees on the University of Michigan campus reported that he had removed a large fungus from the trunk of a certain hard maple tree, which was alive but evidently much behind its neighbors in vitality and vigor, as shown by the small size of its leaves, the less density of its top, and the smaller size of the top as compared with other trees growing in the same row, and presumably of the same age and in similar conditions. The difference between this tree and its neighbor was very marked, and the cause apparently must have been active more than the present season. The situation suggested a probable cause. Two or three years previously new concrete walks had been laid in this part of the campus, and three of these had been laid near enough to this tree to come under its spreading top, and presumably a large proportion of roots of this tree must have been cut off in making the excavations for the walks. Since the trees on the campus under the best conditions suffer for lack of water during the dry periods of the summer season, the loss of water occasioned by a considerable loss of the root system on three sides of this tree might account for the reduced vitality, which the whole appearance of the tree indicated.

The fungus mentioned above as having been removed from this tree had been carted away and could not be found. But the tree was kept under observation for several weeks following, and in August the fungus reappeared, developing the sporophore in the same place from which it had previously been removed. This was directly on the trunk, just at the top of the ground, and even partly below the ground. It extended around the tree for six or seven inches, and the pores characteristic of the family Polyporaceæ began to develop when there was only a thick, rather irregular crust, and the fungus in this place did not take the typical bracket form of many Polyporaceæ.

In addition to this growth on the tree, several other sporophores made their appearance, not on the trunk of the tree, but on the ground a few feet from it, in the direction of the nearest walk. These specimens were gathered and placed in the collection of the University. In October the growth was again found both on the trunk and on the ground in about the same spot as before. These were gathered by a class engaged in the study of plant diseases.

In October also the collection was made in Allen's woods, the specimens being on the ground, on different sides of, and near to a dead red oak tree. The specimens on the ground were stipitate, while Murrill describes the species as sessile only, though in the notes following the technical description he quotes Morgan as having found it with a stipe, though Morgan referred it to Polyporus lucidus Fr.

The situation of these stipitate specimens suggested that they might have developed on roots of the trees near which they were found. Attempts to trace two of them to roots did not succeed, but still left the question unsettled. One ot these specimens had a single central stipe for a group of connate pilei, which started outward and upward. Where the pilei were single the top was horizontal, the outline almost kidney shaped with the indentation at the point of attachment of the stipe, the latter being vertical, and more or less irregular.

There is no doubt whatever that the specimen sessile on the maple trunk and the stipitate specimen on the ground are the same species. They developed together when removed, and all show exactly the same characteristics in all particulars except shape. Nor does there seem to be any doubt that these specimens agree with Murrill's *G. sessile*. They show exactly the characters by which he distinguishes this species from *G. pseudoboletus*, except that some of them are stipitate, and a comparison of the specimens collected with those in the University collection labeled *Polyporus lucidus* shows marked differences, in color, general appearance, character of margin and of pores. The bands of color are exactly as described for *G. sessile*. The margin is very thin and acute, curved somewhat downward in one specimen. The pores are more irregular, often larger, and the dissepiments thinner than in Polyporus lucidus Fr. If the specimens are *Ganoderma sessile* the description of that species ought to include stipitate forms. If they are merely variations of *G. pseudoboletus* (Polyporus lucidus), it would seem that G. sessile is not a well marked species.

The specimens from Allen's woods were growing in very moist ground, and were themselves very wet at the time of collecting, so that considerable water could be squeezed out of them. They were very pliant, but quite tough. After drying they are hard and woody.

As to the parasitism of this fungus, the evidence is not conclusive, since it was not possible to determine by external observation alone how far the maple tree mentioned was affected. If the tree dies and is removed an opportunity to do this will be given. When the fungus was found in fruit on the base of the trunk and also on the ground in the direction toward the nearest walk, it suggested the thought that here was a wound parasite, which had gained entrance to the host at the point where the roots were cut off in laying the nearest walk, had progressed along the root to the base of the trunk, and had produced its sporophores at the base of the trunk as well as from the infected root. The sporophores in the latter position being the stalked forms, since the root was under ground and in a horizontal position. The stalk of one was followed into the ground for three or four inches, but could not be followed as far as a root, nor did it seem to run out laterally into mycelial threads. It seemed to mix with the soil and be indistinguishable from it. On the base of the trunk the sporophore was very closely attached by a broad surface, and had to be cut off with a knife. The bark seemed to be permeated by the mycelium, but no attempt was made at the time of collecting the fungus to determine the extent of injury to the tree.

At the present writing (April, 1905) the tree is still alive, as the buds are swelling preparatory to opening, but a close examination of the trunk shows an area of dead bark, taking the form of a narrow triangle with its base at the point where the sporophore was produced, and its apex about one meter above. This triangle is only a few decimeters wide at the widest part, and its exact limits were not determined for its whole boundary. The bark is dead, brown and brittle down completely to the wood. The cambium is dead also. The outer layers of wood however are solid and apparently uninjured. and "bleed" at the slightest knife cut. On neighboring parts of the trunk the inner layers of bark are light colored, fresh, tough, and with all the appearance of being alive.

On looking for possible points of infection on the trunk, two were found that need mention. One was a small area of exposed dead wood about thirty-five centimeters from the ground, not far from one side of the triangle of dead bark mentioned above. This was surrounded by a healthy growth of bark, which was of several years growth and had almost closed over the old wound. There was no evidence that this had served as the point of infection for the triangle of dead bark, since they were separated by several inches of healthy bark. The other possible point of infection was a dead stump of a branch not yet closed over by growth, about three meters above ground, and directly above the vertex of the triangle of dead bark. Here again, however, there was a long space of healthy bark, about two meters of it, between the dead stub and the triangle. Hence there was no reason for supposing a connection between the two.

Taking into consideration the location of the triangle of dead bark and the shape, it is reasonable to conclude that the cause of death started at the base, where the sporophore of *Ganoderma sessile* had been found, and progressed upward to the vertex of the triangle.

It becomes probable then that this fungus is a parasite, and perhaps the cut roots became the point of infection, while the reduced vitality and vigor brought about by the loss of water made the tree an easy victim for the fungus.

To sum up: Ganoderma sessile has stipitate as well as sessile forms, and this fact should be recognized in the description. It developed three sporophores in one spot during the same season, in July, in August, and September-October.

It is probably a wound parasite, destroying the bark and cambium, but not the living wood.

The last point needs further confirmation, and observations will be continued on the tree for future developments.

University of Michigan.

A CANKER OF THE YELLOW BIRCH AND A NECTRIA ASSOCIATED WITH IT.

JAS. B. POLLOCK.

In January, 1905, Miss Harriet W. Thomson sent to the botanical laboratory at the University of Michigan some branches and twigs of a yellow birch that were badly affected by a form of canker. The material was collected near Port Sanilac, Michigan, and the cause of the trouble, whatever it is, has been at work for a number of years, as shown by the growth of the larger branches since they were first attacked. The collector of the material however can remember when the birches of this same place were completely free from any such trouble, so that it may have been of recent origin in that region.

The largest branches sent in were about 5 cm. normal diameter, but in the enlarged parts adjacent to the dead areas the diameter of some was 7 cm. or more. On the young branches it was easily seen that the disease started around the base of dead twigs in a considerable number of cases. The cause of the trouble does not spread rapidly in the tissues of the wood, since cankered spots separated not more than 5 cm. have not coalesced after several years development. Often the dead areas extend farther in the direction of the circumference of the stem than in the direction of its long axis. A branch may be almost girdled, and yet the dead part has only a slight extent vertically. Thus, one spot measured 14 cm. in the direction around the branch, over the swollen parts adjacent to the dead area of wood, while above and below the dead area the edges of the callus with which the tree tries to cover over the wound were only 1 cm. apart at the nearest point, and 2.5 cm. at the widest part. Apparently the cause of the trouble acts as a stimulus to growth of the living parts adjacent to the killed portion, and this leads to the disfiguring knots or swellings at the border of the dead areas. Over some of the cankered spots on the small branches the outer layers of the bark are still continuous, though the hypertrophy about the border is well marked, leaving a depressed center, which is probably caused not by the actual sinking in of that tissue, but only by the hypertrophy of the tissue around it.

The canker is not only a great disfigurement to the tree, but must seriously interfere with its growth by cutting off a large part of the path along which both water and reserve food must be transported. It is certain, however, that an attacked branch may live and grow for years after the first attack, and perhaps death results only where the branch is completely girdled, and the food and water transportation completely cut off. One branch, with a normal diameter of 13 cm. and a diameter of the swollen part of 20 cm., had only 3.2 cm. of uninjured wood and bark on one side, measured tangentially, yet this branch was alive both above and below the canker that almost girdled it. The capacity of such a branch to transport food and water must be very seriously impaired.

The only organism observed that might be the active agent in the production of the canker was a species of Nectria, fruiting bodies of which were scattered over the surface and in the cracks of dead bark around the canker spots.

On trying to identify the species some difficulty was experienced, as it did not seem to agree exactly with any of the descriptions in Saccardo's Sylloge Fungorum, or Ellis and Everhart's North American Pyrenomycetes. In size of asci and spores it came within the limits of *N. cinnabarina*, but its external appearance was very different from that species. Mr. Preston, an advanced student at the University, has made cultures on artificial media of both N. cinnabarina and the one on the birch, and their cultural characteristics are quite different and constant. So it certainly is not N. cinnabarina. Since this species and also N. ditissima are given credit for producing canker diseases of many trees an attempt was made to identify it with the latter species. Here again the size of the spores and asci agrees rather closely with the descriptions of the various books, except that the spores are wider than the measurements given by Ellis and Everhart. However, comparison with the specimens of *N. ditissima* in North American Fungi, No. 1548, of the latter authors shows plainly that they are not the same. The Nectria upon the birch has larger perithecia, longer asci, thicker spores, and they are of a different shape and more variable in their size, especially the width, than those of *N. ditissima* examined.

Superficially the Nectria on the birch resembles *N. coccinea* (Pers.) Fr., and a close comparison with the specimens of that species in the University herbarium shows a very close similarity in all points, but they do not exactly agree with the descriptions of *N. coccinea* in the books. Hence it is deemed advisable to give the description of the Nectria as found on the yellow birch.

Perithecia single or gregarious, sometimes cespitose, 280-330 m*u* in diameter, obovoid to globular, somewhat conical-papillate, on a stroma which is erumpent, flattened or almost obsolete, a mere stalk with single perithecia, young ones light red, older ones dark red, none seen collapsed; asci cylindrical while young, clavate when old, 70-90 x 9-18 mu, 8-spored; ascospores sometimes monoseriate, generally biseriate only in the widest part of the ascus, varying from pointed elliptical to oval, the former being long and narrow, the latter thicker and somewhat shorter, 11.5-20 x 4.5-9 mu, the thicker ones usually 14-16 x 7-9 mu (this seems to be the mature form), uniseptate, often slightly constricted at middle, especially the thick ones, hyalin in color.

Habitat, on dead bark around the cankered spots on yellow birch, *Betula lutea*, Port Sanilac, Michigan.

The difference in shape and dimensions of spores seems to be due, to some extent at least, to the maturity of the spores and the way in which they lie in the ascus. It seems as if the spores may be pointed elliptical, almost spindle-shaped in the younger stage, while lying closely packed obliquely in the ascus, and later, on becoming free, or on absorbing more reserve food they become thicker, shortening slightly as they swell out laterally and becoming rounded instead of pointed.

Whether this fungus, *Nectria coccinea* is the cause of the canker on the yellow birch, the observations of course have not determined, but in view of the fact that other species of Nectria are known to produce canker of many species of trees it would not be very surprising if this species also could produce the same reaction on some hosts. Only experimental work can determine that point, and it is hoped that some work can be carried out along this line. Mr. Preston has made pure cultures of the Nectria and is at present engaged in studying some of its characters under culture.

Conclusion: The yellow birch is subject to a canker which causes great disfigurement of twigs and large branches, greatly impairing their functions.

The disease is local, not spreading indefinitely from a given point of infection, but spreads by new inoculation.

The points of infection are often the bases of dead lateral twigs, and the cause of the trouble is probably a wound parasite of some kind.

The perithecia of Nectria coccinea (Pers.) Fr. were found associated with the cankered spots, both larger and smaller, and possibly this is the cause of the disease. As yet there is no experimental proof of this supposition.

University of Michigan.

A SPECIES OF HORMODENDRUM ON ARAUCARIA.

Jas. B. Pollock.

The attention of the writer has been called recently to an olive colored mold-like growth on the surface of living branches and leaves of an Araucaria grown as a house plant by Mrs. R. C. Davis of Ann Arbor. The growth is not copious, but is easily visible to the naked eye by the fact that the parts coated by the fungus are of a noticeably different color from the unattacked parts, the former being a darker olive green or brownish green color.

A hand lens showed a filamentous mycelium, and on placing some of the infested leaves in a moist chamber for a few days a well developed growth of conidiophores and conidia was found, and from these the fungus was easily identified as a species of Hormodendrum, but did not seem to be exactly like any of the species described by Saccardo in the Sylloge Fungorum. On looking up the literature it became probable that it was *Hormendendrum cladosporioides* Sacc. A fungus that has been described by several authors as a form of a polymorphic fungus, *Cladosporium herbarum*.

Later the fungus was found in a green house at Ann Arbor growing on diseased violet leaves, associated with *Alternaria violæ* and at the present time experiments are going on at the University of Michigan to determine whether it is parasitic on the violet, and if possible to discover whether it is a form of *Cladosporium herbarum*.

Only one of the species of Hormodendrum has been described as an active parasite, *H. Hordei*, a species quite destructive to barley. If the one found on Araucaria is a parasite it is certainly not a very active one, since it may be present for a considerable period of time without visibly injuring the host. When the Araucaria was first brought to notice it had been badly injured in certain portions, but no trace of the Hormodendrum was found on the obviously injured part, and the part occupied by the fungus showed no serious results. Another Araucaria in the green house mentioned above was also found to have the same fungus on it, nor did it seem to be doing any damage there.

The question arises whether the Hormodendrum is parasitic or not upon the Araucaria. If it is parasitic, it is very weakly so, but if it is not a parasite, it is difficult to understand how it can grow upon the surface of a plant like the Araucaria. If it can live merely on the dust that collects on the surface of such a plant, together with any dead material which the host plant may shed on the surface, and do this in the comparatively dry atmosphere of an ordinary living room in a dwelling house, then it has some remarkable physiological characteristics. This possibility will be taken into consideration in the experiments with the fungus.

The Araucaria plant first mentioned had been kept in the green house for a portion of the year, and the owner of the Araucaria thought that it bore the fungus when returned to her home. The moist atmosphere of a green house of course might furnish conditions favorable to the growth of the fungus, and it may not have spread any in the dryer atmosphere of the dwelling. That it was alive, however, in the latter place was shown by the growth on the detached leaves in a moist chamber, so that either the mycelium or the spores or both must be resistant to the dryness of an ordinary living room. One writer has suggested that a fungus growing in such a way might not be actively parasitic, and yet be injurious to the plant upon which it grew by stopping up the stomata, and so interfering with the functions of the host. Experiments are in progress which it is hoped will throw some light on the questions naturally suggested by the facts reported above.

University of Michigan.

MICHIGAN FUNGI.

JAS. B. POLLOCK AND C. H. KAUFFMAN.

In the fourth report of the Michigan Academy of Science Mr. B. O. Longyear, formerly of the Michigan Agricultural College, began for the Academy the publication of a list of Michigan fungi. This list includes nearly all the species given in a former list by the same author and published in the report of the secretary to the State Board of Agriculture for 1898. Those species not so included were apparently all doubtful ones.

Since Mr. Longyear has left the state and undoubtedly will not continue the work begun, it seems desirable that some one else take it up and publish in the reports of the Academy from time to time lists of Michigan fungi, so that a knowledge of the fungus flora of the state may be available to all interested in the subject.

The present list has been prepared with this in mind, and the authors have used as a starting point the fungi in the herbarium of the University of Michigan. It is not intended to give a catalogue of the fungi in the University herbarium, but to present only those species of Michigan fungi not previously published by Mr. Longyear. The list as here given includes only the Ascomycetes, the imperfect fungi, and the Hymenomycetes. The authors have divided the work so that Mr. Kauffman prepared the list of Ascomycetes, and the families Clavariaceæ and Agaricaceæ, while Dr. Pollock made up the list of imperfect-fungi, and the families Polyporaceæ, Hydnaceæ and Thelephoraceæ.

Most of the fungi in the local collection in the University herbarium were collected by Prof. V. M. Spalding and Mr. L. N. Johnson, the latter especially collecting a large number of specimens. Other collectors who have added substantially to the local collection are Mr. G. H. Hicks, Mr. A. J. Pieters and Miss H. L. Merrow. Some other names also appear.

Many of the specimens have been identified by Dr. Peck of New York, or by Mr. Ellis of New Jersey, well known mycologists. It was deemed advisable to indicate this fact since the identification is thereby vouched for. Where no outside authority for the identification was indicated on the herbarium sheet, the authors have supposed that the collector was responsible for the identification. Ann Arbor is the locality except where stated otherwise. Fortunately the local collectors have been workers of more than average accuracy, and this was especially true of Mr. L. N. Johnson, whose collections were mostly made in 1893 and 1894. Mr. Johnson went over the whole herbarium, making many corrections in the older names, and in every way his work shows extreme care and accuracy. Nevertheless a few specimens were found which were obviously wrongly named, and some others which were doubtful. Those have not been included in the present list, which the authors hope will be reasonably reliable.

It is intended to continue the publication of species of other groups of fungi in the University herbarium, as well as to add to the collection of species known to occur in Michigan. Knowledge along this line is exceedingly meager, and the authors will be pleased to receive the co-operation of mycologists and collectors in all parts of the State. Material can be sent to either of the authors, directed to the botanical laboratory of the University of Michigan, Ann Arbor. Mr. Kauffman is especially interested in the fleshy fungi, and Dr. Pollock is especially interested in the woody fungi.

The authors have followed Engler and Prantl in the matter of names of orders, families and genera.

Among the imperfect fungi are included some species that are known to be conidial forms of Ascomycetes. It seems desirable to list these under the names given to the conidial form, even if the ascus fruit form is known.

A considerable number of specimens listed are the same material as type specimens of new species. These are indicated in the list.

FUNGI IMPERFECTI.

SPHAEROPSIDALES.

Actinonema rosae Fr. On Rosa rubiginosa, August, 1890, Newcombe, Spalding.

Ascochyta cassandrae Pk. On living leaves of Cassandra calyculata, May 27, 1893, Johnson.

Cytospora albiceps E. and Kell. On Juglans regia and Carya alba, March 31, 1893, Johnson, *fide* Ellis.

Cytospora leucosperma (Pers.) Fr. On dead limbs of Acer saccharinum, November 8, 1893, Miss Langdon.

Cytospora persicae Schw. On peach, March 24, 1893, Johnson, *fide* Ellis.

Cystospora salicis (Corda) Rab. On Salix, February 25, 1894, Merrow.

Darluca filum Cast. On Phragmidium on Potentilla and on Melampsora salicina, July 18, 1892, August 14, 1891, Hicks.

Diplodia coryli Fckl ("Probably"). On Corylus Americana, March 24 and May 17, 1893, Johnson, *fide* Ellis.

Diplodia fibriseda (C. & E.) Ell. On Rhus, March 18, 1894, Johnson.

Diplodia juglandis Fr. On Juglans nigra, March 31, 1893, Johnson.

Diplodia maydis (Berk.) Sacc. On dead corn stalks, May 7, 1893, Johnson.

Diplodia sambucina Sacc. On Sambucus, April 26, 1894, Johnson.

Diplodia sassafras Tr. & Earle. On Sassafras, April 7, 1895, Johnson, *fide* Ellis.

Diplodia viticola Desm. On Vitis, April 8, 1893, Johnson.

Discosia artocreas (Tode) Fr. On leaves of Sarracenia purpurea and on hickory nut, April 28, May 26, August 17, 1893, Pieters, Johnson.

Dothichiza cassandrae E. & E. n sp. On Cassandra calyculata, April 26, 1894, Johnson. Type from same stick. Ellis says it is probably the spermagonium of Cenangium cassandrae.

Dothiorella macrospora B. & C. ("Probably"). On Sambucus, April 8, 1893, Johnson, *fide* Ellis.

Entomosporium maculatum Lev. Var. cydoniae C. & E. On Cydonia vulgaris, August and September, 1887. Spalding.

Haplosporella ribis Saccardo. On Ribis floridum, April 1, 1893, Johnson, *fide* Ellis.

Macrophoma rhoina E. & E. On decorticated Rhus, with Teichospora rhypodes E. & E. Johnson, *fide* Ellis.

Phleospora aceris (Lit.) Sacc. On box elder, Pieters, and maple, Michigan Agricultural College, Beal.

Phleospora anemones E. & R. On Anemone virginiana, Grand Ledge, Beal.

Phoma agaricicola E. & E. n. sp. On decaying agaric, November 4, 1894, Johnson, Type from same material.

Phoma sassafras E. & E. On Sassafras, May 2, 1893, Johnson.

Phoma strobiligena Desm. On pine cones, April 5, 1893, Johnson.

Phoma vaccinii E. & E. n. sp. On leaves of Vaccinium oxycoccus. Type from some twig, April 18, 1893, Johnson.

Phyllosticta acericola C. & E. On Acer rubrum, July 3, 1893, Newcombe.

Phyllosticta ampelopsides E. & M. On Ampelopsis quinquefolia, June 22, 1891, M. A. C., Beal.

Phyllosticta anemonis E. & E. n. sp. On Anemone Pennsylvanica, October 30, 1893, Merrow.

Phyllosticta cruenta Kicks. On Smilacina stellata and S. racemosa. July, 1892, Merrow, Spalding.

Phyllosticta fraxinicola Carr. On Fraximus. Battle Creek, September 12, 1885, Spalding.

SPHAEROPSIDALES—*Continued:*

Phyllosticta hamamelidis Cke. On Hamamelis virginiana, June, August, 1892, Merrow, Spalding.

Phyllosticta humuli S. & E. var. major E. & E. On Humulus lupulus, May 30, 1894, Merrow.

Phyllosticta iridis E. n. sp. On Iris versicolor, July 12, 1892, Merrow.

Phyllosticta phomiformis Sacc. On Quercus alba, September 20, 1893, Pieters, *fide* Ellis. In the summer of 1903 this fungus was very abundant on Q. alba in the vicinity of Ann Arbor, many trees having partially dead leaves and looking as if scorched.

Phyllosticta smilacis E. & M. On Smilax, August 8, 1894, Merrow, *fide* Ellis.

Rhabdospora continua (B. & C.) Sacc. On dead scapes of Plantago major, May 11, 1893, Johnson.

Rhabdospora lonicerae (C. & E.) Sacc. On Lonicera, April 17, 1893, Johnson, *fide* Ellis.

Rhabdospora subgrisea Pk. On stems of Solidago, April 4, 1893, Johnson, *fide* Peck.

Septoria Albaniensis Thum. On Salix lucida, Battle Creek, Ann Arbor, August 29, 1885, September 8, 1888, Spalding.

Septoria aquilegiae Penz & Sacc. On Aquilegia Canadensis, M. A. C., October 3, 1891, Beal. Spores larger than in type, 2 x 40-50 mucrous.

Septoria asplenii E. & E. n. sp. On Asplenium angustifolium, M. A. C., October 2, 1891, Hicks.

Septoria atropurpurea Pk. On Aster macrophyllus, July 18, 1892, Spalding.

Septoria cannabis (Lasch) Sacc. On Cannabis sativa, July and October, Spalding.

Septoria cirsii Niessl. On Cnicus muticus, November 11, 1893, Johnson.

Septoria consocia Pk. On Polygala Senega, April, 1878, Spalding.

Septoria conspicua Ell & Mart. On Stironema ciliatum, Ann Arbor, Merrow and Spalding; New Baltimore, Pieters; Park Lake, Beal and Wheeler; M. A. C., Hicks, July to September.

Septoria convolvuli Desm. On Convolvulus sepium, North Lansing, September 27, 1890, Beal.

Septoris coptidis B. & C. On Coptis trifolia April, 1892, Pieters.

Septoria cornicola Desm. On species of Cornus, Ann Arbor, New Baltimore, North Lansing, August to October, Johnson, Spalding, Pieters, Beal.

Septoria corylina Pk. On Corylus Americana, September 22, 1894, Johnson.

Septoria crataegi Kick. On Crataegus, New Baltimore, August 13, 1893, Pieters.

Septoria dianthi Desm. On carnations in green house, October 15, 1893, Pieters, *fide* Ellis.

Septoria divaricata E. & E. On Phlox divaricata, April 20, 1894, Pieters, *fide* Ellis.

Septoria dolichospora E. & E., North Lansing, October 5, 1890, Beal.

Septoria erigeronis Pk. On living leaves of Erigeron. annuus, June 7, 1893, Pieters. Saccardo gives this as Septoria erigerontea. Pk.

Septoria flagellaris E. & E. On Convolvulus sepium, Battle Creek, September 8, 1885, Spalding.

Septoria hippocastani B. & B. On Aesculus hippocastanum, M. A. C., October 27, 1891, Beal.

Septoria infuscata Wint. On Lepachys pinnata, July 18, 1887, Spalding.

Septoria lactucae Pass. On Lactuca sativa Ann Arbor and M. A. C., 1890, August 16, 1895, Merrow, Beal.

Septoria lapparum Sacc. On Arctium lappa, October 8, 1890, M. A. C., Beal.

Septoria littorea Sacc. On Apocynum androsaemifolium, September 22, 1894, Johnson.

Septoria lysimachiae, Ell. & Halst. On Steironema ciliatum, New Baltimore, August 13, 1893, Pieters.

Septoria malvicola Ell. & Mart. On Malva rotundifolia, Ann Arbor, Johnson, Spalding; Battle Creek, Spalding, October and November.

Septoria mirabilis Pk. On Onoclea sensibilis, Battle Creek, August 19, 1885, Spalding.

Septoria oenotherae West. On Oenothera biennis, Ann Arbor, New Baltimore, Battle Creek, M. A. C., Merrow, Pieters, Spalding, Wheeler.

Septoria pileae Thum. On Pilea pumila, August 16, 1892, Spalding.

Septoria petroselini Desm. On cultivated parsley in green house, January 13, 1894, Merrow.

Septoria piricola Desm. On living leaves of pears, September 22, 1892, Pieters, June 1903, Pollock.

Septoria podophyllina Pk. On Podophyllum peltatum, Ann Arbor, New Baltimore, Merrow, Johnson, Spalding.

SPHAEROPSIDALES—*Continued:*

Septoria polygonicola (Lasch.) Sacc. On Polygonum hydropiper, Battle Creek, September 3, 1885, Spalding.
Septoria polygonorum Desm. On living leaves of Polygonum lapathifolium. Ann Arbor, Battle Creek, Pieiters, Spalding, July to September.
Septoria populicola Pk. On Populus balsamifera, Battle Creek, N. Michigan, September, Spalding, Beal.
Septoria pruni Ell. On Prunus virginiana, N. Michigan, September, 1890, Beal.
Septoria psilostega Ell. & Mart. On Galium circaezans, June 9, 1894, Johnson.
Septoria ribis Desm. On Ribes (cult.) R. rubrum, R. prostratum, Ann Arbor, Battle Creek, M. A. C., August and September, Merrow, Spalding, Wheeler.
Septoria rubi West. On leaves of Rubus, Ann Arbor, Battle Creek, July to September, Johnson, Spalding.
Septoria scrophulariae Pk. On Scrophularia nodosa, Ann Arbor, Battle Creek, July September, Merrow, Spalding.
Septoria scutellariae Thum. On Scutellaria lateriflora, M. A. C., October 3, 1891, Hicks.
Septoria sicyii Pk. On fruit and cotyledons of Echinocystis lobata, April 28, 1893, and June 11, 1895, Johnson.
Septoria sisymbrii Ell. On Sisymbrium officinale May 22, 1892, Merrow.
Septoria solidagonicola Pk. On Solidago Canadensis, June 23, 1894, Pieters.
Septoria toxicodendri M. A. Curtis. On Rhus toxicodendron, July, August, Spalding, *fide* Ellis.
Septoria trillii Pk. On Trillium erectum, May 26, 1894, Johnson.
Septoria verbenae Robt. & Desm. On Verbena urticaefolia and V. hastata, June, July, Merrow, Johnson.
Septoria veronicae Rob. On Veronica arvensis, May 21, 1894, Pieters.
Septoria violae Westd. On Viola pubescens, May 25, 1894, Johnson.
Sphaeropsis gleditschiaecola Cke. On Gleditschia triacanthos, April 8, 1893, Johnson.
Sphaeropsis menispermi Pk. On Menispermum Canadense, May 24, 1894, Merrow.
Sphaeropsis Mali (West) Sacc. On dead limbs of cultivated apples, March 24, 1893, Johnson.
Sphaeropsis malorum Pk. On decaying apples, Johnson.
Sphaeropsis pericarpi Pk. On pericarp of Carya, April 3, 1893, Johnson.
Sphaeropsis sambuci Pk. On Sambucus, March 31, 1893, Johnson.
Sphaeropsis smilacis E. & E. On Smilax hispida, April 8, 1893, Johnson.
Vermicularia compacta C. & E. On dead stems of Asclepias, common, April 8, 1893, Johnson.
Vermicularia coptina Pk. On Coptis trifolia, May, 1892, Pieters.
Vermicularia liliacearum West. On herbaceous stems, and on Allium Canadensis, May and July, Merrow, Johnson.
Vermicularia Peckii Sacc. On Viola cucullata, May and August, 1873, Merrow.
Vermicularia subglabra Cke. & Hark. On Helianthus, May, 1904, Johnson.

MELANCONIALES.

Cylindrosporium Dearnessii E. & E. On Carpinus Americana, June 9, 1894, Johnson.
Cylindrosporium fraxini E. & K. (N. A. F. 1639). On Fraxinus viridis, M. A. C., September 6, 1890, Beal.
Gloeosporium aridium Ell. & Holw. On leaves of Fraxinus, May 23, 1894, Johnson.
Gloeosporium Canadense E. & E. On Quercus alba, July 22, 1894, Merrow.
Gloeosporium caryae Ell. & Kell. On Carya alba Park Lake, September 2, 1890, Beal and Wheeler.
Gloeosporium coryli (Desm.) Sacc. On Corylus Americana, September 27, 1894, Johnson.
Gloeosporium fructigenum Berk. On apple fruits, M. A. C., February, 1892, Beal. [Glomerella fructigena (Clinton) Sacc.]
Gloeosporium septoriodes Sacc. On Quercus coccinea, Battle Creek, and Q. tinctoria, M. A. C., August, September, Spalding, Beal.
Gloeosporium venetum Speg. On Rubus, M. A. C., 1892, Beal.
Hendersonia Desmazieri Mont. On Platanus occidentalis, April 5, 1893, Johnson.
Leptothyrium vulgare (Fr.) Sacc. On Helianthus, May 4, 1893, Johnson.
Marsonia Delastrei (De Laer) Sacc. On Lychnis githago, Battle Creek, July 6, 1885, Spalding.
Marsonia juglandis (Lib.) Sacc. On Juglans cinerea, Battle Creek, August 22, 1885, Spalding, North Lansing, October 4, 1890, Beal.
Zythia aurantiaca (Pk.) Sacc. On Cornus alternifolia, May 4, 1893, Johnson.

HYPHOMYCETES.

Alternaria tenuis Nees. On fruits of Ptelea trifoliata and leaves of Asclepias cornuti, September, Pieters, Johnson.

Alternaria violae Dorsett. On violets in green house, January, 1905, Pollock.

Aspergillus glaucus (L) Link. with Eurotium herbariorum. On involucre of Buckeye, Pieters.

Aspergillus griseus Lk. On Merulius lachrymans, Alma, C. A. Davis, *fide* Peck.

Botrytis argillaceus Cke. On old wood, September 24, 1894, Johnson, *fide* Ellis.

Botrytis cinerea Schum. On rotten logs, September, 1894, Johnson.

Botrytis fuliginosa C. & E. On dead wood, April, September, Johnson, *fide* Ellis.

Botrytis vulgaris, Pers. On geranium leaves in green house, January 27, 1894, Johnson. On rose fruits which were on the bushes all winter, April 10, 1905, Pollock.

Camarosporium subfenestratum (B. & C.) Sacc. On Robina pseudacacia, June, 1894, Johnson.

Cephalothecium roseum Corda. On all sorts of dead plant material, including wood and bark, also as a contamination of cultures in the laboratory at all times of the year, Pollock.

Cercospora acalyphae Pk. On Acalypha Virginica, M. A. C., September 6, 1891, Hicks.

Cercospora apii Fr. On Apium graveolens, Jackson, July, 1893, Beal.

Cercospora apocyni E. & K. Apocynum cannabinum, North Lansing, Grand Ledge July, September, 1890, Dewey, Beal.

Cercospora beticola Sacc. On Beta vulgaris, Ann Arbor, Battle Creek, M. A. C., August and September, Spalding, Beal.

Cercospora cana Sacc. On Erigeron annuus and E. Canadense, June, August, Merrow.

Cercospora ceanothi K. & Sw. On Ceanothus Americana, September 22, 1894, Johnson. (Spores 100-200 mu long, brown.)

Cercospora cicumscissa Sacc. On cultivated cherry, July 18, 1892, Spalding.

Cercospora clavata (Ger.) Cke. On Asclepias cornuti, Ann Arbor, Grosse Isle, July, August, 1885, 1892, Spalding, D. H. Campbell.

Cercospora desmodii E. & K. On Desmodium acuminatum, July, August, 1890, 1892, Spalding.

Cercospora dubia (Reiss.) Wint. On Chenopodium album, Grosse Isle, August, 1885, Campbell.

Cercospora Echinocystis E. & M. On Echinocystis lobata, Battle Creek, September 8, 1885, Spalding.

Cercospora elongata Pk. On Dipsacus sylvestris, August 8, 1894, Merrow.

Cercospora grisella Pk. On Erigeron Canadense, Battle Creek, July 4, 1885, Spalding.

Cercospora menispermi E. & H. On Menispermum Canadense, Battle Creek, Spalding.

Cercospora Merrowi E. & E. n. sp. On Isopyrum biternatum, May 12, 1894, Merrow, Type from same source.

Cercospora microsora Sacc. On Tilia Americana, June, July, 1892, 1894, Spalding, Johnson.

Cercospora pustula, Cke. On Ampelopsis quinquefolia, M. A. C., August, 1890, Beal.

Cercospora resedae Fckl. On Reseda odorata, M. A. C., August 20, 1894, Wheeler.

Cercospora sagittariae E. & K. On Sagittaria variabilis, July, September, Johnson, Spalding.

Cercospora symplocarpi Pk. On Symplocarpus fetidus, August 25, 1894, Pieters.

Cercospora varia Pk. On Viburnum acerifolium, Grand Ledge, August 1, 1891, Beal.

Cercospora venturioides Pk. On Asclepias incarnata, M. A. C., October 5, 1890, Beal.

Cercospora viciae E. & H. On Vicia Caroliniana, October 13, 1894, Johnson.

Chaetopsis grisea Ehren. On Tilia Americana, May 23, 1895, Johnson, *fide* Ellis.

Chaetopsis rosella E. & E. n. sp. On Quercus, March 10, 1894, Johnson. Type from same material.

Cladosporium carpophilum. Thum. On Prunus vulgaris fruit, M. A. C., September 18, 1891, Beal.

Cladosporium herbarum (Pers.) Lk. On Eleocharis, September, December, 1893, Pieters, *fide* Ellis.

Dendryphium Ellisii Cke. On Quercus, September 25, 1894, Johnson, *fide* Ellis.

Didymaria Ungeri Corda. On Ranunculus septentrionalis, May 4, 1894, Pieters.

Epicoccum neglectum Desm. On leaves of Lindera benzoin and on Cratægus, September 24, 1894, Johnson.

Epicoccum purpurascens Ehrenb. On old paper, April 25, 1894, Johnson.

Exosporium tiliae Pk. On dead sticks of Tilia, June 3, 1893, Johnson.

Fumago vagans Pers. On Salix glaucophylla and Berberis vulgaris, M. A. C., July and September, Beal and Wheeler.

HYPHOMYCETES—*Continued:*

Fusarium lateritium Nees. On Robinia pseudacacia, June 1, 1894, Johnson, *fide* Ellis.

Fusicladium dendriticum (Wallr.) Fckl. (Perfect form is Venturia.) On leaves of apple and pear, Ann Arbor, Lansing, June to September, Pieters, Smith, Merrow, Spalding.

Fusicladium depressum B. & Por. On Angelica atropurpurea, M. A. C., October, 1891, Hicks.

Fusicladium fasciculatum C. & E. On Euphorbia Preslii, M. A. C., August 30, 1893, Wheeler.

Gonatobotrys flava Bon. On Mucorini (?) on decaying agaric, January 10, 1894, Merrow.

Gonytrichum caesium Nees. On Vitis, May 12, 1893, Johnson, *fide* Ellis.

Haplographium chlorocephalum Fres. On Carya, March 23, 1895, Johnson, *fide* Ellis.

Helicoma ambiens Morg. On Quercus, May 5, 1894, Johnson, *fide* Ellis.

Helicoma monilipes, Ellis and Johnson, n. sp. On bark of Quercus, May 5, 1894, Johnson. Type from same material.

Helicomyces cinereus Pk. On fallen Quercus, June 3, 1894, Johnson.

Helicomyces elegans Morg. On bark of Populus, April 5, 1895, Johnson. (Spores not as wide as description.)

Helicomyces olivaceus Pk. On Corylus Americana and Quercus, April, May, 1893, Johnson.

Helicoon ellipticum (Pk) Morgan. On pine or hemlock boards, September 18, 1894, Johnson.

Heterosporium cladosporioides E. & E. n. sp. On old paper. April 28, 1894, Johnson. Type from same paper.

Illosporium carneum Fr. On Peltigera canina, April 29, 1893, Johnson.

Isaria felina (D. C.) Fr. On mouse dung, laboratory culture, February 10, 1894, Johnson.

Macrosporium iridis C. & E. On cultivated Iris, August 2, 1894, Merrow.

Monilia aurantiaca Pk. Occurs often in the laboratory as a contamination of other cultures, has exceedingly rapid growth of mycelium, Pollock.

Monilia aureo-fulva E. & E. On rotten logs, June, 1893, April, 1894, Johnson, Miss Langdon.

Monilia fructigena Pers. (Perfect form is Sclerotinia). On decaying peaches, cherries, plums, Johnson, Spalding.

Monilia Linhartiana, Sacc. On leaves of Cratægus, May, 1894, Pieters.

Oedocephalum roseum Cke. On decaying bean pods, October 23, 1893, Johnson.

Oospora fasciculata (Berk.) Sacc. & Vogel. On decaying oranges, March, 1894. Johnson.

Penicillium glaucum, Lk. On decaying Polyporus, Merrow. Grows on almost everything, the most frequent cause of contamination of cultures in the laboratory.

Podosporium rigidum Schw. On Rhus Toxicodendron, Johnson.

Polythrincium trifolii Kze. On Trifolium repens. Ann Arbor and Grosse Isle, Spalding and Campbell.

Ramularia armoraciae Fckl. On Nasturtium armoracia and Brassica nigra, Ann Arbor, Battle Creek, M. A. C., May, September, November, Spalding, Pieters, Beal.

Ramularia arvensis Sacc. On Potentilla norvegica, Ann Arbor, Whitmore Lake, May to August, Spalding, Johnson.

Ramularia celastri E. & M. On Celastris scandens, Ann Arbor, Battle Creek, August, September. Spalding.

Ramularia contexta E. & E. n. sp. On Menispernum Canadense, August 29, Spalding, Type from same package.

Ramularia decipiens E. & E. On Rumex crispus and R. obtusifolius, Ann Arbor, M. A. C., June to September, Spalding, Beal.

Ramularia dulcamarae Pk. On Solanum dulcamara, October 10, 1894, Johnson.

Ramularia hamamelidis Pk. On Hamamelis Virginiana, M. A. C., October 8, Beal.

Ramularia heraclei (Oud) Sacc. On Heracleum lanatum, June 8, 1894, Johnson.

Ramularia macrospora Fr. var. asteris Sacc. On Aster Novae-Angliae, Whitmore Lake, June 26, 1894, Merrow.

Ramularia mitellae Pk. On Mitella diphylla, August 4, 1894, Merrow.

Ramularia multiplex Pk. On Vaccinium oxycoccus, M. A. C., July 26, 1890, Beal.

Ramularia plantaginis E. & Mart. On leaves of Plantago major, Ann Arbor, Battle Creek, May, July, Johnson, Spalding.

Ramularia rudbeckiae Pk. On Rudbeckia laciniata, Ann Arbor, M. A. C., May, November, Johnson, Beal.

HYPHOMYCETES—*Continued:*

Ramularia taraxaci Karst. On Taraxacum officinale, Ann Arbor, M. A. C., May, September, Merrow, Beal.
Ramularia Tulasnei Sacc. On Fragaria, May to August, Merrow, Spalding, Smith.
Ramularia urticae Schw. On Urtica gracilis, Ann Arbor, Battle Creek, July, eptember, Merrow, Spalding.
Ramularia variabilis Fckl. On Verbascum thapsus, Ann Arbor, Battle Creek, June, July, Merrow, Johnson, Spalding.
Rhinotrichum Curtisii Berk. Rotten wood, June, September, Langdon, Johnson, *fide* Ellis.
Scolecotrichum graminis Fck. On Glyceria fluitans and Phleum pratensis, Battle Creek, Ann Arbor, July, Spalding, Pieters.
Septonema spilomeum Berk. Common on fence rails, April 28, 1893, Johnson.
Sporodesmium vesiculosum E. & E. n. sp. On rotten wood, September 20, 1894, Johnson. Type from same log.
Streptothrix atra B. & C. On Juniperus Virginiana, common. Juglans cinerea (*fide* Ellis) and Hamamelis, April, 1893, Johnson.
Strumella coryneoides Sacc. & Wint. On dead bark of Quercus, March 2, 1895, Shaffner and Pieters.
Stysanus stemonites (Pers) Corda. On dung of muskrat and dove, Johnson; also on slice of potato that had brown vascular bundles, in culture dish in laboratory, 1903, Pollock.
Trichoderma lignorum (Tode) Fr. On Quercus, April 15, 1893, Johnson, *fide* Ellis.
Trichosporium sphaericum Sacc. On Zea mays, November 25, 1894, Johnson.
Trimmatostroma Americana Thum. On dead limbs of Salix, very common, March 11, 1893, Johnson.
Tubercularia celastri Sz. On Celastrus scandens, March 24, 1893, Johnson.
Tubercularia vulgaris Tode. (Condial form of Nectria cinnabarina). On Gleditschia triacanthos, April 8, 1892, Johnson. On dead hickory twigs, November, 1904, C. A. Davis, *fide* Pollock.
Zygodesmus bicolor E. & E. On rotten wood, October 23, 1893, Johnson, *fide* Ellis.
Zygodesmus olivacea-cinereus E. & E. n. sp. On rotten wood, September 15, 1894, Johnson. Type from same material.
Zygodesmus pruinosus E. & E. n. sp. On wood, September 20, 1894, Johnson. Type from same log.

HYMENOMYCETINEAE.

HYDNACEAE.

Hydnum sulphureum Schw. On Ulmus Americana, September, Johnson.
Irpex mollis B. & C. On logs, in May, Pieters.
Irpex sinuosus Fr. On rotten wood. May be collected all through the year, Pollock.

POLYPORACEAE.

Fomes (Ganoderma) sessile Murrill. On living maple trunk and on the ground, Ann Arbor, July, August and October, Pollock.
Merulius incarnatus Sz. On rotten logs, May, 1895, *fide* Ellis.
Merulius pulverulentus Fr. On Larix Americana, Ann Arbor, May, *fide* Ellis.
Polyporus fumosus Pers. On rotten logs and stumps, collected in autumn by numerous collectors, rather common.
Polyporus picipes Fr. On logs, May, Pieters, Johnson, Pollock.
Poria floccosa Fr. On logs, Ann Arbor, September, Johnson, *fide* Peck.
Poria inermis E. & E. On decaying logs, on Quercus and on Salix, Johnson, *fide* Ellis. Also found on Crataegus by Kauffman and on wild plum by Wood. It is distinctly stratose in old specimens, and in this resembles a resupinate form of Fomes. This stratose form may become several millimeters thick, and the writer has seen several specimens a centimeter or more thick.
Poria mollusca Fr. On old stumps, May, Johnson, *fide* Ellis.
Poria semitincta Pk. On dead half buried sticks, April, Johnson, *fide* Peck.
Poria sinuosa Fr. On dead logs, September, Johnson, *fide* Ellis.
Trametes rigida Berk. & Mont. On dead limbs in woods, April, Shaffner.

THELEPHORACEAE.

Corticium salicinum Fr. On Salix, Februrary and April, Pieters, *fide* Peck.
Hymenochaete imbricata (Schw.) Lev. On rotten wood, April, Graves.
Solenia ochracea Hoff. On Carpinus, April, November, Johnson, Langdon.
Stereum bicolor (Pers.) Fr. On dead wood, Pollock.

J. B. P.

CLAVARIACEAE.

Clavaria mucida Pers. On rotten wood. Ann Arbor, Oct. 21, *fide* H. L. Merrow.
Clavaria pyxidata Pers. On ground. Ann Arbor. Summer. *fide* Ellis.

AGARICACEAE.

Collybia amabilipes Pk. In woods. Ann Arbor, May 23, *fide* Peck.
Collybia cirrhata Fr. On rotten wood. Ann Arbor, Oct. 12, *fide* C. H. K.
Crepidotus albidus E. & E. n. sp. (The type taken from this material.) On dead trees. Ann Arbor, May 23, 1894. *leg* A. J. Pieters.
Crepidotus cinnabarinus Pk. n. sp. (The type taken from this material.) Logs. Ann Arbor, Sept. 24, 1894, *Leg.* L. N. Johnson.
Crepidotus malachius B. & C. Logs. Ann Arbor. Sept. 16, *fide* Peck.
Crepidotus mollis Schaeff. Logs. Ann Arbor. May 25, *fide* Ellis.
Flammula sapinea Fr. Woods. Ann Arbor, Nov. 8, *fide* Peck.
Inocybe calospora Quel. Woods. Ann Arbor, Oct. 16, *fide* Atkinson.
Inocybe geophila Fr. Ground in woods. Ann Arbor, Oct. 10, *fide* C. H. K.
Lepiota Friesii Lasch. Ground in woods. Ann Arbor, Sept. 21, *fide* C. H. K.
Lentinus Lecomtei Fr. Rotten log and stumps. Ann Arbor, June 6, *fide* Farlow.
Marasmius elongatipes Pk. Rotten log. Ann Arbor, May 5, *fide* Peck.
Mycena praelonga Pk. Ground. Ann Arbor, May 23, *fide* Peck.
Naucoria Highlandensis Pk. Ground. Ann Arbor, May 15, *fide* Peck.
Omphalia Epichysium Pers. Logs. Ann Arbor, Nov. 8, *fide* Peck.
Pleurotus applicatus Batsch. On oak. Ann Arbor, Oct. 23, *fide* L. N. J.
Pleurotus atro-caerulius Fr. On bark of trees. Ann Arbor, July 11, *fide* Bradfield.
Pleurotus dryinus Pers. Red oak stump. Ann Arbor, Oct. 20, *fide* Pollock.
Psilocybe camptopoda Pk. Rotten wood. Ann Arbor, Nov. 8, *fide* Peck.
Stropharia stercoraria Fr. Horse dung. Ann Arbor, Oct. 15, *fide* C. H. K.
Tricholoma terreum. Schaeff. Ground. Ann Arbor, Oct. 23, *fide* Peck.

ASCOMYCETES.

PROTODISCINEAE.

Exoascus deformans (Berk) Fckl. Peach leaves. Ann Arbor, June, *fide* Prof. Spalding.
Exoascus potentillae (Farl.) Sacc. On Potentilla. Ann Arbor, May, *fide* Ellis.

HELVELLINEAE.

Gyromitra esculenta (Pers) Fr. Ground. Ann Arbor, May 22, *fide* L. N. J.
Morchella esculenta (L) Pers. Ground. Ann Arbor, May 25, *fide* L. N. J.

PEZIZINEAE.

Ascobolus immersus Pers. Muskrat dung. Ann Arbor, Dec. 12, *fide* L. N. J.
Ascobolus purpureus Pers. Cow dung. Ann Arbor, Sept. 29, *fide* L. N. J.
Ascophanus carneus (Pers) Boud. Rotting Paper. Ann Arbor, Apr. 30, *fide* L. N. J.
Ascophanus pilosus Boud. Cow dung. Ann Arbor, Apr. 16, *fide* L. N. J.
Ascophanus saccharinus (B. & C.) Boud. Ann Arbor. Muskrat dung. *fide* L. N. J.
Bulgaria inquinans Fr. Dead wood. Ann Arbor, May 19, *fide* Spalding.
Cenangium populneum (Pers) Rehm. Populus branch. Ann Arbor, Mar. 25, *fide* C. H. K.
Cenangiun triangulare Fr. Oak twigs. Ann Arbor, May 12, *fide* Ellis.

PEZIZINEAE.—*Continued:*

Ciboria Johnsoni E. & E. n. sp. (Type taken from this material) On bare soil. May 6, 1893. *Leg.* L. N. Johnson.
Coryne sarcoides (Jacq) Tul. Sticks. Ann Arbor, Oct. 21, *fide* Peck.
Coryne Ellisii Berk. Rotten logs. Ann Arbor, Sept. 24, *fide* Ellis.
Helotiun citrinum (Hedw) Fr. Rotten wood. Ann Arbor, Oct. 23, *fide* L. N. J.
Sarcoscypha carneo-sanguinea Fck. IGround. Ann Arbor, Sept. 15 *fide* L. N. J.
Sarcoscypha coccinea Jacq. Ground. Ann Arbor. Apr. *fide* L. N. J.
Sarcoscypha occidentalis Schw. Dead sticks. Ann Arbor, May 25, *fide* L. N. J.
Phialia cyathoidea Bull. Sticks. Ann Arbor, Oct. 23, *fide* Ellis.
Mollisia cinerea Pers. Stalks of weeds. Ann Arbor, Nov. 26, *fide* L. N. J.

HYSTERIINEAE.

Dichaena faginea (Pers) Fr. On beech. Ann Arbor, May 13, *fide* Ellis.
Glonium lineare Fr. Sacc. Dead Hamamelis. Ann Arbor, Apr. 17, *fide* L. N. J.

PLECTASCINEAE.

Gymnoascus ruber Van Tieg. Mouse dung. Holland. leg. et. *fide* A. J. Pieters.

PYRENOMYCETINEAE.

Botryosphaeria fuliginosa (M. & N.) Ell. On Rhus & Quercus. Ann Arbor, Mar.-May. *fide* L. N. J.
Calonectria chlorinella (Cke) E. & E. On Ulmus Amer. Ann Arbor, Sept. 15, *fide* L. N. J.
Calosphaeria barbirostris (Dufour) E. & E. On Prunus & Quercus. Ann Arbor April, *fide* L. N. J.
Chaetomium bostrychodes Zopf. Muskrat dung. Ann Arbor, Feb. 3, *fide* L. N. J·
Chaetomium olivaceum C. & E. On old basket. Ann Arbor, Mar. 10, *fide* L. N. J.
Chaetomium olivaceum C. & E. var. chartarum E. & E. Paper in Laboratory. Ann Arbor, Apr. 6, *fide* L. N. J.
Claviceps purpurea (Fr) Tul. On Rye kernels. Ann Arbor, Aug. *fide* L. N. J.
Clypeosphaeria Hendersonia (Ell) Sacc. On Rubus. Ann Arbor, May. *fide* Ellis.
Cucurbitaria crataegi Schw. On Crataegus. Ann Arbor, May 10, *fide* Ellis.
Cucurbitaria cassandrae E. & E. n. sp. (Type taken from this material) On Cassandra. Ann Arbor. April 18, 1893. *leg.* L.N. Johnson.
Cucurbitaria elongata (Fr) Grev. On Robinia. Ann Arbor, May 4, *fide* Ellis.
Diaporthe albovelata (B. & C.) Sacc. On Rhus. Ann Arbor, *fide* L. N. J.
Diaporthe bicincta (C. & P.) Sacc. On Juglans. Ann Arbor, May 28, *fide* L. N. J.
Diaporthe leiphaemia (Fr.) Sacc. On Quercus. Ann Arbor, Apr. 1, *fide* L. N. J.
Diaporthe spiculosa (A. & S.) Nit. On Sambucus. Ann Arbor, Apr. 1, *fide* L. N. J.
Diaporthe ulmicola E. & E. On Ulmus. Ann Arbor, Apr. 24, *fide* L. N. J.
Diatrype albopruinosa (Schw) Cke. On Fagus, Corylus, Quercus. Ann Arbor, Mar.-Apr. *fide* Ellis.
Diatrype platystoma (Schw.) E. & E. On Acer. Ann Arbor, Apr. *fide* L. N. J.
Diatrype tumida E. & E. Ann Arbor. May 6, *fide* Ellis.
Diatrype virescens (Schw.) E. & E. On Fagus. Ann Arbor, May 25, *fide* L. N. J.
Diatrypella prom inens (Howe) E. & E. On Platanus. Ann Arbor, Apr. 8, *fide* L. N. J.
Diatrypella verrucaeformis (Ehr.) Nits. On Corylus. Ann Arbor, Apr. 31, *fide* L. N. J.
Didymosphaeria epidermidis (Fr) Fckl. var. herbeola E. & E. n. var. (Type from this material.) On Apocynum. Ann Arbor, *leg.* L. N. Johnson.
Erysiphe aggregata (Pk). Farlow. On Aments of Alnus. Charlevoix. *fide* Prof. Spalding.
Erysiphe cichoracearum D. C. Ann Arbor etc. on various hosts. Aug.-Oct., *fide* Spalding.
Erysiphe communis (Wallr) Fr. Ann Arbor etc. On various hosts. Aug.-Sept. *fide* L. N. J.
Erysiphe galopsides D. C. On Chelone & Scuttelaria. Lansing, Aug.-Sept. *fide* L. N. J.
Erysiphe graminis D. C. On Grass. Ann Arbor. *fide* Farlow.
Eutypa leioploea (Fr.) Cke. On Salix. Ann Arbor, Apr. 1, *fide* L. N. J.
Eutypa spinosa (Pers.) Tul. On Quercus. Ann Arbor, Apr. 1, *fide* L. N. J.
Eutypella cerviculata (Fr) Sacc. On Carpinus. Ann Arbor, Mar. 11, *fide* L. N. J.
Eutypella stellulata (Fr.) Sacc. On Rhus. Ann Arbor, May 7. *fide* Ellis.
Gnomoniella coryli (Batsch.) Sacc. On Corylus. Battle Creek, Aug.-Sept. *fide* Spalding.

PYRENOMYCETINEAE.—*Continued.*

Gnomoniella fimbriata (Pers) Sacc. On Carpinus. Sept. 10. Agr. College.
Hypocrea gelatinosa (Tode) Fr. Rotten wood. Ann Arbor, Sept. 20, *fide* L. N. J.
Hypomyces polyperinus Pk. On a Polyperus. Ann Arbor, April 25, *fide* Ellis.
Hypoxylon atropunctatum (Schw.) Cke. On Fagus. Ann Arbor, Apr. 22, *fide* L. N. J.
Hypoxylon caries (Schw.) Sacc. Wood. Ann Arbor, Nov. 11, *fide* A. J. Pieters.
Hypoxylon coccineum Bull. Sticks. Ann Arbor, May 26, *fide* L. N. J.
Hypoxylon cohaerens Fr. On Fagus. Ann Arbor, Apr. 29, *fide* L. N. J.
Hypoxylon fuscum (Pers) Fr. On Corylus. Ann Arbor, Mar. 31, *fide* L. N. J.
Hypoxylon Howeanum Pk. On Carpinus. Ann Arbor, May 13, *fide* L. N. J.
Hypoxylon marginatum (Schw.) Berk. On Quercus. Ann Arbor, Apr. 28, *fide* L. N. J.
Hypoxylon Morsei B. & C. On Ulmus Americana. Ann Arbor, April 1, *fide* Ellis.
Hypoxylon perforatum (Schw.) Sacc. On Corylus & Quercus. Mar. & Apr. *fide* L. N. J.
Hypoxylon rubiginosum (Pers.) Fr. On Salix & Quercus. Ann Arbor, Apr. & May, *fide* L. N. J.
Lasiosphaeria canescens (Pers.) Karst. Carpinus. Ann Arbor, Sept. 20, *fide* L. N. J.
Lasiosphaeria hispida (Tode) Fckl. Rotten log. Dec. 29, Ann Arbor, *fide* L. N. J.
Lasiosphaeria ovina (Pers.) Ces. & DeNot. On populus. Ann Arbor, Oct. 30, *fide* Ellis.
Leptosphaeria eustoma (Fr.) Sacc. On Zea. Ann Arbor, Nov. 25, *fide* Ellis.
Leptosphaeria dolium (Pers) Ces. & DeNot. On Helianthus, Apr. 28, *fide* L. N. J.
Leptosphaeria subconica (B. & C.) Sacc. Helianthus. Ann Arbor, May 15, *fide* L. N. J.
Leptosphaeria tritici (Gas.) Pass var. papicola E. & E. Old paper. Ann Arbor, May 5, *fide* Ellis.
Lophiostoma caulinum (Fr.) DeNot. On Lonicera & Verbascum. Ann Arbor, April 15, *fide* L. N. J.
Lophiostoma spiraeae Pk. On Physocarpus. Ann Arbor, Mar. 14, *fide* Ellis.
Massaria vomitaria B. & C. On Acer. Ann Arbor, May *fide* L. N. J.
Microsphaera alni (D. C.) Winter. On Syringa etc. Aug.-Sept. Ann Arbor, Lansing, Battle Creek, etc. *fide* Spalding.
Microsphaera diffusa C. & P. On Desmodium etc. Ann Arbor, Aug.-Sept. *fide* Spalding.
Microsphaera Euphorbiae (Pk.) B. & C. On Euphorbia. Aug.-Sept. Ann Arbor. Battle Creek, etc. *fide* Spalding.
Microsphaera grossulariae Wallr. On Sambucus. Ann Arbor, Sept. *fide* Spalding.
Microsphaera quercina (Schw.) Burrill. On Quercus. Ann Arbor, Sept.-Oct. *fide* Spalding.
Microsphaera menispermi Howe. On Menispermum. Ann Arbor, Sept. 23, *fide* L. N. J.
Microsphaera Russelii Clint. On Oxalis. Ann Arbor. Aug.-Nov. *fide* Spalding.
Nectria cinnabarina (Tode) Fr. On Celastrus. Ann Arbor, Mar. & Apr. *fide* L. N. J.
Nectria coccinea (Pers.) Fr. On Populus. Ann Arbor, Sept. & Oct. *fide* L. N. J.
Nectria episphaeria (Tode) Fr. On Diatrype, Valsa etc. Ann Arbor, Mar.-May. *fide* L. N. J.
Nectria perforata E. Holw. On bark. Ann Arbor, Sept. 24, *fide* Ellis.
Nectria pezizae Fr. On Salix. Ann Arbor, Sept.-Oct. *fide* L. N. J.
Nectria sanguinea (Sibth.) Fr. On rotten wood. Ann Arbor, Apr. & May. *fide* L. N. J.
Nectria vulpina Cke. Ann Arbor, *fide* Ellis.
Ophiobolus acuminatus (Sow) Duby. On Cnicus. Apr. 28, *fide* L. N. J.
Ophiobolus porphyrogenus (Tode) Sacc. On Solanum. Ann Arbor, Sept. 20, *fide* L. N. J.
Phyllactinia suffulta (Reb.) Sacc. On leaves of Fraxinus etc. Ann Arbor, Sept. & Oct. *fide* A. J. Pieters.
Pleonectria Berolinensis Sacc. On Ribis. Ann Arbor, *fide* L. N. J.
Pleospora aceris (Lib.) Sacc. On leaves of Negundo & Acer. Ann Arbor, Sept. 27, *fide* A. J. Pieters.
Plowrightia morbosa (Schw.) Sacc. On Plum trees. *fide* Spalding.
Podosphaera biuncinata C. & P. On Hamamelis. Ann Arbor, Aug. 25, *fide* Spalding.
Podosphaera oxycanthae (D. C.) On leaves of Prunus etc. Ann Arbor, etc., Aug. & Sept., *fide* Spalding.

PYRENOMYCETINEAE.—*Continued.*

Pseudovalsa haplocystis (B. & Br.) Sacc. Ann Arbor, Apr. 5, *fide* Ellis.
Pseudovalsa profusa (Fr.) DeNot. On Robinia. Ann Arbor, June 5, *fide* L. N. J.
Rosellinia aquila (Fr.) DeNot. On Salix. Ann Arbor, Apr. 4, *fide* L. N. J.
Rosellinia ligniaria (Grev.) Sacc. On chips. Ann Arbor, Apr. 18, *fide* L. N. J.
Rosellinia pulveracea (Ehr.) Fckl. On Rhus. etc. Ann Arbor, Mar. & May, *fide* L. N. J.
Rosellinia pulveracea Ehr. var. millegrana. Schw. On barrel staves. Ann Arbor, Apr. 17, *fide* L. N. J.
Rosellinia subiculata (Schw.) Sacc. Rotten wood. Ann Arbor, Sept. 24, *fide* Ellis.
Sordaria curvula DeBar. Muskrat dung. Ann Arbor, Feb. 3, *fide* L. N. J.
Sordaria fimicola (Rab.) Ces. & DeNot. var. papyricola. Wint. On paper Ann Arbor, Mar. 12, *fide* L. N. J.
Sphaerella impatiensis Pk. & Clint. On Impatiens (leaves) Ann Arbor, July 3, *fide* Spalding.
Sphaerella lactucae E. & K. Park Lake. On Lactuca. Sept., *fide* W. J. Beal.
Sphaerella pontederiae Pk. On Nuphar. Ann Arbor, Sept. 18, *fide* L. N. J.
Sphaerella sarracenae (Schw.) Sacc. On Sarracenia. Ann Arbor, June *fide* L. N. J.
Sphaerella zizaniae Schw. On Zizania. Agr. College, *fide*, W. J. Beal.
Sphaeria flabelliformis Schw. On logs. Ann Arbor, May 23, *fide* Ellis. (This is an abortive form of Xylaria according to Ell.)
Sphaerotheca castagnii Lev. Agr. College etc. Sept., *fide* W. J. Beal.
Sphaerotheca humuli (D. C.) Lev. On Spiraea etc. Ann Arbor, Oct., *fide* Spalding.
Sphaerotheca mors-uvae (Schw.) B. & C. On Ribes. Ann Arbor, June, *fide* Spalding.
Uncinula circinata C. & P. On Acer. Ann Arbor, *fide* L. N. J.
Uncinula Clintonii Pk. On Tilia. Ann Arbor, etc. Sept. *fide* L. N. J.
Uncinula macrospora Pk. On Ulmus. Agr. College. Aug., *fide* Wheeler.
Uncinula necator (Schw.) Burrill. On Ampelopsis & Vitis. Ann Arbor, Oct., *fide* Spalding.
Uncinula salicis (D. C.) Winter. On Salix. Agr. College. Oct., *fide* Beal.
Ustulina vulgaris. Tul. On logs. Ann Arbor, Mar., *fide* L. N. J.
Valsa ambiens (Pers.) Fr. On Larix, Crataegus, Pyrus, & Ulmus. Ann Arbor, Mar. & Apr., *fide* L. N. J.
Valsa borella Karst. On Salix. Ann Arbor, April 17, *fide* Ellis.
Valsa cornina Pk. On Cornus. Ann Arbor, Mar. 28, *fide* C. H. K.
Valsa cenisia DeNot. On Juniperus. Ann Arbor, Apr. 8, *fide* Ellis.
Valsa leucostoma (Pers.) Fr. On Prunus. Ann Arbor, May 12, *fide* L. N. J.
Valsa nivea (Hoff) Fr. On Populus. Ann Arbor, April 18, *fide* L. N. J.
Valsaria istiva Ces. & DeNot. On Carya, Vitis, Quercus & Corylus. Ann Arbor, Mar. & Apr., *fide* L. N. J.
Xylaria corniformis Fr. Ann Arbor, *fide* Spalding.
Xylaria polymorpha. (Pers.) Grev. Ann Arbor, *fide* L. N. J.

Most Pyrenomycetes grow on dead branches, twigs and stalks of the host given; the genera Erysiphe, Microsphaera, Podosphaera, Sphaerotheca, and Uncinula are parasitic on the leaves of living plants. The genus Sphearella (Syn. Mycosphaerella) also grows on leaves, but saprophytically.

As it is desirable to complete the list of the fleshy and ascomycetous fungi of Mich. any who are interested in the work are requested to correspond with the writer.

C. H. K.

A STUDY OF PLANTS IN RAVINES NEAR ADRIAN.

FRANCES L. STEARNS.

An attempt has been made to correlate the development of vegetation of the river valley with the physiographic changes which have marked the history of its establishment. These, briefly outlined, are the gully, the ravine, first with steep sides and later with a gentler slope, the bluff, and flood plain with meandering streams—this study does not include the flood plain.

The area worked on is a small part of the bank of the Raisin River at Adrian and the ravines of one of its tributaries. The Raisin is a small, sluggish stream meandering in a valley one-half to one mile wide with outer banks 25 to 100 feet high and at this point drains a part of the Defiance terminal moraine. The moraine forms knolls and depressions and the small streams are continually cutting back gullies and ravines. The soils are various, gravelly till, clay, sand and muck, seeming to be scattered without any system. Part of the drift is land-laid and in other places the gravel and sand is sorted by water and distinctly stratified. The development of the drainage is closely allied with the glacial history of the region and the mature river valley in its present condition may have passed through stages not now illustrated by any portion of the system, but various phases appear which can be taken as stages in the developmental history.

The initial stages of ravine formation are seen in the gullies. Where the original forest covering has been cut and the land is under cultivation the gully eats back rapidly, the washouts being most destructive in sandy and gravelly fields, no water remaining in the gully.

The first gully studied was in a cultivated field and was in a broad depression. It was about 50 feet long and 6 feet deep and cut through sand underlaid by clay. The shifting of the newly exposed soil produces nearly desert conditions. The plants which do develop are annuals or plants which have fallen down the side carried by part of the bank or those which spread by rootstalks.

The weeds of the cultivated field early gain a foothold on more stable sides. These are such plants as ragweed, Ambrosia artemisiæfolia, Lactuca scariola, Plantago major which are characterized by rapid growth and seed dispersal and protection from destruction by animals. Other weeds from neglected meadows, such as Aster and Thistle, are introduced by the seeds carried by wind. The most striking example of plants spreading by root stalks is Rumex acetosella. This is best seen in the second gully studied. This was in the same field and was about 90 feet long, 20 feet deep and cut in sand. Here Rumex sends rootstalks often five feet long down the side of the bank, acting as a soil binder. The same work is done less perfectly by grasses and sedges. This gully is very barren of vegetation, fewer weeds having developed than in the first. In the first of these gullies a small part of the side was covered by a characteristic ravine growth. Where the water seeped out of the soil, keeping the surface moist, mosses, algæ and liverworts appear. Oscillatoria, Botrychium and Conocephalus occur together.

The third gully is in open pastured oak-hickory woods. The soil is sand with a clay layer below. In this gully or young ravine there is great conservation of moisture and we find a smaller development of weeds; shrubs, blackberry and raspberry, gain a foothold; there is a greater development of hydrophytic mosses and algæ; the more hydrophytic plants characteristic of river margin invade the ravine running back from the river, examples are Prunella vulgaris and Impatiens biflora; herbs of oak-hickory forest, as Campanula rotundifolia, occasionally occur.

Gullies cut in the deeply shaded forest where there has been little change of drainage progress more slowly, since they are filled by accumulation of vegetable matter which enriches soil, holds moisture and prevents destruction by rain wash. The desert condition rarely appears in these localities or is of short duration. The gullies on the river bank studied are of this type, but are not in natural condition, being held by brush, etc.

A desert condition may also occur when the meandering stream cuts into the old outer bank. Here banks 20-50 feet of clay or sand rise almost vertically from the river and are devoid of vegetation except that which falls from the top. In this locality the destruction seems more rapid in clay than in sand, just the opposite being true for lateral extension of gullies.

Ravine I is three hundred feet long and thirty or more feet deep at its oldest part widening to twenty-five feet. It is cut partly in clay and partly in sand. There is an oak-hickory forest on the west and cultivated field on the east. Near the head the banks are washed out, forming side gullies, farther down we have true ravine, well developed, passing into a broad ravine at the outlet. The gullies are sand and are desert or are held by blackberry thickets in whose shade mesophytic herbs develop. There are also climbers, Rhus and Ampelopsis.

As some stability of bank is attained two groups of plants appear, a group of shrubs abutting on the forest and represented by Carpinus Caroliniana and Hamamelis Virginiana and a rich flora of mesophytic herbs on shady banks; this includes Adiantum pedatum, Trillium grandeflorum, Thalictrum dioicum, Mitella diphylla. The shrub zone rarely reaches the water's edge, but the stream is bordered by herbs and more hydrophytic plants, as Conocephalus, which also grow on the wet clay bank. These plants are adapted to shade, they bloom early and have thin leaves.

Scattered groups of Acer rubrum and Populus tremuloides occur on the bank.

In the shade of these shrubs and trees seedlings of the oak-hickory forest are developing and young Ulmus Americana, Tilia Americana and Fraxinus Americana are found.

In Ravine II practically the same relation of plants is found, but heavy blue clay is in all of the bottom and there is a much larger area covered by hydrophytic plants and stream margin and bog plants are found.

A broad ravine is found on the bank behind the cemetery where a small stream cuts through the river bank. Here we have deep shade and the size of the trees shows great age. There is an absence of pioneer plants even on the cut sides. The gully is filled by leaves. The characteristic thing is the mesophytic trees, Tilla Americana, Ulmus Americana, Acer saccharinum and with them Carpinus and Hamamelis. There are also shrubs which belong to the oak-hickory forest, Cornus floridus, Prunus Virginiana and the oak and hickory have invaded from the bank.

The arrangement of plants on an established bank is better shown in the diagram, 50 feet high, 120 feet long. This bank is 66 feet above level of the river.

The highest parts are covered by the oak-hickory forests spreading over bank. It soon meets the zone of ravine plants, elm, basswood, Hamamelis and the herbs, Thalictrum dioicum, fern, etc. There is a struggle to hold the bank and the oak-hickory is gaining ground. Below this the slope is wet by hillside springs and forms a bog which has a characteristic flora. The soil is black humus with much organic matter and with much lime a few feet below the surface. Still lower, quicksand is found. The plants which grow here are Tilia Americana **Fraximus** Americana, Cratægus, Ribes, Xanthoxylum Americana, but most abundant Spathyema, sedges, mosses, Cardamine bulbosa, Eupatroium, **purpureum**, Lobelia sylphitica, Galium asprellum, etc.

Its position suggests that this bog may not have been a part of ravine development, but may have been swamp or lake bottom when the river stood at different level. Mastodon bones found in similar place a quarter of a mile further point toward ancient origin.

The succession of groups of plants is shown by chart.

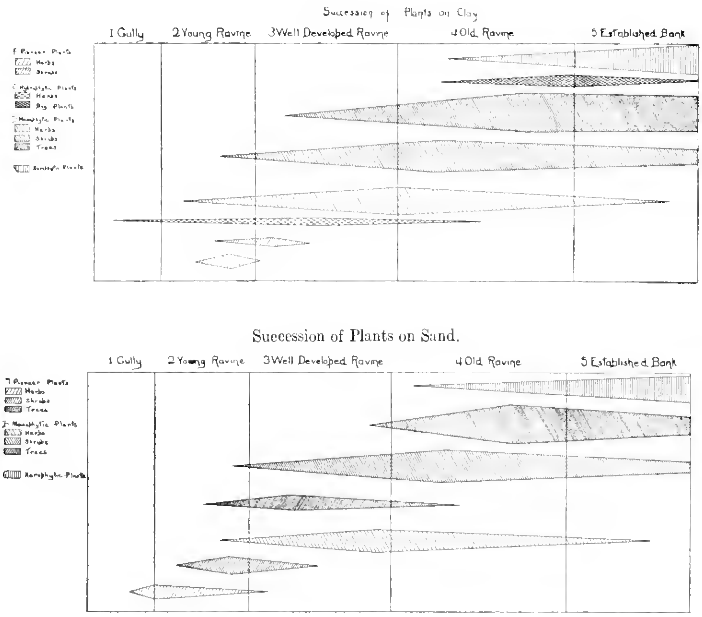


FIG. 1 — Charts showing the succession of plants in the development of ravines in clay and sandy soil.

LISTS OF PLANTS CHARACTERISTIC OF RAVINES.

Characteristic Pioneer Herbs
- Poa
- Rumex Acetosella
- Chaetolochia glauca
- Euphorbia maculata
- Lactuca Scariola
- Plantago major
- Rumex crispus
- Leptiloa Canadenses
- Ambrosia artemisiaefolia
- Lepidium Virginicum

Characteristic Pioneer Shrubs
- Rubus nigrobaccus
- Rubus occidentalis
- Rhus radicans
- Sambucus Canadenses
- Ribes cynosbati

Characteristic Pioneer Forest
- Acer Rubrum
- Populus tremuloides
- Populus grandidentata

Characteristic Mesophytic Trees
- Ulmus Americana
- Tilia Americana
- Acer Saccharinum
- Fraxinus Americana
- Ulmus fulva

Characteristic Mesophytic Shrubs
- Carpinus Cariolinana
- Hamamelis Virginiana
- Crataegus sp
- Cornus alternifolia (?)
- Prunus Virginiana (?)
- Parthenocissus quinquefolia
- Rhus radicans
- Amelanchier Canadensis

Characteristic Mesophytic Herbs
- Mnium
- Funaria
- Aulicomnia
- Bartramia
- Conocephalus
- Onoclea sensiblis
- Adiantum pedatum
- Polystichum acrostichoides
- Thalictrum dioicum
- Geranium maculatum
- Hepatica Hepatica
- Galium boreale
- Vagnera stellata
- Vagnera racemosa
- Trilium grandiflorum
- Salomonia biflorum
- Mitella diphylla
- Uvularia perfoliata
- Deringa Canadenses
- Solidago sp
- Aster sp

Characteristic Trees of the Oak-Hickory Forest
- Quercus alba
- Quercus rubra
- Quercus coccinea
- Hickoria glabra
- Hickoria alba

Characteristic Shrubs of the Oak-Hickory Forest
- Cornus florida
- Prunus Virginiana
- Ostrya Virginica
- Corylus Americana
- Crataegus sp
- Malus coronaria
- Gaylussacia resinosa
- Sassafras Sassafras
- Smilax rotundifolia

Characteristic Herbs of the Oak -Hickory Forest
- Antennaria plantagnifolia
- Falcata comosa
- Campanula rotundifolia
- Vicia Caroliniana
- Solidago sp.
- Hieracium scabrum
- Aster sp.
- Equisetum hymale
- Poa pratense
- Hepatica Hepatica
- Deringa Candensis
- Euphorbia corollata
- Monarda fistulosa

Characteristic Plants of Spring Bank

Trees
- Tilia Americana
- Fraxinus Americana
- Ulmus fulva
- Carpinus Caroliniana

Shrubs
- Sambucus Canadensis
- Xanthoxylum Americana

Herbs
- Conocephalus
- Mesophytic mosses
- Spathyema foetida

Characteristic Plants of Spring Bank

Herbs
- Geranium maculatum
- Cardamine bulbosa
- Menispermum Canadensis
- Eupatorium purpureum
- Teucrium Canadense
- Cicuta maculata
- Lobelia syphilitica
- Galium Aparine
- Galium asprellum
- Senecio aurens
- Sedges

Characteristic Plants of the Stream Margin
- Epilobium coloratum
- Impatiens biflora
- Eupatorium perfoliatum
- Prunella vulgaris
- Ranunculus sp

Hydrophytic Plants
- Oscillatoria
- Botrydium
- Conocephalus
- Mosses

Note. The nomenclature of Britton's Manual has been used.

The distribution of the plant groups is conditional on several factors: The first is the drainage. In general the height above water level divides the vegetation into upland and lowland floras. The first of these is mainly the one we have to deal with.

Usually the banks are dryer than the lowlands, but this is locally varied by the slope of the bank, steep banks not retaining water as well as slopes; again the moisture content varies with the soil, clays and water retaining soils may sustain mesophytic or hydrophytic groups of plants even on steep slopes; the collection of humus increases the water retaining power of soil, old banks even of steep slope supporting mesophytic plants.

Secondly, the physical nature of the soil also affects the succession in another way. The penetration of clays and hard soils by root stalks and seedlings is more difficult than of loose soils and these plants therefore appear later in clay. On the other hand the wet clay invites surface plants, as mosses, etc., and they readily develop. The pioneer herbs and shrubs which have rapid growth, are limited in clay.

Third, the atmospheric conditions affect the moisture content of the soil. The air is dryer and has a greater range of humidity on the banks than in the lowlands.

The temperature of both air and soil varies more on the high bank than in the lowland, while the soil of the bog below the surface has a lower and more constant temperature than is found elsewhere.

The light intensity probably excludes some plants from young ravines which develop when shade is afforded.

The most conspicuous factor affecting the succession of ravine plants is erosion. The cutting away of the soil desrtoys the old flora or carries it into the ravine and the cycle may be interrupted at any point and the succession started anew.

Adrian, Michigan, March 30, 1905.

CLIMATIC CENTERS AND CENTERS OF PLANT DISTRIBUTION.

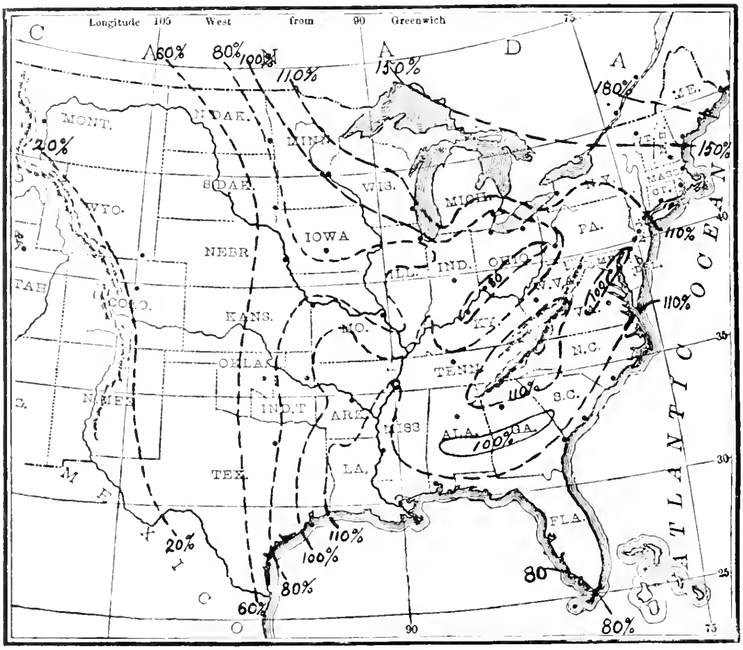
E. N. TRANSEAU.

Many attempts have been made to divide the continent of North America into zones or life areas which should represent natural divisions of the flora and fauna, and aid in the investigation of the geographic distribution of plants and animals. The earlier writers divided the continent into several transcontinental zones by means of isotherms. These zones were supposed in the main to correspond with the actual distribution of many ecologically or floristically related forms. Other authors, laying special emphasis on the relation between vegetation and rainfall, have recognized divisions having a generally north and south trend. Schimper, following Sargent, bases the climatic formations of North America on moisture mainly. Recently transcontinental zones have been worked out by Merriam, which are based on "sums of positive temperatures" during the growing season. These zones have been mapped in considerable detail and correlated with the distribution of plants, animals and crops. Still more recently, Adams has pointed out that both animals and plants are distributed about certain centers and do not follow transcontinental lines. Certainly in the case of the greater plant formations this is true, and transcontinental zones cannot be drawn which will include throughout plants of either the same ecological or floristic type. Taking, for example, the Transition zone of Merriam, there are brought together the forests of New England, the treeless plains of eastern Montana, the foothill forests of eastern Colorado, the pine lands of the Arizona plateau, the wooded slopes of the southern Coast Ranges and the dense conifer forests of the Puget Sound region. A greater mixture of vegetation types, viewed from either a floristic or ecological standpoint, is almost impossible. While such zones may be of very great value for an agricultural basis, they do not aid materially in pointing out forest relationships. In fact in so far as the forests are concerned there is a closer relationship between Merriam's Canadian, Transition and Upper Austral *zones* in eastern North America than between the Alleghanian, Arid and Pacific *areas* of the Transition zone.

Investigation shows that forests, grasslands and deserts are arranged about certain centers, which owe their positions on the continent mainly to climatic causes. That such centers cannot be correlated with the distribution of heat or rainfall alone is evidenced by an examination of the monthly, seasonal and annual distribution of these climatic elements.

The fact that so large a part of the adaptations shown by plants are more or less directly connected with transpiration, led the writer to construct a map combining the figures for rainfall and evaporation. The amount of evaporation depends upon the temperature of the evaporating surface, the relative humidity of the air and the velocity of the wind. Therefore if we combine the figures for rainfall and evaporation we have a number which will represent at least four climatic factors, that must powerfully influence the water relations and distribution of plants.

In the accompanying map the ratios, found by dividing the mean annual rainfall by the depth of evaporation at the same station, are represented by percentages. If this map be compared with the map published by Sargent in the Ninth Census report, it will be noted that there is a remarkable coincidence between its divisions and the forests of the eastern United States. The Northeastern Conifer Forest Center is marked by a rainfall-evaporation ratio amounting to between 100 and 200 per cent. The Deciduous Forest Center is indicated by the area lying between the 100 and 110 per cent lines. The Southeastern Conifer Center has a ratio above 110 per cent. The Great Plains are marked by an



amount of rainfall equal to from 20 to 60 per cent of the evaporation. Where the ratio rises to between 60 and 80 per cent, the prairie region, where dense forests are confined to the river bottoms, is indicated. The region where "open forests," "oak openings" and "groves" occur on the uplands and dense forests on the low grounds, is indicated by the 80 to 100 per cent ratios. The map can only be considered as an approximation, nevertheless it shows why the Northeastern and Southeastern centers are separated from one another in the Mississippi valley and are more or less mixed in the Alleghany region. It suggests that the Southeastern Conifer Center is dependent upon climatic as well as edaphic factors.

The conclusion seems warranted that a map based on rainfall-evaporation ratios (since they involve four climatic factors: temperature, relative humidity, wind velocity and rainfall) will show climatic centers which coincide approximately with the centers of plant distribution. In the selection of the species for individual centers these factors have a varying importance, their influence being further modified by edaphic, geographic and historical considerations.

Alma College, March 15, 1905.

THE NERVE-LAYER IN THE CORAL COENOPSAMMIA.*

BY J. E. DUERDEN AND S. A. AYRES.

In 1879 the brothers O. and R. Hertwig ("Die Actinien," Jenaische Zeitschrift, XIII) published their important results upon the nervous system of the Actiniaria. By means of sections and macerations they proved the existence of a definite nervous system, diffuse in character. Distinct multipolar nerve cells and epithelial sensory cells with nerve fibrils were demonstrated, and in certain regions the nerve fibrils were found to constitute a distinct nerve layer (Nervenschicht). In the reports on the "Challenger" Actiniaria (Vols. VI and XXVI) R. Hertwig was the first to use anatomical characters for taxonomic purposes, a method followed by all subsequent workers on the group.

Dr. Carlgren in 1900 ("Ostafrikanische Actinien," Mitt. a. d. Nat. Mus., Hamburg, XVII) introduced a classification of the Actiniaria in which he made the presence of a columnar nerve layer one of the fundamental features. Carlgren attempted to subordinate external and anatomical characters to histological details, the principal of which is the presence of a nerve layer associated with a longitudinal ectodermal musculature in the column wall and stomodaeum; with these are often associated the absence of gonidial grooves from the stomodaeum and ciliated streaks from the mesenterial filaments. In Carlgren's opinion Actiniaria were primitively provided with a nerve layer and an ectodermal longitudinal musculature in the column wall and oesophagus. He would divide the Actiniaria into two main tribes—the *Protantheae*, actinians retaining their primitive histological and anatomical structures, and the *Nynatheae*, those forms more highly developed in their histology, anatomy and external characters.

Carlgren's classification has not been generally accepted. Writers such as McMurrich, van Beneden and Duerden would be prepared to look upon the ectodermal columnar nerve and muscle layers as ancestral and the forms in which they occur as the lowest members of their group. But they regard the details rather as characters which may turn up in forms now very widely separated, showing that the species possessing them do not represent a homogeneous group.

Recent studies have shown that the madreporarian polyps are closely allied to the Actiniaria, but no ectodermal columnar nerve or muscle layer has hitherto been found, yet they have many of the characters claimed to be ancestral, particularly the absence of gonidial grooves from the stamodaeum and ciliated streaks on the mesenterial filaments. In examining polyps of Coenopsammia manni Verrill, collected by one of us from the Hawaiian Islands, a well defined ectodermal nerve layer was

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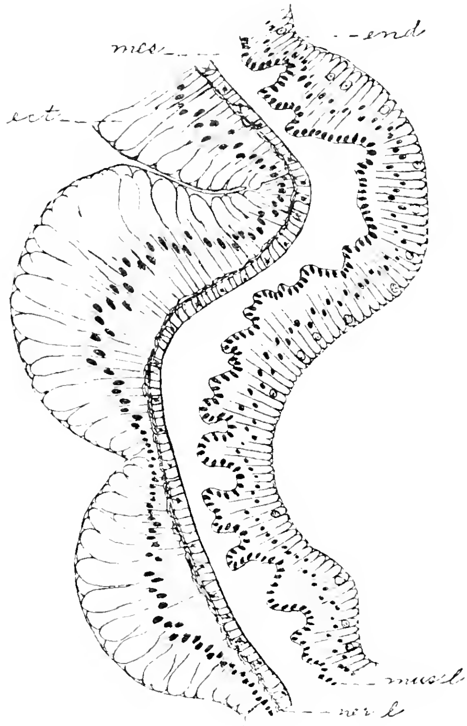
*Contributions from the Zoological Laboratory of the University of Michigan, No. —The work has been carried out by the aid of an appropriation from the Carnegie Institution.

found to extend almost throughout the length of the column wall and oesophagus. Its appearance is represented in the accompanying figure. The section was taken from the column wall and stained in iron haematoxylin. The nerve layer (ner. l.) is made up of nerve fibres which interlace a short distance from the mesogloea, and among the fibres are ganglion cells scattered here and there. Also in 1900 J. Stanley Gardiner (Willey Zool. Results, IV), in an account of the "Anatomy of a supposed new species of Coenopsammia from Lifu," alludes to and depicts ectodermal nerve granules, but attaches no morphological importance to them.



Longitudinal section through column wall of Coenopsammia. ect. ectoderm; *end.* endoderm; *mes* mesogloea; *mus.l.* muscle layer; *ner.l.* nerve layer.

In the presence of this well defined nerve layer on its column wall, the coral Coenopsammia differs from all other Madreporaria hitherto described, but its other anatomical characteristics show the genus to be in no ways exceptional. One would not be prepared to accord a mere special development of the nervous elements any taxonomic importance even among the group of the corals, much less can the genus be regarded as in any way closely related to those Actiniaria in which a similar nerve layer is conspicuous.

In this connection attention may be drawn to a valuable paper on the nervous system of the Actiniaria by Havet (La Cellule, Tom. XVIII, 1901). He was the first to apply with success the Golgi method in tracing the nervous elements of Actiniae, thereby strengthening the results of the Hertwigs. In young specimens of Metridium dianthus he demonstrates uni-, bi-, and multi-polar sensory cells, having fine prolongations which often constitute thin layers of nerve fibrils. On these fibrils are also small cells which are probably sensory cells in different stages of growth. Near these sensory fibrils are other nerve cells of larger size, the motor cells, which are usually multipolar. Havet found these nerve elements in the endoderm and mesogloea as well as in the ectoderm. Besides a nerve layer in the column wall a high degree of nervous development appeared in the septa, oesophagus and tentacles.

From the evidences we now have, it would seem that development of nervous elements among the Anthozoa is rather a matter of degree, varying much in individual species. Where a well defined nerve layer is present, it is a special development of such nerve elements as are always present, and manifestly can have but little phylogenetic or systematic importance.

University of Michigan.

SOME RESULTS OF A STUDY OF VARIATION IN PARAMECIUM.[1]

RAYMOND PEARL AND FRANCES J. DUNBAR.

(Preliminary Communication.)

1. The results here set forth form a small part of those which have been obtained in a quantitative study of variation and correlation in Paramecia reared under definite and controlled cultural conditions. The purpose with which the work was undertaken was to determine as exactly as possible the effect of a measured environmental change on the degree of the correlation existing between length and breadth of body in this form. Incidentally, of course, the variation exhibited by the individuals in the different cultures was studied. We shall deal here solely with some of the results regarding variation.

The plan on which the experiments to be considered in this paper were carried out was in outline as follows:[2] a "standard" culture solution was made by putting 30 gr. of finely chopped hay into a litre of water, heating to 90° C. and straining the infusion through cheese cloth. Then a single individual (not an ex-conjugant) was isolated from a flourishing "wild" culture of Paramecium and transferred to some of this "standard" medium. Multiplication then went on until finally we had a well developed culture containing *only individuals which were descendants of the original single ancestor.* In other words we had in such a culture a single "fraternity" of the closest possible degree of selection of original ancestry. Then from this culture experiments were set up in homoeopathic vials. For each experiment three vials were filled to a certain point with culture fluid containing the Paramecia. One of the three vials (*A*) served as a control, and was

[1]Contributions from the Zoological Laboratory, University of Michigan, No. 99.

[2]A detailed account of the experimental methods, making of the measurements, etc., will be given in the complete report of this work. Space is lacking for more than an outline here.

not further manipulated. To one of the others (B) was added 2 parts of an $m/1$ NaCl solution to each 98 parts of culture solution. To the third (C) was added 1 part of $m/1$ cane sugar solution to each 99 parts of culture fluid. The three vials (corked) were then put in the same conditions with reference to light, temperature and other varying factors of the laboratory environment. So far then as it was possible to control the matter experimentally the environmental conditions surrounding the individuals in vials A, B, and C were identical except that there was more NaCl in B than in A, and more sugar in C than in A. On account of the complex nature of the culture medium chemically it is of course impossible to make any statement regarding the *absolute* concentration of NaCl or sugar in the cultures. We merely know that we are changing in a definite way a single factor in the chemical environment.

At the expiration of a certain period of time all the Paramecia in each of the three vials were killed with Worcester's formol-sublimate fluid,[1] thoroughly washed and preserved in 4% formalin. This formol-sublimate fluid we have demonstrated to be a practically perfect killing fluid for infusoria, producing no measurable distortion, when used by one who has had experience with it. With the specimens still remaining in the formalin the length and breadth of each individual were measured by means of a filar ocular micrometer. The measuring on all the experiments is not yet completed. When finished we shall have measurements of the length and breadth of between 7,000 and 8,000 individual Paramecia.[2]

We shall discuss here a part of the variation results for three of the experiments which are designated in our notes as Experiments 1, 2, and 7. In Experiment 1 the Paramecia were in the experimental vials 100 hours; in Experiment 2, 200 hours, and in Experiment 7, 300 hours. In Experiments 2 and 7 at the expiration of the first 100 hours there was added to the B vial an amount of $m/1$ NaCl solution equal to what was put in at the start. Or in other words, the concentration of the solution in respect to NaCl was approximately doubled. In the same way the concentration of the sugar in the C vial was doubled at the end of the first 100 hours. In Experiment 7 a second addition of the same amounts of NaCl and sugar to the B and C vials respectively was made at the expiration of the second hundred hours. So then in these two experiments, 2 and 7, we had a regular increase in the amount of NaCl and sugar in the culture solution in vials B and C respectively, occurring at 100 hour intervals. All of the 3,000 individuals here included were the descendants of the same original ancestor. We shall consider in this paper variation in length only. The point which we wish especially to bring out here is the rather remarkable effect on the variation constants which is produced by the addition of cane sugar solution to the culture fluid.

2. In order to bring together in convenient form the data on this point we have prepared the following frequency distributions. The first distribution (Table I) shows the variation in length of a random sample of Paramecia taken from an ordinary laboratory culture set

[1]Pearl, R. Worcester's Formol-Sublimate Fixing Fluids. Jour. Appl. Micros. Vol. VI, No. 8, p. 2451.

[2]The long and tedious task of making these measurements has been carried through with the utmost care and patience by Miss Dunbar. R. P.

with Ceratophyllum and other pond weeds. At the time the sample was taken the culture was in a flourishing condition, the individuals multiplying by fission. No conjugation was occurring so far as could be determined. This sample of individuals (which we shall designate throughout as the "D sample") may be considered to represent the normal condition of Paramecia of this vicinity with unselected ancestry.

TABLE I.

Frequency Distribution. Length of Paramecia of Unselected Ancestry.

Class Unit = 10 mikrons.

Length in mikrons.	Frequency.	Length in mikrons.	Frequency.
120–129	1	220–229	35
130–139	....	230–239	38
140–149	....	240–249	32
150–159	....	250–259	59
160–169	1	260–269	23
170–179	....	270–279	32
180–189	3	280–289	5
190–199	1	290–299	1
200–209	9	300–309	2
210–219	8	Total	250

This distribution is shown graphically in Figure 1. The constants deduced from Table I are as follows:

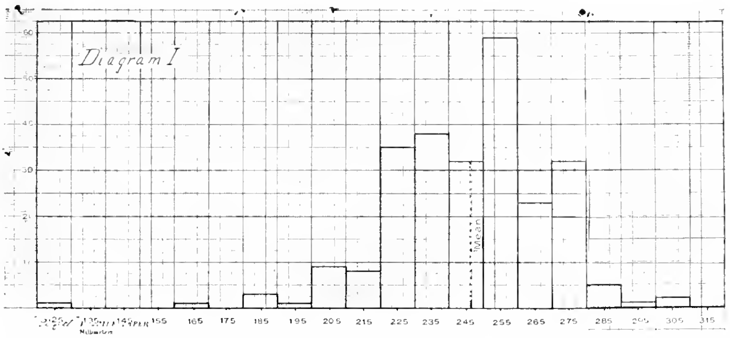


Fig. 1. Diagram I, showing variation in length in sample of Paramecia from "wild" culture of unknown ancestry. The abscissae give lengths in mikrons and the ordinates frequencies of individuals

TABLE II.

Variation Constants for Length of Body in Paramecia of Unselected Ancestry.

Mean	246.080 ± .983 mikrons
Standard Deviation	23.041 ± .695 "
Coefficient of Variation	9.363 ± .285 %

For comparison with the above the following table of values from Pearson's* note on Simpson's data is introduced. The character is "length of body," and the series included 100 Paramecia. It will be noted that the individuals in our series are considerably larger and somewhat more variable than those in Simpson's series.

Length of Paramecium, 100 Individuals.

Simpson's Data.

Mean	229.050 mikrons
Standard Deviation	19.152 mikrons
Coefficient of Variation	8.361 %

The next three distributions (Table III) show the variation in length of the "control" individuals in Experiments 1, 2, and 7. These individuals multiplied in the standard hay-infusion culture medium throughout their lives. The 1,500 individuals whose measurements are recorded in Table III are all the descendants of the same original single ancestor. The other conditions regarding these series are explained above.

TABLE III.

Frequency Distributions. Length of Paramecia of Selected Ancestry. Controls.

Class Unit = 10 mikrons.

Length in mikrons.	Frequency.		
	Experiment 1. 100 hour series.	Experiment 2. 200 hour series.	Experiment 7. 300 hour series.
120–129	....	....	2
130–139	....	....	2
140–149	....	1	6
150–159	1	1	31
160–169	3	6	63
170–179	3	18	119
180–189	21	61	116
190–199	34	82	92
200–209	72	105	55
210–219	101	101	14
220–229	96	88	....
230–239	67	29	....
240–249	65	7	....
250–259	34	1	....
260–269	3	....	....
Total	500	500	500

These distributions are shown graphically in Figure 2. Their variation constants are exhibited in Table IV.

*Biometrika, Vol. I, p. 405.

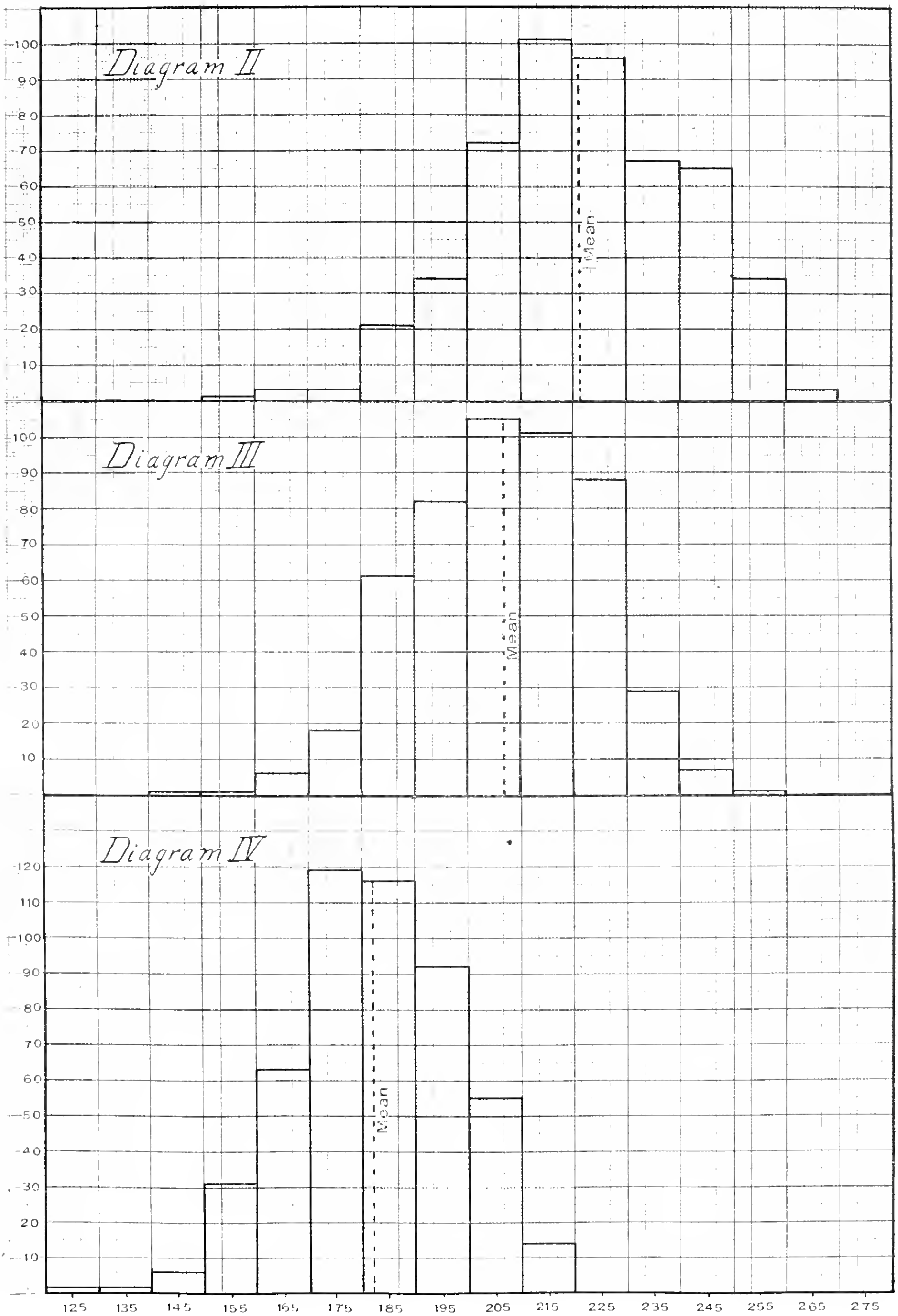


Fig. 2. Diagrams showing variation in length in control series of Paramecia of selected ancestry. Diagram II, 100 hour series. Diagram III, 200 hour series. Diagram IV, 300 hour series.

TABLE IV.

Constants for Variation in Length of Body in Paramecia of Selected Ancestry. Control Series.

	Mean.	Standard Deviation.	Coefficient of Variation.
Experiment 1. 100 hour series	221.800 ± .587	19.457 ± .415	8.772 ± .189
Experiment 2. 200 hour series	207.080 ± .518	17.171 ± .366	8.292 ± .178
Experiment 7. 300 hour series	182.200 ± .480	15.917 ± .340	8.736 ± .188

Turning now to the series in which cane sugar solution was added to the culture fluid we have the frequency distributions given in Table V.

TABLE V.

Frequency Distributions. Length of Paramecia of Selected Ancestry. Sugar Solution added to Culture Fluid.

Class Unit = 10 mikrons.

Length in mikrons.	Frequency.		
	Experiment 1. 100 hour series.	Experiment 2. 200 hour series.	Experiment 7. 300 hour series.
150–159	....	....	5
160–169	1	2	12
170–179	7	19	14
180–189	7	22	34
190–199	16	53	46
200–209	62	87	88
210–219	103	80	99
220–229	116	91	96
230–239	76	77	76
240–249	72	57	23
250–259	37	12	7
260–269	3	....	....
Totals	500	500	500

These distributions are shown graphically in Figure 3. The constants deduced from them are given in Table VI.

TABLE VI.

Constants for Variation in Length of Body in Paramecia of Selected Ancestry. Sugar Series.

	Mean.	Standard Deviation.	Coefficient of Variation.
Experiment 1, 100 hour series	224.980 ± .533	17.680 ± .377	7.859 ± .169
Experiment 2, 200 hour series	217.380 ± .592	19.630 ± .419	9.030 ± .194
Experiment 7, 300 hour series	213.340 ± .601	19.936 ± .425	9.345 ± .201

It will be remembered that the 1,500 individuals of Tables V and VI all came from the same original ancestor as those in Tables III and IV.

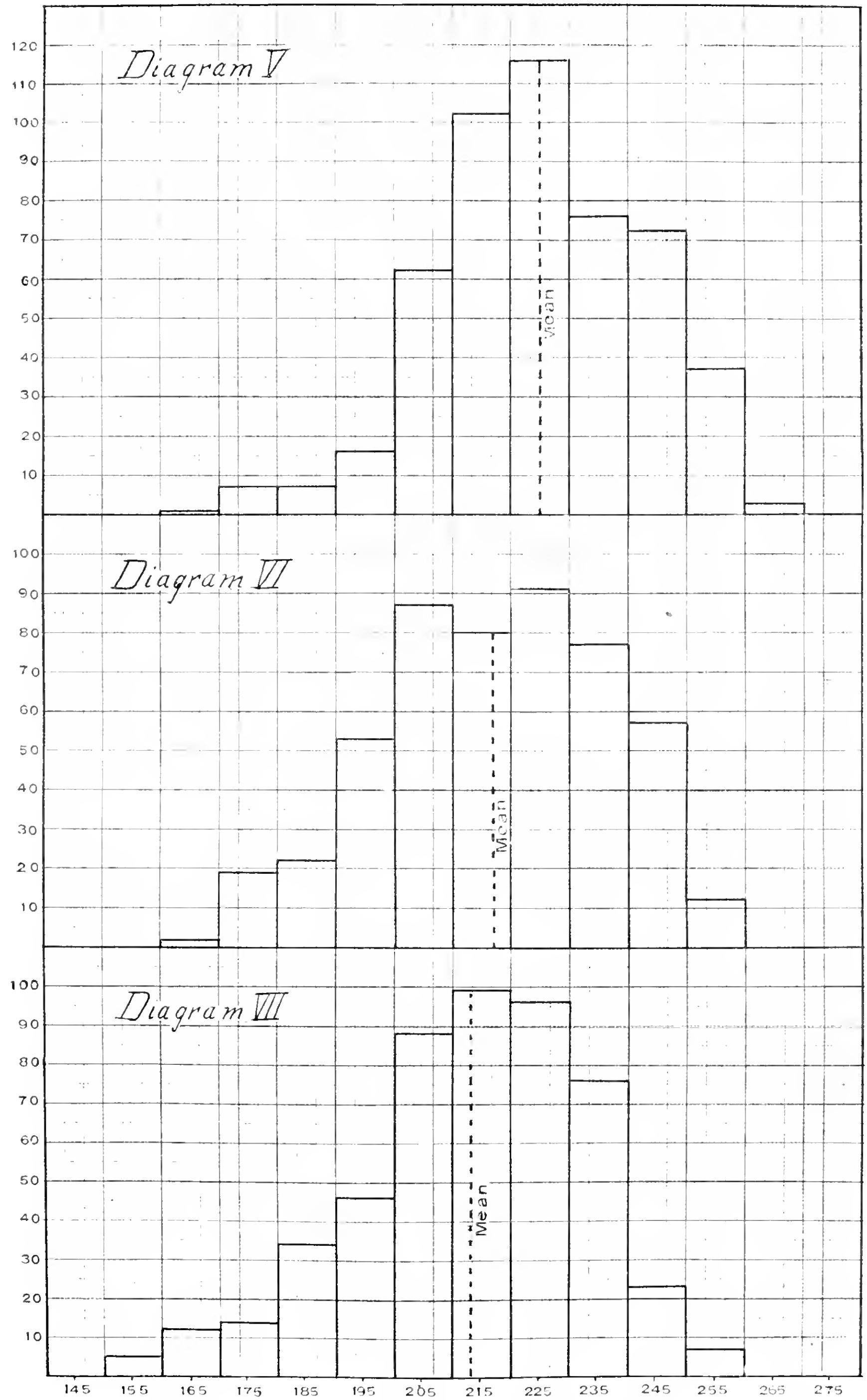


Fig. 3. Diagrams showing variations in length in "sugar." series. Paramecia of selected ancestry. Diagram V, 100 hour series. Diagram VI, 200 hour series. Diagram VII, 300 hour series.

3. With the data in hand we may proceed to a discussion of the results. The first thing one notes in looking over the tables and diagrams is that all the individuals reared under experimental conditions average shorter than do the individuals in the "wild" culture (Table II, and Diagram I). Furthermore the means for the 200 hour series are lower than those for the 100 hour series, and those for the 300 hour series are still lower. In other words it appears that the conditions under which the organisms were put in the experiments tended to cause a decrease in the mean length of the body, and the longer the stay in the experimental vials the greater the decrease became. We are not yet prepared to make any positive statements as to the cause of this tendency for the organisms in the vials to decrease in length, although we hope to present conclusive evidence on the matter in the complete paper. The case here very obviously resembles superficially the well known results of Semper and de Varigny on certain molluscs. They found that these organisms (e. g., *Physa*, *Lymnaea*, etc.) decreased in size when kept in relatively small amounts of water. The size of the organism appeared to be very directly related to the size and shape of the containing vessel. Objectively this is just what we have here. It might be thought that in the present case the decrease in the mean length of the individuals in a relatively small amount of water is due to failure of the food supply to multiply as rapidly as do the Paramecia. There would not be, then, a sufficient amount of food present to admit of completing the growth after each division. This, however, seems unlikely, for the reason that the vials were never as crowded with Paramecia as thriving portions of "wild" cultures very frequently are. There are other reasons which cannot be entered into now, which also seem to indicate that the decrease in length in the experimental animals is not due primarily to lack of adequate food supply.

The addition of cane sugar to the culture medium seems in a measure to check this tendency towards a decrease in length. This comes out clearly if we compare the means of the control and sugar series. Thus from Tables IV and VI we have

Mean length (100 hour sugar series)—mean length (100 hour control series)=3.180.

Mean length (200 hour sugar series)—mean length (200 hour control series)=10.300.

Mean length (300 hour sugar series)—mean length (300 hour control series)=31.140.

The rate of decrease of the means is evidently much slower in sugar than in control series. The same fact is shown in the diagrams.

Turning now to the variation results we note:

(a) That in the control series the variability is, as we should expect, considerably reduced below that of the general population of a "wild" culture.[1] The mean coefficient of variation for the three control series is 8.600 (Table IV), while that for the individuals from the "wild" culture (Table II) is 9.363. Or, in other words, the variation in the samples known to have originated from a single ancestor is 91.85 per cent of that shown by the general population, when in addition to the

[1]In comparing variabilities we shall have to make use of the coefficients of variation throughout, for the reason that such considerable changes in mean size have been induced in the experiments that comparisons of standard deviations will obviously be unfair.

selection of ancestry practiced in the experiments the environmental conditions were as uniform as it was possible to get them. For sexually reproducing forms Pearson[1] has shown that the limit of reduction of variability in offspring when the parents are selected with exactly similar characters is 89.44 per cent of the variability of the general population. This limit is reached if the selection be carried on for 5 generations; selection for any number of generations beyond that will not further reduce the variability. Our selected Paramecium samples apparently show somewhat less than this 11 per cent reduction of variability. We are not prepared as yet, however, to draw any general conclusion regarding the reduction of variability with selection of ancestry in this form. There are several factors which must be taken into account, the data on which are now being reduced. For one thing the question arises as to whether we have obtained a true value for the "general population" variability. A laboratory culture of Paramecium probably in ordinary cases consists of at most a comparatively few fraternities, and it is easily possible that by taking a sample from one part of a culture we might get a series of individuals nearly all descended from a single ancestor *in that same culture*. We should expect then relatively low variability. The point which we wish to emphasize here is that there is a considerable lowering of variability manifested in our Paramecium series when we deal with pure strains from a single ancestor.

(b) The amount of variation is, as we should expect it to be, sensibly the same in each of the control series. The extreme values for the coefficients are $8.772 \pm .189$ and $8.292 \pm .178$, giving a difference of .480 with a probable error of $\pm .260$. The difference evidently cannot be considered significant. In other words, though the individuals become smaller the longer they stay in the culture vials, yet in proportion to their size, the variability does not change. This is of course the result we ought theoretically to get. The agreement between the results actually obtained is good evidence both of the accuracy of the measurements of these 1,500 individuals, and of the uniformity of the experimental conditions in the three series.

(c) In the case of the sugar series we have an altogether different result. Here we find for the 100 hour group a coefficient of variation of $7.859 \pm .169$, for the 200 hour group $9.030 \pm .194$, and for the 300 hour group $9.345 \pm .201$. The longer the stay in the culture fluid to which sugar has been added the greater becomes the variation until in the 300 hour series we have a group of individuals not sensibly less variable than a random sample from a "wild" culture. Yet the individuals of this 300 hour group are the direct descendants of a single ancestor, and have all lived in the same environment. The difference between the coefficient of variation for our "wild" culture sample (D sample) and that for the 300 hour sugar series is $.018 \pm .349$, an obviously insignificant one.

This result appears to be of considerable interest as showing the importance of environmental conditions in determining the amount of variation in this form. It is evident that this increase in variation in the sugar series cannot be attributed to less *uniformity* of environment, because there is no reason to suppose that after the sugar solu-

[1] Proc. Roy. Soc. Vol. 62, p. 399.

tion has been added and mixed with the culture fluid the conditions are less uniform than in the control vials. It would seem more likely that the sugar solution through a specific physiological influence causes the individuals either to divide less evenly than usual, or to grow less uniformly after division. That cane sugar has in other cases a specific influence on growth processes has been demonstrated by studies in experimental embryology.

The bearing of these results on current theories as to the origin of variation will be discussed in the complete paper.

The points brought out in this preliminary communication may be summarized as follows, it being understood that they are not stated as final conclusions, but are subject to such modifications as may be necessary when our data are completely reduced:

1. Paramecia in our experiments when reared in relatively small volumes of culture fluid—10 c. c. or less—show a progressively lower mean length the longer they remain under such conditions.

2. In the case of pure strains—i. e., groups of individuals coming from a single ancestor—reared under the conditions mentioned in 1, the variation, in length of body for the fraternity so reared is reduced from 8 to 10 per cent below that of the general population, in the samples analyzed up to this time.

3. By the addition of cane sugar solution to the culture fluid so that as a maximum there were 3 parts of *m*/1 cane sugar to each 100 parts culture fluid, in the series of experiments here reported, the variation in length of body in the series of selected ancestry was increased until it equalled the variation in the same character shown by a random sample of unknown ancestry from a "wild" culture.

I wish here to acknowledge my indebtedness to the Carnegie Institution of Washington for a grant in aid of biometric work of which this forms a part.

University of Michigan.

FURTHER EXPERIMENTS ON STATIC FUNCTION.*

L. MURBACH.

At the 1903 meeting of The Michigan Academy of Science, a short report was given of some experiments made to determine to what extent the jellyfish, Gonionemus, depends on its otocyst organs for regulating its position in space. This jellyfish was chosen as it is very easily obtainable for several months during the summer at the Marine Biological Laboratory, and especially because it has more definite or characteristic movements in vertical directions than any other medusa known to the writer. The experiments were not considered conclusive, especialy as they indicated a result that I had not expected. The subsequent discussion determined me to make further experiments.

* Work done at the Marine Biological Laboratory, Wood's Hole, Mass.,—Season 1904. For facilities I am indebted to the Laboratory.

The preliminary experiments referred to were in the nature of crushing the otocyst organs and also puncturing the otocyst vesicles thinking thus to put the organs out of function. Although the otocyst organs were very much mutilated the animal behaved better than could be expected. But this was interpreted as showing that the organs were not rendered ineffective. After many experiments which aimed to incapacitate these organs, it was found that they could be cut away with a portion of the margin, leaving small portions between for the attachment of the velum. After the velum was again grown to the bell all around, the remaining portions of the margin were removed in the same way until microscopic examination revealed no more organs present. Repeated trials convinced me that the jellyfish could swim normally after removal of the otocyst organs, showing that these are not essential. Injuries or imperfections of a considerable nature in the velum, the principal muscular organ of locomotion, caused greater disturbances in the swimming movements, and led me to believe that the orientation of these animals is more largely in the muscular sensation.[1]

These results induced me to examine the behavior in a few crustaceae in which orientation has been found to be wholly due to otocyst organs. The well-known experiment of Kreidl was repeated. It will be remembered that in this experiment the shrimp Palaemonetes, in a freshly moulted condition is placed in filtered sea water to which some iron-filings are added. It is indeed a fascinating sight when the animal repeatedly thrusts all the iron-filings that it can hold with its second chelaepeds into the space between the rostrum and the antennules. Sometimes the filings were dropped on the antennules with a pipette, and in this and the former case the chelaepeds were used as if rubbing the filings into the otocysts. Yet the process was so long continued before the animal responded to the magnet that the entrance of any particles into the otocysts seemed rather accidental. A 680 windings primary coil with half-inch core of soft iron wires and six cell dry battery were used. It was found that two cells were enough when the animal was moving. While stationary, or braced in an angle of the containing vessel, the animal could not easily be disturbed and soon seemed to get used to the pull of the magnet. Normally it responded by bracing against the pull of the magnet, and in one case, even, lying on its side with *ventre* directed toward the magnet. In some cases, however, it was apparently pulled over with the dorsal side toward the magnet. It will be seen that this is a result that Prentiss[2] did not get. If the circuit is made suddenly, while the animal is swimming, it sometimes swims spirally a turn or two.

Now there is no doubt that the animal feels a pull and he takes up a natural attitude toward this pull. From considerable observation on the habits of Palaemonetes I have concluded that presenting the ventral side of the body is a natural attitude of defense against their mates and enemies. I believe it is the pull of the magnet on the iron that makes the animals uncomfortable to the extent of defending themselves and thus turning against the direction of the pull.[3]

While I do not think that these considerations disprove the static function of otocyst organs, I do think that Kreidl's experiment is open

[1]The results of these experiments were published in Am. Jour. Physiol. Vol. X No. IV. p. 201.
[2]Bulletin of the Mus. of Comp. Zoology, Harvard University, 1901.

to the above interpretation. That the pull alone on other organs or parts of the body will not usually make the animal turn, I found by inserting small pieces of soft iron, silver-plated for the purpose, in various parts of the dorsal region of the body. Later, also, I cemented such pieces to the antennules. There was ordinarily no response until the pull of the magnet was sufficient to tend to unbalance the animal, and then the response was somewhat similar to that obtained when there were iron-filings in the otocysts.

It has been stated that the palaemonetes as well as other curstaceae when freshly moulted are unable to orient properly on account of the loss of otoliths. But it must be remembered that just at this time their hard exoskeleton, the firm attachment for the muscles, has been removed.[1] Virbius, a crustacean which is permanently in a soft condition, is of rather unsteady motion. In this animal there are no otocyst organs present and this is said to account for its acrobatic feats.[2] But these are no less remarkable than those of Gammarus.

Mysis was next operated on. After some attempts to unbalance the animal by removing the segment of the tail fin containing the otocyst organs, the whole fin was removed. The animals kept their up and down position very well and a few of them turned over and over as has been described by others. Now when we remember that the tail fin of these little crustaceae is their chief rudder, I believe we are safe in saying that Mysis is not much dependent on its otocyst organs, when the loss of both these and the rudder causes only unsteady motion, not a serious unbalancing as to the vertical.

Detroit, Mich., April, 1905.

THE STATUS OF EUTAENIA BRACHYSTOMA.

C. C. WHITTAKER.

Mr. Ruthven in his paper on "Butler's Garter Snake" (Biol. Bulletin, Vol. VII, No. 5, Nov., 1904) after mentioning the fact that the only specimen of *brachystoma* is in the collection of the Philadelphia Academy of Natural Sciences, quotes A. E. Brown as saying that "there is little ground for thinking this specimen other than a dwarfed *E sirtalis sirtalis*." Ruthven then continues "After a comparison with the specimens of *E butlerii* from here Mr. Brown writes me 'I have re-examined the type of *E brachystoma* Cope, and still find no reason to believe it other than an anomalous *E sirtalis sirtalis.*' Cope says 'it is small but not young.' I myself see no way to determine this, it may or it may not be so. The specimen was about ready to shed when he got it, which, of course, obscured the pattern. I cannot think it the same as *E butlerii.*'" Mr. Ruthven apparently accepts this as final for he goes on to the discussion of the difference between *butlerii* and *E vagrans* without remark. This treatment seems somewhat summary in view of the fact that Cope's descriptions of *brachystoma* and *butlerii*

[1], [2] Prentiss discusses both cases but the view he presents seems to me not proved.

resemble each other so remarkably in all essential points, and differ only in such minor details, if at all, that one is naturally led to inquire if they are not the same. At Dr. Clark's suggestion I undertook a detailed comparison and my results are presented herewith.

In order to bring out clearly how strikingly similar these snakes are according to Cope's own descriptions, the characters have here been tabulated in parallel columns. Before going further it is well to note that Cope's *brachystoma* was described from one specimen and that one alcoholic and just ready to shed its skin when captured. His *butlerii* is based on two specimens.

brachystoma	*butlerii*
"Head not distinct from neck."	"Head little distinct from neck.
Labial plates $\frac{6-6}{8-8}$	Labial plates $\frac{7-7}{8-8}$
Oculers 1—3.	Oculars 1—3.
Temporals 1—2.	Temporals 1—1.
"Parietal scuta convex and not contracted posteriorly."	"Parietal scuta abruptly contracted."
Scale rows 19, all keeled.	Scale rows 19, all keeled.
Gastrosteges 132.	Gastrosteges 144.
Urosteges 72.	Urosteges 62.

HEAD.

Beginning with the head Cope says of *brachystoma* "it is not distinct from the neck." Concerning *butlerii* he says "head very little distinct." This certainly does not constitute a specific difference.

LABIAL PLATES.

The number of labial plates for *brachystoma* is $\frac{6-6}{8-8}$ and for *butlerii* $\frac{7-7}{8-8}$. It will be noticed that the lower labials, the point in which *brachystoma* is strikingly different from *e sirtalis sirtalis*, are 8—8, exactly the same number as in *butlerii*. Moreover in both snakes the orbit is above two labials. In regard to the upper labials of which Cope's single *brachystoma* has 6—6 and his two *butlerii* 7—7, it is interesting to note that nine of Ruthven's twenty specimens have 6—6 supra labials, four have 6—7 and only seven have 7—7. Of the Olivet specimens six have 6—6 supra labials, two have 6—7, and one has 7—7. Summarizing these figures we find that out of these twenty-nine *butlerii* (lists of Dr. Clark and Mr. Ruthven), fifteen have 6—6 supra labials, six have 6—7 and eight have 7—7. Hence it seems quite clear that the mere fact of the single *brachystoma* having 6—6 supra labials does not in any way tend to prove that it is not *butlerii*. In fact it rather strengthens the inference that it is, since about 52 per cent of *butlerii* have 6—6, and only about 28 per cent have 7—7, the number given by Cope for *butlerii*, the remaining 20 per cent having 6—7 or 7—6. Indeed it seems probable that 6—6 is the normal number of supra labials for *butlerii*.

OCULARS.

Turning now to the oculars we find *brachystoma* and *butlerii* agree and this number (1—3) the statistics of Dr. Clark and Mr. Ruthven tend to corroborate although twelve out of twenty-nine vary on one or both sides.

TEMPORALS.

Cope notes the temporals of *brachystoma* as 1—2 and of *butlerii* as 1—1. Nine of Ruthven's twenty *butlerii* have 1—2, seven have 1—1 and three have $\frac{1-1}{1-2}$ and one is not tabulated. The Olivet specimens are even more remarkable. Six of the nine specimens have 1—2 temporals, only one has 1—1, one has 1—3 and one has $\frac{1-3}{1-2}$. Summing up we find that fifteen out of the twenty-eight specimens (*butlerii*) or 53½ per cent have $\frac{1-2}{1-2}$ temporals, the number given for *brachystoma*, seven or twenty-five per cent have $\frac{1-1}{1-1}$, three have $\frac{1-2}{1-1}$, one has $\frac{1-2}{1-3}$, and one has $\frac{1-3}{1-3}$. Here again the fact that Cope's single *brachystoma* had 1—2 temporals so far from constituting a specific difference strengthens the view that *brachystoma* and *butlerii* are identi-

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cal, and since more than 50 per cent of the *butlerii* thus far recorded have $\frac{1-2}{1-2}$ temporals and only 25 per cent have $\frac{1-1}{1-1}$ the number given for *butlerii*, it seems probable that $\frac{1-2}{1-2}$ is the normal number of temporals for *butlerii*.

PARIETAL SCUTA.

Cope describes the parietal scuta of *brachystoma* as " convex in outline and not contracted posteriorly," and those of *butlerii* with "external border abruptly contracted." A glance at his own figures (Annual report of the Smithsonian Institute for 1898, pages 1031 and 1057) is sufficient to show how small the difference is, even in his three specimens, and the Olivet specimens show that this character is too variable to be of value, while the fact that in both cases the mouth is so short as to end under the posterior end of the parietals tends strongly to show that the snakes are identical.

SCALE ROWS.

We quote Cope's words: "*brachystoma*—Scales in nineteen series all keeled except the inferior row which has a trace of a keel." "*butlerii*—Scales in nineteen longitudinal rows, the inferior one much the widest and keeled." It is evident that this is no difference. The wide inferior row is characteristic of *eutania* and the keel of *butlerii* is faint as in *brachystoma*.

GASTROSTEGES.

Brachystoma has 132 gastrosteges and *butlerii* 144 according to Cope. Mr. Ruthven gives the number as 140 for *butlerii* and the mean of the twenty-nine specimens shows that this is about right, the average showing approximately 139. This in itself proves nothing except that the gastrosteges of *butlerii* are fewer than Cope supposed. It is worthy of note, however, that 132 gastrosteges (*brachystoma*) is not an unusually small number for *butlerii*. Ruthven's list shows a *butlerii* with only a 131 and Clark's shows one with 133, numbers respectively one below and one above the 132 of *brachystoma*. In addition there are several *butlerii* with 134 or 135 136 gastrosteges so that the small number in *brachystoma* cannot in any way distinguish it from *butlerii*.

UROSTEGES.

The number of urosteges (72) seems large but is by no means abnormal, in *butlerii*, especially when the important matter of sex is taken into consideration. Ruthven's list shows a *butlerii* with 71 (urosteges) and two with 68 and 67 respectively. Mr. Sperry's investigations of *Eutaenia* ('03 p. 175-179) shows clearly that there is a very decided correlation between sex and the length percentage of tail and the number of urosteges. The males have a larger number of urosteges and a correspondingly larger tail percentage. So marked is this difference that sex can almost unfailingly be determined by these characters alone. Cope's *brachystoma* was doubtless a male, and although Mr. Ruthven has not tabulated the sex of his *butlerii*, the three mentioned as having a large number of urosteges :71, 68, 67) are undoubtedly males as there tail per cent shows. They are .236, .261 and .255 respectively, an average of about .25. Cope's *brachystoma* shows a tail per cent of .248. Bearing these facts in mind it becomes evident that the 72 urosteges of *brachystoma*, so far from constituting a specific difference merely show that it is a normal *butlerii*.

COLORATION.

Allowing for the fact that Cope's single *brachystoma* was an alcoholis specimen and just ready to shed its skin when captured, the general coloration of these snakes (*butlerii* and *brachystoma* is so much alike as to need no discussion. Two or three special points seem to require mention, however. The median dorsal stripe covers exactly one and two half rows of scales in both snakes, and its color is practically the same. Dr. Clark and Mr. Ruthven, both of whom have examined a number of specimens (*butlerii*) whereas Cope had only two, agree that Cope's statement that the lateral stripe of *butlerii* covers the second and third scale rows is not correct. The lateral stripe really includes (Dr. Clark '03, p. 85 "all the third row, the lower half of most of the fourth row and the upper half of many in the second row."

Cope says of *brachystoma*: "The absence of spots on the gastrosteges distinguishes it from most of the sub-species of *E. sirtalis*;" and of *butlerii*: "With a vertical black spot at the anterior border of each end of each of the gastrosteges." It seems clear that Cope's assertion of the absence of gastrostegeal spots in *brachystoma* is another error since Mr. Brown ('01, p. 29) says of *brachystoma*: "The color appears to have faded; on stretching the skin indications of the dorsal spots appear and the ventral spots of *sirtalis* are not absent as stated, in the description (Cope's) but are plainly present though small." The dorsal spots are apparent also in the Olivet specimens of *butlerii*, in spite of the fact that their absence is given by Cope as a character peculiar to *butlerii*. *Brachystoma* and *butlerii* are then clearly identical both in the matter of gastrostegeal and dorsal spots. The same harmony is found in regard to the parietal spots. They are described (Cope) as "faint but present" in the alcoholic *brachystoma* and "small but present in the usual position" in *butlerii*.

We thus see that a comparison of the specific characters of *brachystoma* and *butlerii* shows that not only is there no real difference according to Cope's own descriptions but that the characters are identical and that even when there were apparent discrepancies it was due to errors of Cope. When these errors are corrected by observations on a larger number of specimens, *brachystoma* is found to be identical with *butlerii* in these as in the other characters, and since *butlerii* is the name first given, that seems to be the correct name of this species.

Brown (Pro. Acad. Nat. Sci. '01, pp. 26-28) gives the names *brachystoma* and *butlerii* as synonyms of *E. sirtalis sirtalis*. Ruthven apparently accepts this dictum with regard to *brachystoma* as already stated, but considers *butlerii* a good and valid species. If as contended in this paper *brachystoma* and *butlerii* are the same, then it becomes necessary to clear up the status of *brachystoma* with regard to *sirtalis*. That *brachystoma* is not *sirtalis* seems to be quite clear when the wide differences between these species are taken into consideration. The surprising thing is not that Brown considers *brachystoma* and *butlerii* to be synonyms, but that he should have thought it possible for *butlerii* to be the same as *sirtalis*. The fact that Brown did not distinguish *butlerii* from *sirtalis* is in itself enough to cast doubt upon his statement that *brachystoma* is an anomalous *sirtalis*. For the sake of clearness the term *brachystoma* will be continued when referring to Cope's type specimen.

HEAD.

There is a marked difference in the shape of the head as a glance at Cope's own figures (Loc. cet.) will show. The head of the *sirtalis* is larger in proportion to the neck and more distinct from it. A difference more easily seen than described, however. A striking difference is found in the length of the mouth. The mouth ends before the posterior end of the parietal scuta in *brachystoma*, but extends considerably beyond in *sirtalis*. The number of labials for *brachystoma* is $\frac{6-6}{8-8}$. This number is so small that Brown (loc. cet.) says truly, "it is doubtless correlated with the shortness of the mouth." The fact remains that in this remarkable reduction of labials *brachystoma* differs widely from *sirtalis*. Moreover the difference is very constant. Out of 320 specimens of *sirtalis* examined by Clark ('03 p. 86) 6 have 6 upper labials on one side but not one has that number on both sides, while twelve have 8 on one side and two have 8-8. Now in a character that is so constant that 94 per cent of *sirtalis* have 7-7 supra labials, and not one out of 320 specimens has 6-6, it would seem that there is a real difference between *brachystoma* with 6-6 and *sirtalis* with 7-7. In the matter of the lower labials, 8-8 and 10-10, the difference is equally striking.

Of the 320 *sirtalis* examined 268 or about 90 per cent have 10—10 lower labials, of the remaining 10 per cent only two or .6 of 1 per cent have 8-8, and these are clearly distinguished from *brachystoma* by other characters such as number of gastrosteges and urosteges, and shape and length of head and body.

In view of these facts it seems clear that since $\frac{7-7}{10-10}$ labials of *sirtalis* are so constant both in the upper and lower, the $\frac{6-6}{8-8}$ labials of *brachystoma* constitute a specific difference.

GASTROSTEGES.

In the matter of gastrosteges again there is a very remarkable difference. In *brachystoma* there are 132 while 320 *sirtalis* average 151 with a range of 142-159. The average number in sirtalis is thus 27 more than the number given for *brachystoma* and the lowest number here recorded for *sirtalis* is 10 more than *brachystoma* has. Brown gives the minimum of gastrosteges for *sirtalis* as 138, and even accepting his figures *brachystoma* has five less. This is a wide divergence in an important character and certainly seems worthy of being considered a specific difference.

BODY AND TAIL PER CENT.

Brachystoma has a body per cent of total length of .752 and tail per cent of .248 while 212 male *sirtalis* show a body per cent of .769 and tail per cent of .231, a difference of nearly two per cent. Moreover such a difference would be far more obvious to the eye than the figures indicate. That it is in marked contrast with *sirtalis* is shown by Brown's own statement, that "the body of *brachystoma* is disproportionately short."

COLOR.

The imperfect condition of *brachystoma* and Cop's very incomplete description together with the extraordinary variety of coloration in *sirtalis* and allied species make color distinctions of little value. Even if the coloration were the same these snakes are sharply distinguished from each other by more important and constant characters. The conclusion follows from these facts that the specific characters of *brachystoma* separate it sharply from *sirtalis*. On the other hand as shown in the first half of this paper they are identical with those of *butlerii* and there can be no question but that *brachystoma* is a synonym of *butlerii* and not of *sirtalis*.

OLIVET, MICH.

THE DISTRIBUTION OF POLYGYRA IN MICHIGAN.

BRYANT WALKER.

This paper is based upon the records accumulated in the Census of Michigan Mollusca compiled under the direction of the Academy, which include all the collections both public and private known in the state, and therefore represents very accurately the extent of our present knowledge of the distribution of the genus in the state.

The genus *Polygyra* is one of peculiar interest to students of American Conchology, as it is purely North American in its range, not being known, either living or fossil, from South America or any of the continents of the Old World. The region of the greatest differentiation and therefore the probable centre of distribution is the southern portion of the Appalachian Mountains. This accords with the geological fact that this region (in the way of continuous emergence) is the oldest portion of the eastern part of the continent.

Of the three subgenera now recognized in *Polygyra*, only two, *Triodopsis* and *Stenotrema*, are found in Michigan, *Polygyra s. s.*, with the exception of a single species found in southern Indiana, not ranging north of the Ohio river.

The species of *Triodopsis* found in Michigan, fall into two natural groups, which were formerly considered of subgeneric value; those with a more or less globose shell having the aperture but slightly obstructed by labial and parietal teeth, of which *P. albolabris* is the leading form, and those grouping around *P. palliata*, in which the aperture has a well defined trilobed appearance, owing to greater development of the apertural teeth. These two groups are separated in the following list of all the species of the genus, which have been recorded from the state.

Triodopsis.

P. albolabris (Say.)
P. exoleta (Binn.)
P. multilineata (Say)
P. profunda (Say)
P. mitchelliana (Lea)
P. pennsylvanica (Green)
P. clausa (Say)
P. elevata (Say)
P. sayii (Binn)

P. palliata (Say)
P. tridentata (Say)
P. fraudulenta Pils.
P. inflecta (Say)

Stenotrema.

P. monodon (Rack.)

P. hirsuta (Say)

On the accompanying maps the distribution of the different species is shown by counties. No attempt has been made to indicate the range of any of the varietal forms except in the case of *P. monodon*, where the range of the well marked variety, *P. monodon fraterna*, is remarkably different from that of the typical form.

For purposes of comparison, the occurence of the different species in the Chicago Area as given by Baker is also indicated. The accessible information of the fauna of northern Indiana and Ohio is too meagre to be of any practical service.

From our present information only two species can be said to have a range over the entire state. These are *P. albolabris* and *P. monodon fraterna*.

The recorded range of these forms is shown on Plate I.

It is interesting to notice how closely the records of the two species coincide. In the majority of cases, where one of them has been found, the other occurs also and in several other instances where only one has occurred in a particular county the other has been found in a neighboring one. The fact that while *P. albolabris* is the largest of our species, and therefore less likely to be overlooked by the average collector, *P. monodon fraterna* is next to smallest in size, is also of importance as tending to show that the other species were not overlooked by the collectors furnishing these records. On the other hand, it is to be borne in mind, that these species, being of general distribution, probably occur in greater abundance than the allied species, whose range is apparently more limited, and which may occur only in localities specially adapted to them, and hence more likely to be missed by sporadic collecting, such, as must be admitted, is the basis of a large proportion of the present records. The most that can be safely said at the present time is, that in the counties where these two species have alone been found, the others did not occur in the particular localities visited by the collector.

Plate I is also a fair exhibition of the extent of our present knowledge of the distribution of the mollusca in the different counties of the state and, unfortunately, of the still greater extent of our ignorance on that subject. It will be observed that while the southeastern portion of the state and the Saginaw-Grand Valley has been fairly well covered, the whole region north of the Saginaw-Grand Valley with the exception of the shore counties, is practically unexplored. There is also great need of more work in the southwestern portion of the state. The importance of extending our knowledge over these unknown portions of the state will be mentioned later. But it is obvious that, in the present state of affairs, in regard to most of the species, any attempt to generalize would be futile, and any statements in that direction must be considered as tentative only. So far as the two species indicated on Plate I, however, are concerned, it may be fairly said that they will be found in suitable localities in all portions of the state.

On Plate II is shown the recorded range of four species of *Triodopsis* i. e. *P. exoleta, multilineata, profunda* and *thyroides*, which apparently have a general range across the state south of the Saginaw-Grand Valley. The occurrence of some of these species in counties lying north of the Valley, would tend to indicate that some or all of them have a more northern limit than the present records would support. The almost entire absence of records from this region is a matter of great regret and, until this deficiency is supplied, the question must necessarily rest in abeyance. The occurrence of two species as far north as Chippewa County is very striking. But, although these records have been checked by the inspection of specimens, it would be very desirable to have them verified.

Judging from the records, *P. profunda* is not as generally or, at least, as abundantly distributed in the southern part of the state as the other speties given on this plate. How far this is true is another question that must be left to the future.

The five species of *Triodopsis* shown in Plate III are all apparently, of very limited occurrence in the state, and any further information in regard to them would be very desirable.

The single record of *P. mitchelliana* is based on a single specimen from the collection of the late Dr. G. A. Lathrop of Saginaw and now in the collection of the writer, said to have been found at Armada, Macomb County. It was listed by him as *P. clausa*.

Polygyra clausa was originally listed by Sager in his Catalogue of 1839. The citations in Miles' Catalogue of 1862, and in Currier's Catalogue of 1868 were probably based on Sager's citation. There are no Michigan specimens in the Currier collection at the present time. Its occurrence in Kent county has been verified by the inspection of a specimen collected there by Mr. W. Miller of Grand Rapids. No specimens of this species from Genesee County are to be found in any of the existing collections. The following note from the late Dr. Manly Miles is of interest in this connection, "Sager's listing of *H. clausa* as a Michigan species was repeatedly verified in the early collections of shells in Genesee County by members of the Flint Scientific Institute. Unfortunately these specimens have been scattered and lost. As Binney in Terr., Moll., II. p. 109 makes *H. mitchelliana* a synonym of *H. clausa*, no attempt was made to separate the two forms and it may be that we labelled "*clausa*" in some cases that would now be placed under "*mitchelliana*"

The present range of *Polygyra elevata* seems to be limited to the western part of the state. The records from Berrien and Kent counties have been verified by the inspection of specimens. That for Osceola County was reported by Mr. W. Miller of Grand Rapids. The Washtenaw County record is based on dead shells from recent deposits. It has not been found living there.

We have, as yet, no authentic record of *Polygyra pennsylvanica* having been found living in Michigan. The Monroe County record is based on specimens purchased from Ward of Rochester and labelled "Petersburg, Mich." No information as to the source of these specimens could be obtained. Mr. Jerome Trombly, the only collector known from that locality, has never found it. The Wayne County record is based on a single dead specimen found by the writer on the shore of Bois Blanc, one of the islands at the mouth of the Detroit River. A careful search failed to find it alive on the island, which is comparitively small and has no timber left on it. Whether this specimen was brought down from some locality further up the Detroit River or some of its tributaries, or is a stray "ballast" shell, is therefore wholly uncertain.

Polygyra sayii is a boreal species and is no doubt confined to the northern part of the state It is evidently of rather rare occurrence in the state, as most of the records are based on single specimens. As it has not yet been found in the Upper Peninsula, and is not cited from Minnesota by either Grant or Sargent, Michigan probably represents its extreme western range.

The distribution of the four species of *Triodopsis* grouping around *P. palliata* as shown on Plate IV, is apparently very peculiar in the entire absence of any records from the southwestern part of the state. But as three of the species are listed by Baker from the Chicago Area and all of them are of general occurrence in Indiana according to Daniels, the probability is that lack of records from this portion of the state is due rather to the ill luck of the collectors, than to the actual non-existence of these species in that district. The poverty of our knowledge of the fauna of the counties lying north of the Saginaw-Grand Valley renders it impossible to say whether the apparent restriction of the range of all the species of this group to the north is a real one or not.

The distribution of the species of *Stenotrema* in Michigan, as shown on Plate V, is quite interesting.

Polygyra hirsuta has probably a general distribution across the southern part of the state, although the record is lamentably deficient. It has not, as yet, been recorded from north of the Saginaw-Grand Valley.

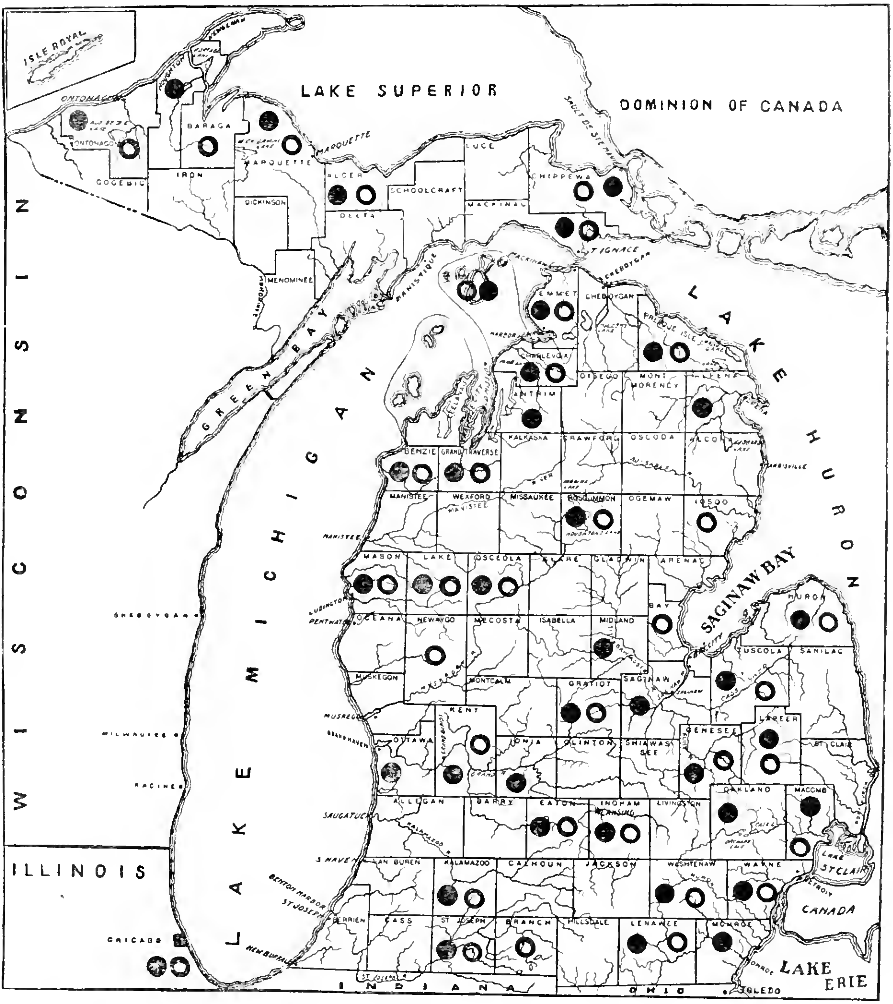
The typical form of *Polygyra monodon* was originally described in 1822 from specimens collected in Alpena County. This is probably the earliest record of any Michigan species. It is one of our most abundant species wherever found, but has not yet been recorded from the northwestern part of the lower peninsula, nor from the upper peninsula.

On the other hand the varietal form *P. monodon fraterna* as shown on Plate I, is one of the forms, whose occurrence in all parts of the state seems unquestionable.

The main conclusion to be drawn from the records, as they now stand, is the absolute necessity for more facts before any reliable results can be deduced in regard to the distribution of the species of this interesting genus in Michigan. Any data bearing on the range of any of the species would be acceptable and may be forwarded to the writer for permanent record in the census.

Detroit, Mich.

PLATE I.

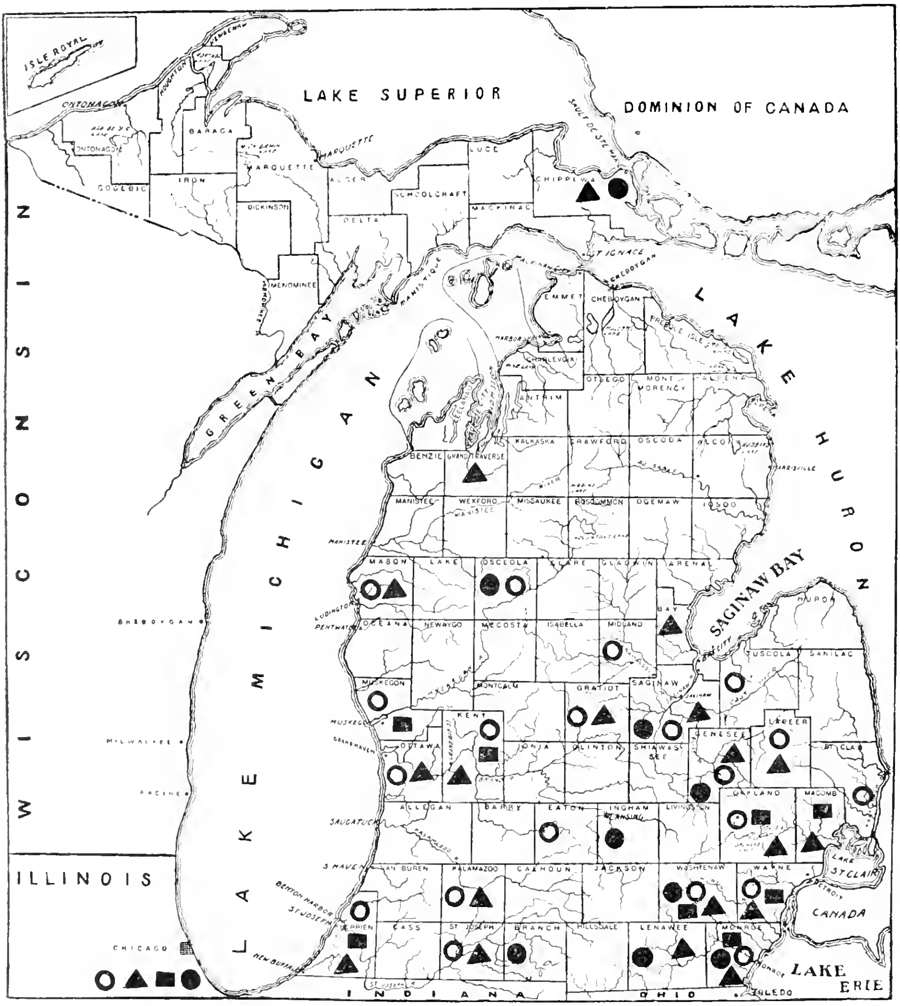


Recorded distribution in Michigan of:

Polygyra albolabris (Say).. ●

Polygyra monodon fraterna (Say).. ○

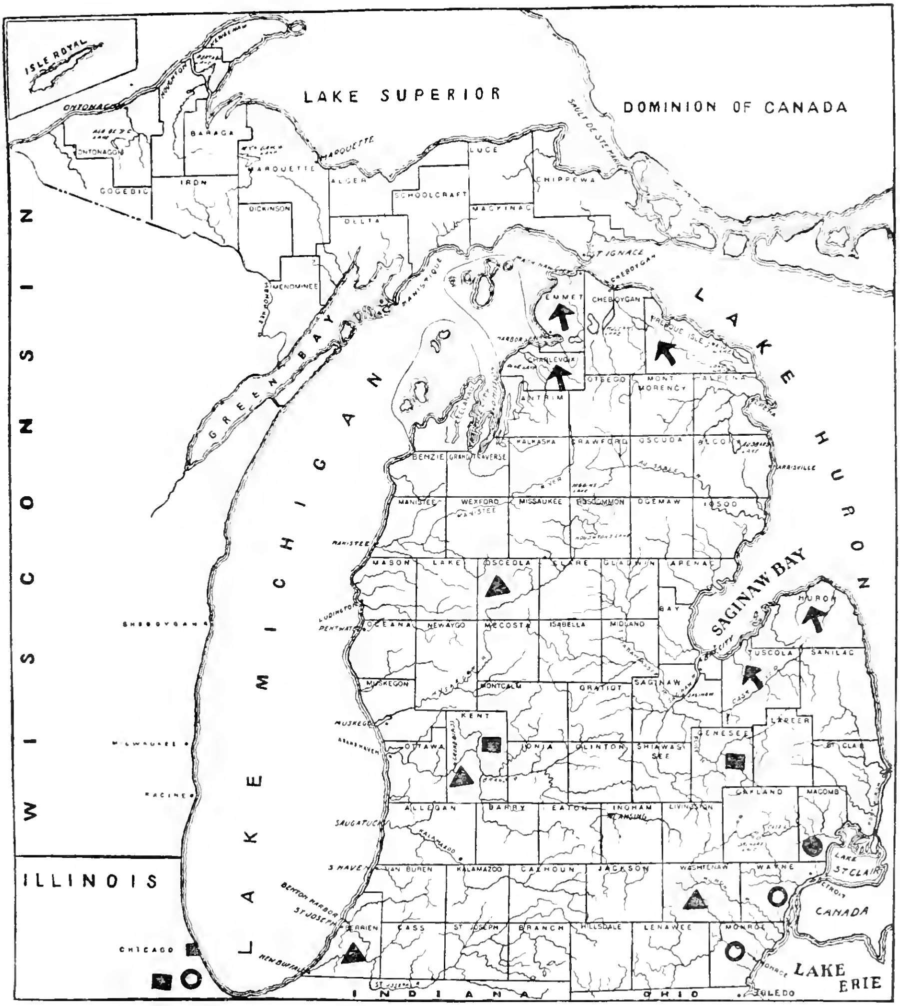
PLATE II.



Recorded distribution in Michigan of:

Polygyra exoleta (Binn.)....................●
Polygyra multilineata (Say.)....................○
Polygyra profunda (Say.)....................■
Polygyra thyroides (Say.)....................▲

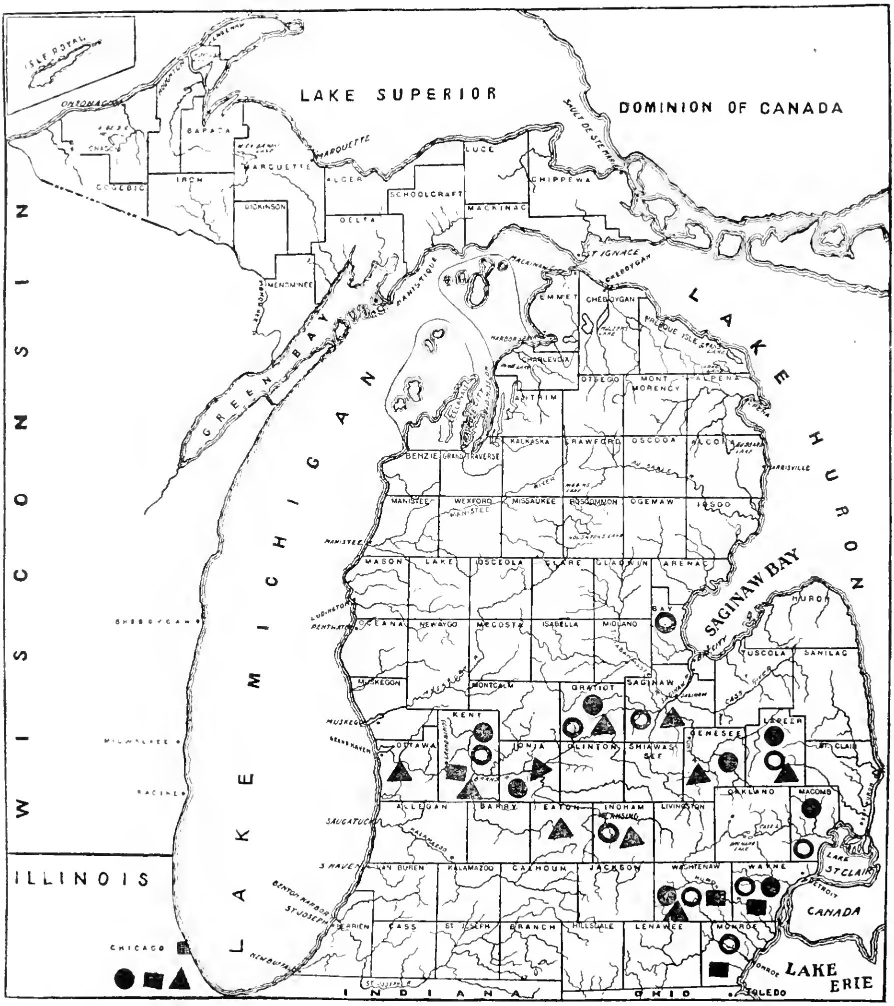
PLATE III.



Recorded distribution in Michigan of:

Polygyra mitchelliana (Lea.) . . . . ●
Polygyra pennsylvanica (Green) . . . . ○
Polygyra clausa (Say) . . . . ■
Polygyra elevata (Say.) . . . . ▲
Polygyra sayii (Binn.) . . . . ➔

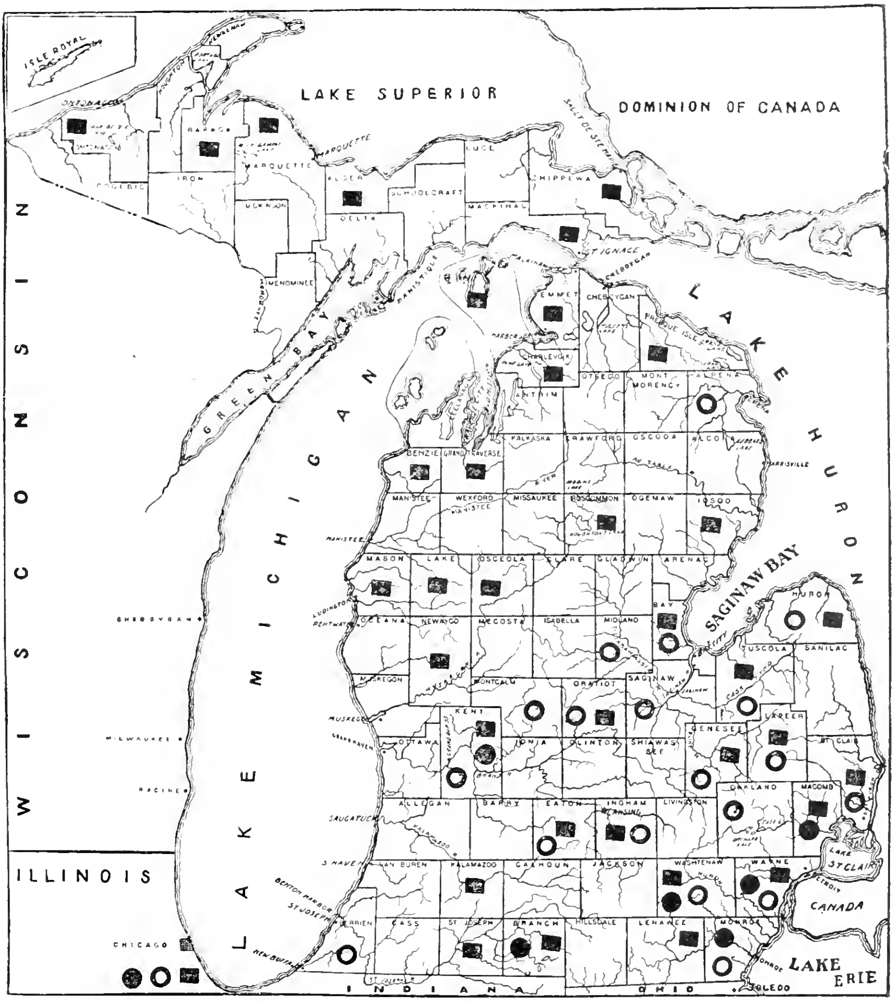
PLATE IV.



Reported distribution in Michigan of:

Polygyra palliata (Say.) .... ○
Polygyra fraudulenta Pils .... ●
Polygyra tridentata (Say.) .... ▲
Polygyra inflecta (Say.) .... ■

PLATE V.



Recorded distribution in Michigan of:

Polygyra hirsuta (Say.)..●
Polygyra monodon (Rack.)......................................○
Polygyra monodon fraterna (Say.)...............................●

VARIATION IN THE BLUE RACER.

C. C. WHITTAKER.

In the Amer. Nat., Vol. 73, Jan., 1903, Dr. Clark summarized his work on our common water snakes *Natrix leberis*, *N. fasciata sipedon*, and *Natrix erythrogaster*, and in the Pro. Mich. Acad. Sci., 1903, Mr. Sperry summed up the results of his investigation of variation in our common garter snake *Thamnophis sirtalis* comparing its variation with that of *Erythrogaster* and *Sipedon*. The present paper will follow the same general outline and aims to sum up the variation observed in the blue racer, (*Bascanion constrictor*) and compare the variation of that snake with that of *Natrix* and *Eutaenia*. The deductions with regard to the blue racer are based upon 58 specimens taken in the springs of 1903 and 1904 in Olivet and vicinity.*

NATURAL HISTORY.

The habits of *Bascanion* have been so fully given by Cope (Rep. Nat. Museum, 1898, pp. 783-795) as to need no general discussion here. The color of the Michigan blue racer when adult is very constantly a dull brownish blue color, and more or less clear light blue below. These snakes are exceeding active and can travel as fast as the average man can run. They are good climbers and will sometimes take to trees to avoid capture. Their pugnacity is very marked and they will strike viciously when attacked, some individuals will even assume the offensive and move to the attack with the head raised a foot or two from the ground, especially when cornered, and if a person is timid and shows a disposition to retreat, they may even pursue.

The fear so commonly aroused by these snakes is however entirely groundless. The wound made by a blue racer bite is very slight and almost painless. If one could overcome the instinctive retraction when the snake strikes it may even be doubted if their tiny teeth would draw blood. Of course, retraction causes them to scratch and sometimes the wound will then bleed freely. Their constricting power even if used certainly is not dangerous to any except very small children. Cope's statement that they are easily tamed is open to question. Specimens kept in confinement for over a year were as pugnacious at the end as at the beginning of confinement. It seems, however, to be largely a matter of individual temperament, as one young male was very gentle when taken and remained so in captivity. Older specimens, especially of the males are very savage. The chief food of the blue racer consists of moles, mice, young birds, and birds eggs. They do not, as many suppose, eat frogs, at least none of the Olivet specimens, even when hungry, could be induced to do so.

* The term variation has been objected to in this connection but since it was used in similar papers by Messrs. Clark and Sperry it is thought best to retain it here even though some other term, such as diversity, might be preferable.

Variation due to Age.

It is a well known fact that many characters change considerably with age. For instance the young of the blue racer is banded on the back with brown, so that to the superficial observer it resembles a young water snake. At this stage it is very different from the older specimens. The relative measurements also vary quite noticeably. In order to establish a standard by which young and adult blue racers could readily be classified it was arbitrarily determined to consider all snakes under 1200mm. in length as young and all over that limit as adult. Working on this basis it was found that there was a marked difference in the relative length of head in young and adults. The young blue racers have a head .04 % of body length, while the adults have a head per cent only .025, a difference of .015 %. Seven specimens just out of the eggs were interesting in this connection. They have an average head % of .051, or more than twice as much in proportion to body length as adults. Tail length shows a slight variation. The young have a tail % of .238 and adults .235, a very slight indication that in young blue racers the tail % is greater than in the adults. The seven specimens from the egg show an average tail % of .24, .002% more than all the young averaged together, and .005 % greater than the adults, indicating that up to adult life the proportion of tail length to body length gradually becomes less.

The Difference due to Sex.

The difference due to sex are surprisingly slight. Adult males show an average length of 1466mm. and females 1343mm. showing that males are .09 % longer than females. The head % of adult males and females is the same (.025%) and although the figures at hand give young males a head % of .36, and females .044, there is reason to believe that a larger number of specimens will show that no such disparity exists. The great apparent difference here is due to the fact that the larger proportion of very young snakes happened to be females. The male tail % of .234 is a trifle less (.003) than the female of .237%.

In the matter of gastrosteges and urosteges the same surprising similarity between the sexes appear. Adult males and females average 184 and 181 gastrosteges respectively with ranges of 175-192 and 171-189. Males average 89 urosteges with a range of 78-98, and females average 84 with a range of 73-93. This difference in the number of urosteges was hardly to be expected when the close agreement of the sexes in tail % was taken into consideration. But like other blue racer variations due to sexes it is so small, that a larger number of specimens may increase the similarity. Curious variations were shown by individuals. One had two half plates (gastrosteges) interpolated on opposite sides and the first five gastrosteges of another were divided. The most interesting specimen in this connection however was a large female which had 15 gastrosteges divided and 15 urosteges undivided.

Twenty-six out of thirty-five males have their upper labials normal (7-7) four have 8 on one side, one has 7½-7, one 6½-6½, one 7-6½, one 6-7, and one very large specimen (1601mm.) had only 6-5. Of the twenty-three females 17 are normal, 4 have 8 on one side and two have 6 on one side. .743% of the male are normal and .735% of the females, again emphasizing the close agreement in the sexes of blue racers.

The tabulation of lower labials in the spring of 1903 was made on the basis of 9-9, that is, counting the seven large plates—4 before and two after the fifth and largest, and also counting the two small scales that are under the upper labials. Examination by Dr. Clark and myself of the thirty-eight specimens captured that spring led us to the belief that the 7-7 large plates are the normal lower labials and in 1904 the presence or absence of these alone, was recorded.

Of the 22 males captured in 1903 16 have 9-9 lower labials, 5 have 8 on one side and one has 8-8. Of the 13 males taken in 1904, 12 were regular, having the 7-7 large lower labials, and one remarkable specimen, the same large male (1601mm.) before cited as having 6-5 upper labials, had only 5-5 lower labials.

The 16 females of 1903 show more variation than the males, 11 have 9-9 lower labials, 3 have 8 on one side, and 2 have 8-8. Six of the seven females of 1904 have 7-7 and one has 6-7.

Summing up: 89% of the males are found to be normal, and 70 % of the females.

Thirty-four of the thirty-five males had the normal number (2-2) of post-oculars, and had 3-2. One had 2 labials on each side, one had 2-2 pre-oculars, one had 2-1 pre-oculars and one had 6-6 temporals.

The twenty-three females all had 2-2 post -oculars. One had a sub-loreal on the left.

97 % of the males and all the females were therefore regular in the number of post-oculars. 11 % of the males varied in the matter of pre-oculars or loreals, and only 6 %

of the females. In the matter of oculars and loreals the males would thus seem to be slightly more variable. Averaging these four percentages of normality for each sex a mean of 85 % males and 84 % for females was obtained. Again bringing out the remarkable similarity between the sexes.

COMPARISON OF BLUE RACER, GARTER SNAKE AND WATER SNAKE.

The number of specimens at hand is not sufficient for conclusive proof, but if, as seems probable, a larger number of specimens should confirm the facts here given, the blue racer shows an interesting divergence from the conclusion of Clark and Sperry concerning water and garter snakes, that the females in these two genera are decidely more variable.

Young blue racers show a tail greater than the adult, as do both garter and water snakes. In the matter of length blue racers show a very decided difference from the other two. In the blue racer the males are considerably the larger, while the females of the other snakes examined are the larger. The most sriking thing brought out in this paper is the remarkable similarity of variation in blue racer males and females as opposed to the much greater variability of females of other genera, and while 58 specimens is admittedly too small a number upon which to base definite conclusions, it is hoped that the apparent results herein recorded may lead to further investigations of these points.

Olivet, Michigan.

SOME RESULTS OF A STUDY OF CORRELATION IN THE CRAY-FISH[1].

A. B. CLAWSON.

The problem dealt with in this paper may be stated in the following way: Do morphologically homologous characters exhibit a generally higher degree of correlation in their variation than non-homologous characters? This question is one of considerable interest both from the standpoint of comparative morphology, and also from that of the analysis of the fundamental nature of organic correlation. There is available but little quantitative evidence on the question. The following authors have, in the memoirs indicated, briefly discussed the matter:

(a) Duncker, Georg. Weber Asymmetrie bei "Gelasimus Pugilator" (Latr.) Biametrika Vol. II, pp. 307-320. 1902-3.
(b) Lewenz & Whiteley, "A Second Study of the Variability and Correlation of the Hand." Biometrika, Vol . I, pp. 345-360, 1902.
(c) Schuster. "Variation in Epagurus prideauxi" (Heller.) Biometrika, Vol. II, pp. 191-210, 1902-3.
(d) Warren, "An Investigation on the Variability of the Human Skeleton." Phil. Trans. B 1897 Vol. 189, pp. 125-227.
(e) Yerkes, "A Study of Variation in the Fiddler Crab Gelasimus Pugilator" (Latr.) Proc. of the American Academy of Arts & Sciences. Vol. 36, pp. 417-442, 1900-1.

The joints of the legs in the crayfish are organs especially well adapted for a study of this question, because we have in this case strict serial homology of individual members, accompanied with a definite and considerable degree of differentiation in the different legs. Furthermore the firm exoskeleton makes it possible to attain accuracy in measuring with comparative ease and certainty.

As material for the investigation a collection of cray fish (*Camborus propinquus*, Girard.) belonging to the University of Michigan museum was kindly placed at our disposal by the Curator, Mr. Chas. C. Adams. The individuals comprised in this collection were taken July 24, 1903, without selection by Mr. J. B. Field from the River Rouge near Birmingham, Michigan. They form a homogeneous sample of the species as it exists in that locality.

In all there were about 450 adult individuals, including both sexes, in the collection. For reasons which need not be entered into here it was decided to use only males in this work. Out of the 450 individuals some 325 were found to be males. Of these a certain number had joints that we wished to measure either lost or undergoing regeneration. All such individuals were discarded. There were left finally 283 individuals with the parts chosen for measurement present in normal condition. Eleven measurements were made on each individual.

The following characters were measured:

1. Length of the meripodite of the right great cheliped from the edge of its proximal dorsal process for articulation with the ischiopodite to the distal edge of the joint on dorsal medium line. Fig. I, a-b.
2. Length of the meripodite of the first walking leg of the right side, measurements from same points as in 1.
3. Length of the meripodite of the second walking leg of the right side; measurements from the same points as in 1 and 2.
4. Length of the carpopodite of the right great cheliped from the proximal dorsal edge to the end of the distal dorsal process where it articulates with the propodite. Fig. I, d-e.

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[1]Contributions from the Zoological Laboratory, University of Michigan, No. 98.

Note. In a general plan of investigation of organic correlation it was proposed as one item to make a thorough study of the degree of correlation existing between the different members of a group of serially homologous, but differentiated organs. The appendages of the crayfish seemed to be very favorable objects for such a study and consequently I suggested to Mr. Clawson that he take up the problem on this form. This was done in the second semester of the academic year 1903-04. The present paper is the first report on a portion of the results obtained. A complete account of the results will be published later. I am responsible for the arrangement of the present paper. I am indebted to the Carnegie Institution of Washington for a grant to aid in this and other biometric work now in progress.

RAYMOND PEARL.

5. Length of the carpopodite of the first walking leg of the right side; measurements from the same points as in 4.
6. Length of the carpopodite of the second walking leg of the right side; measurements from the same points as in 4 and 5.
7. Length of the propodite of the great cheliped of the right side from the proximal dorsal process where it articulates with the carpopodite to the extreme distal end. Fig. I. f-g.
8. Length of the propodite of the second walking leg of the right side; measurements from the same points as in 7.
9. Length of the propodite of the second walking leg of the right side; measurements from the same points as in 7 and 8.
10. Length of the carapace from the tip of the rostrum to the posterior edge on dorsal median line.
11 Breadth of the head between points on either side in the cervical groove just in front of the two lateral spines.

FIG. I.

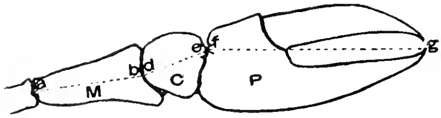

Figure of portion of great cheliped showing points from which measurements were taken.
M.—Meripodite. C.—Carpopodite. P.—Propodite.

All the measurements were made with a pair of fine pointed dividers, and read off by means of a hand-lens on a millemeter rule graduated to fifths of a millemetre. By noting whether the points rested on or between marks the measurements could be made to tenths of a millemetre. They may be considered to be accurate to a fifth of a millemetre.

For the eleven characters measured the means, standard deviations and coefficients of variation together with their probable errors were determined. The coefficients of correlation and their probable errors were computed for all possible pairs of the characters. There are with eleven characters fifty-five different combinations of two possible.

We may turn now to the results. In Table I are given the values of the coefficients of correlation between homologous joints on the one hand, and non-homologous joints on the other.

TABLE I.

Correlation Between Joints of Crayfish Appendages.

A.—HOMOLOGOUS JOINTS.

Joints.	Legs I—II.	Legs II—III.	Legs I—III.
Meripodite-meripodite	.9665 ± .0026	.9729 ± .0021	.9686 ± .0025
Carpopodite-carpopodite	.9034 ± .0074	.8854 ± .0087	.8685 ± .0099
Propodite-propodite	.9506 ± .0039	.9678 ± .0025	.9468 ± .0042
Mean	.9402 ± .0104	.9420 ± .0156	.9280 ± .0167

B. NON-HOMOLOGOUS JOINTS.

Joints.	Legs I—II.	Legs II—III.	Legs I—III.
Meripodite-carpopodite	.8908 ± .0083	.8632 ± .0102	.8652 ± .0101
Carpopodite-meripodite	.9502 ± .0039	.9185 ± .0063	.9601 ± .0031
Carpopodite-propodite	.9531 ± .0037	.9056 ± .0072	.9530 ± .0037
Propodite-carpopodite	.8898 ± .0084	.8673 ± .0099	.8613 ± .0104
Meripodite-propodite	.9578 ± .0033	.9626 ± .0030	.9646 ± .0028
Propodite-meripodite	.9440 ± .0044	.9670 ± .0026	.9539 ± .0036
Mean	.9309 ± .0080	.9140 ± .0119	.9264 ± .0123

In this table and those following the numerals I, II and III refer to the great cheliped, first and second walking legs respectively. In each case the name to the left in the column marked joints goes with the numeral to the left under Legs, and the right with the right. Thus under B. the .8908 in the column headed Legs I—II and in the row marked Meripodite-corpopodite is the co-efficient of correlation between the meripodite of the I leg and the corpopodite of the II leg.

Comparing mean coefficient[1] for homologous joints and non-homologous joints we have the following results:

Legs I—II. Mean coefficient (homologous joints)—mean coefficient (non-homologus joints) = .9402—.9309 = .0093 ± .0135.
Legs II—III. Mean coefficient (homologous joints)—mean coefficient (non-homologous joints)= .9420—.9140 (=) .0280 ± .0196.
Legs I—III. Mean coefficient (homologous joints)—mean coefficient (non-homolgous joints)= .9280—.9264 = .0016 ± .0207.

In each case the mean coefficient for the non-homologous joints is smaller than that for the homologous. In the case of the Legs I-II and Legs II-III the difference between mean coefficients of homolgous and non-homologous joints is less than the probable error of the difference,[1] and with the Legs II-III the difference is but little more than the probable error. It would seem then that the differences are not significant.

Taking the mean of the means of the three leg pairs we get as a general average for the correlation between homologous joints in the three legs a coefficient of .9367 ± .0085. The general average for the non-homologous joints is .9238 ± .0063. The difference between the two is then .0128 with a probable error of ± .0106. It would thus appear that the homologous and non-homologous joints of the legs of the crayfish are correlated to sensibly the same degree.

In order to analyze the data somewhat more closely it seemed desirable to consider each joint separately. This has been done in Tables II, III, and IV.

TABLE II.

Meripodite Correlation.

A. HOMOLOGOUS JOINTS.

Joints.	Legs I—II.	Legs II—III.	Legs I—III.
Meripodite-meripodite	.9665 ± .0026	.9729 ± .0021	.9686 ± .0025

B. NON-HOMOLOGOUS JOINTS.

Joints.	Legs I—II.	Legs II—III.	Legs I—III.
Meripodite-carpopodite	.9808 ± .0083	.8632 ± .0102	.8652 ± .0101
Carpopodite-meripodite	.9502 ± .0039	.9185 ± .0063	.9601 ± .0031
Meripodite-propodite	.9578 ± .0033	.9626 ± .0030	.9646 ± .0028
Propodite-meripodite	.9440 ± .0044	.9670 ± .0026	.9539 ± .0036
Mean	.9357	.9278	.9359

From Table II the general average coefficient for the correlation of meripodite with meripodite for the three pairs is .9693 ± .0010. For the non-homologous joint pairs in which a meripodite enters as one variable the general average coefficient is .9332 ± .0015. The difference then is .0361 ± .0018, the homologous joints showing the higher correlation.

The considerable difference in average correlation shown in this table is to be explained in part as a result of the inclusion in the B group of the pairs of joints containing as one member a carpopodite. It has appeared throughout the work that there is a general tendency for carpopodite correlations to run relatively low. This being the case it is evident that if we include in one half of a table several such pairs of joints which generally exhibit a relatively low correlation and exclude any such pairs from the other half, we should expect to get a significant difference between the average coefficients for the two halves. This is exactly what occurs in the table.

TABLE III.

Carpopodite Correlation.

A. HOMOLOGOUS JOINTS.

Joints.	Legs I—II.	Legs II—III.	Legs I—III.
Carpopodite-carpopodite	.9034 ± .0074	.8854 ± .0087	.8685 ± .0099

[1]It should be stated that the probable errors of the mean coefficient deduced from the tables were calculated by the ordinary formula for the probable error of a mean, viz., P. E. means $= .67449 \frac{\sigma}{\sqrt{n}}$. In obtaining σ each coefficient was given equal weight or in other words a frequency of 1.

B. NON-HOMOLOGOUS-JOINTS.

Joints.	Legs I—II.	Legs II—III.	Legs I—III.
Meripodite-carpopodite	.8908 ± .0083	.8632 ± .0102	.8652 ± .0101
Carpopodite-meripodite	.9502 ± .0039	.9185 ± .0063	.9601 ± .0031
Carpopodite-propodite	.9531 ± .0037	.9056 ± .0072	.9530 ± .0037
Propodite-carpopodite	.8898 ± .0084	.8673 ± .0099	.8613 ± .0104
Mean	.9240	.8886	.9099

The carpopodite correlations in Table III are generally lower than either the meripodite or propodite correlations of tables II and IV. In table III the mean coefficient for carpopodite with carpopodite is .8858 ± .0054. For non-homologous joints from the same table the mean coefficient is .9075 ± .0073. The difference between the two means is then .0217±.0079, the non-homologous joints showing the higher correlation.

TABLE IV.

Propodite Correlation.

A. HOMOLOGOUS JOINTS.

Joints.	Legs I—II.	Legs II—III.	Legs I—III.
Propodite-propodite	.9506±.0039	.9678±.0025	.9468±.0042

B. NON-HOMOLOGOUS JOINTS.

Joints.	Legs I—II.	Legs II—III.	Legs I—III.
Carpopodite-propodite	.9531 ± .0037	.9056.0 ± 072	.9530 ± .0037
Propodite-carpopodite	.8898 ± .0084	.8673.0 ± 099	.8613 ± .0104
Meripodite-propodite	.9578 ± .0033	.9626.0 ± 030	.9646 ± .0028
Propodite-meripodite	.9440 ± .0044	.9670.0 ± 026	.9539 ± .0039
Mean	.9362	.9256	.9332

Finally in Table IV. we have the propodite correlations alone. Here the mean coefficient for propodite with propodite correlation is .9551±.0036. For the non-homologous joints in the same table the mean coefficient is .9317±.0017. The difference between the two is .0234±.0040 in favor of homologous joints.

What was said above regarding the reasons for the considerable difference between homologous and non-homologous joints also applies here. The influence of the low carpopodite correlations is not equally distributed in the two halves of the table. In order to indicate to what an extent these carpopodite correlations influence the results in Tables II. and IV. the following tables (V. and VI.) have been proposed in which meripodite and propodite correlations are considered alone. Tables V. and VI. are to be regarded as supplements to II. and IV. respectively.

TABLE V.

A. HOMOLOGOUS JOINTS.

Joints.	Legs I—II.	Legs II—III.	Legs I—III.
Meripodite-meripodite	.9665±.0026	.9729±.0021	.9686±.0025

B. NON-HOMOLOGOUS JOINTS.

Joints.	Legs I—II.	Legs II—III.	Legs I—III.
Meripodite-propodite	.9578± .0033	.9626± .0030	.9646± .0028
Propodite-meripodite	.9440± .0044	.9670± .0026	.9539± .0036
Mean	.9509±	.9648±	.9592±

TABLE VI.

A. HOMOLOGOUS JOINTS.

Joints.	Legs I—II.	Legs II—III.	Legs I—III.
Propodite-propodite	.9506±.0039	.9678±.0025	.9468±.0042

B. NON-HOMOLOGOUS JOINTS.

Joints.	Legs I—II.	Legs II—III.	Legs I—III.
Meripodite-propodite	.9578± .0033	.9626± .0030	.9646± .0028
Propodite-meripodite	.9440± .0044	.9670± .0026	.9539± .0036
Mean	.9509±	.9648±	.9592±

In Table V. the mean coefficient for homologous joints is .9693±.0010, and the mean coefficient for non-homologous joints .9583 ± .0022. In comparing meripodite correlations we have: mean coefficient (homologous joints)—mean coefficient (non-homologous joints)=.9693-.9583=.0110±.0024.

In Table VI. the mean coefficient for homologous joints is .9551±.0036, and the mean coefficient for non-homologous .9583±.0022. For propodite correlations we find then as follows: Mean coefficient (non-homologous joints)—mean coefficient (homologous joints)=.9583-.9551=.0032±.0042.

Combining Tables V. and VI., or in other words, excluding from Table I. all correlation coefficients in which a carpopodite enters as one of a correlated pair, we have Table VII.

TABLE VII.

A. HOMOLOGOUS JOINTS.

Joints.	Legs I—II.	Legs II—III.	Legs I—III.
Meripodite-meripodite	.9665± .0026	.9729± .0021	.9686± .0025
Propodite-propodite	.9506± .0039	9678± .0025	.9468± .0042
Mean	.9585	.9703	.9577

B. NON-HOMOLOGOUS JOINTS.

Joints.	Legs I—II.	Legs II—III.	Legs I—III.
Meripodite-propodite	.9578± .0033	.9626± .0030	.9646± .0028
Propodite-meripodite	.9440± .0044	.9670± .0026	.9539±. 0036
Mean	.9509	.9648	.9592

From this table we get: mean coefficient for homologous joints .9622 ±.0022, and mean coefficient for non-homologous joints .9583±.0022. Here then the mean coefficient for homologous joints—mean coefficient non-homologous joints=.9622-.9583= .0039±.0031. This difference is not significant.

Putting all the results together it appears that there is not nearly so great a difference in degree of correlation between homologous joints on the one hand, and non-homologous joints on the other hand, as would probably be predicted on *a priori* grounds. Probably the fairest comparison is that instituted in Table I., which shows that the slight differences in the direction of correlations in homologous joints are insignificant in comparison with their probable errors. In the case of Tables II and IV, for the reasons stated above, the difference obtained cannot be considered to represent the true state of the case.

The whole question of the relative degree of correlation in homologous and non-homologous pairs of organs will be more fully discussed in the complete report of this study of the crayfish. Until the more complete analysis of the material has been finished we may safely conclude, I think, that, *so far as our data* indicates, morphologically homologous joints of the legs of the crayfish show approximately the same degree of correlation, one with another, as is exhibited by non-homologous joints. While the coefficients of correlation between homologous joints are in most instances slightly higher than those between non-homologous joints, yet the differences are generally found to be insignificant when compared with their probable errors. In other words, there is no marked or uniform advantage of homologous over non-homologous joints in regard to degree of correlation.

Zoological laboratory, University of Michigan, Ann Arbor, Mich.

A PRELIMINARY LIST OF THE AMPHIBIA AND REPTILIA OF MICHIGAN.

MORRIS GIBBS, F. N. NOTESTEIN AND H. L. CLARK.

The following list is presented at the present time in its incomplete and imperfect condition for the purpose of providing a nucleus about which a complete and accurate account of the amphibia and reptilia of Michigan may be formed. At the present time the literature is full of improbable and unreliable records and it is very important to rid ourselves of these errors and verify all the hypothetical species which really belong in Michigan. The following list is therefore presented in two parts, the first containing all species whose occurrence has been verified and vouched for by at least one of us, and the second contains those species reported as occurring in the State, but of whose presence here one (or more) of us is so strongly in doubt that objection has been made to admitting it in the list. Information is greatly desired in regard to these hypothetical species and also concerning the geographical distribution within the State of the bona fide forms. After the names of each species is given a list of localities from which we have records. It will be seen that the list is in most cases very small. We sincerely request *you* to help us extend it. We need and desire *your* help. Will you not give it to us and *do it now?*

BONA FIDE LIST.

1. Mud Puppy.—*Necturus maculosus.*—Detroit, Port Huron, Allegan, Kalamazoo, Olivet. Montcalm Co., VanBuren Co.
2. Spotted Salamander.—*Ambystoma maculatum.*—Olivet.
3. Blotched Salamander.—*Ambystoma tigrinum.*—Montcalm Co., Ann Arbor, Kalamazoo, Olivet, Moline.
4. Blue-spotted Salamander.—*Ambystoma jeffersonianum.*—Olivet, Montcalm Co.
5. Four-toed Salamander.—*Hemidactylium scutatum.*—Olivet.
6. Gray Salamander.—*Plethodon cinereus.*—Red-backed Salamander.—*Plethodon cinereus erythronotus.*—Olivet. Montcalm and Antrim Counties.
7. Stout Salamander.—*Plethodon glutinosus.*—Kent Co.
8. Newt. Water Salamander.—*Diemictylus viridescens.*—Olivet.
9. Toad.—*Bufo lentiginosus americanus.*—Olivet, Kalamazoo, Ann Arbor. Montcalm Co.
10. Cricket Frog.—*Acris gryllus.*—Olivet. Kalamazoo Co.
11. Three-striped Cricket Frog.—*Chorophilus nigritus triscriatus.*—Olivet. Antrim Co.
12. Common Tree Toad.—*Hyla versicolor.*—Olivet, Montcalm, Kent, Ottawa, Barry, & VanBuren Cos.
13. Pickering's Tree Toad or Peeper.—*Hyla pickeringii.*—Olivet. Van Buren, Kalamazoo, Antrim and Montcalm Counties.
14. Leopard Frog—*Rana pipiens.*—Olivet. Van Buren, St. Joseph, Montcalm, Kent, Ottawa, Antrim, Kalamazoo and Barry Cos.
15. Cold Swamp Frog.—*Rana palustris.*—Detroit, Kalamazoo, Montcalm & Van Buren Counties.
16. Green Frog.—*Rana clamitans.* Olivet, Van Buren, Antrim, Kalamazoo & Montcalm Counties.
17. Wood Frog.—*Rana sylvatica.*—Olivet. Kalamazoo, Antrim, Van Buren & Montcalm Counties.—*R. s. cantabrigensis.* Upper Peninsula.
18. Northern Frog.—*Rana septentrionalis.*—Upper Peninsula.
19. Bull Frog.—*Rana catesbeiana.*—Olivet. Kalamazoo, Van Buren, Antrim, Montcalm, Kent, Ottawa, Barry and St. Joseph Counties.
20. Ground Snake.—*Carphops amoenus.*—Kalamazoo, Ann Arbor.
21. Little Brown Snake.—*Storeria dekayi.*—Olivet, Ann Arbor. Antrim, Kalamazoo and Montcalm Counties.
22. Red-bellied Brown Snake.—*Storeria oesipitomaculata.*—Porcupine Mountains, IsleRoyale, Kalamazoo County.
23. Kirtland's Snake.—*Clonophis kirtlandi.*—Ann Arbor, Kalamazoo.
24. Ribbon Snake. *Thamnophis saurita.*—Olivet, Ann Arbor. Kalamazoo, Barry, Montcalm, Kent, Ottawa and Van Buren Counties.
25. Streaked or Garter Snake.—*Thamnophis sirtalis.*—Olivet, Ann Arbor. Montcalm, Antrim, Kalamazoo, Kent, Ottawa, Mackinaw, Barry, St. Joseph and Van Buren Counties.
26. Short-mouthed Snake.—*Thamnophis butleri.*—Olivet, Ann Arbor, Chelsea.
27. Western Garter Snake.—*Thamnophis radix.*—Kent Co., Kalamazoo Co., Montcalm Co.
28. Common or Black Water Snake.—*Natrix sipedon fasciata.*—Olivet, Ann Arbor. Kalamazoo, Antrim, Van Buren, Kent, Ottawa, Barry, St. Joseph and Montcalm Counties.
29. Red-bellied Water Snake.—*Natrix erythrogaster.*—Olivet, Lansing.

30. Olive Water Snake.—*Regina leberis.*—Olivet. Kalamazoo, Van Buren and Montcalm Counties.
31. Pilot Snake. Black Snake.—*Callopeltis obsoletus.*—Olivet, Ann Arbor, Kalamazoo, Van Buren and Montcalm Counties.
32. Fox Snake.—*Callopeltis vulpinus.*—Grosse Isle, Saginaw?
33. Green or Grass Snake.—*Liopeltis vernalis.*—Olivet, Ann Arbor. Kalamazoo, Van Buren, Montcalm, Barry and Kent Counties.
34. Blue Racer.—*Bascanion constrictor.* From Oceana and Muskegon to Arenac, Saginaw and St. Clair counties and southward.
35. Ring-necked Snake.—*Diadophis punctatus.*—Olivet, Kalamazoo. Montcalm and Van Buren Cos.
36. Milk Snake.—Spotted Adder.—*Lampropeltis doliatus triangulus.*—Olivet, Ann Arbor. Kalamazoo, Antrim, Montcalm, Kent, Ottawa, Barry and Van Buren Counties.
37. Blow Snake; Spreading Adder; Hog-nosed Snake; Viper.—*Heterodon platirhinos.*—Wayne, Kalamazoo, Van Buren, Allegan and Barry Counties.
38. Swamp Rattlesnake. Massasauga.—*Sistrurus catenatus.*—Benzonia to Au Sable River and southward, probably throughout.
39. Blue-tailed Lizard. Swift. —*Eumeces fasciatus.*—Kalamazoo, Kent, Ottawa, St. Joseph, Van Buren, Montcalm and Barry Counties.
40. Soft-shelled Turtle.—*Aspidonectes spinifer.*—Brookfield, Ann Arbor, Olivet. Kalamazoo, Van Buren. Montcalm and Allegan Counties.
41. Snapping Turtle.—*Chelydra serpentina.*—Olivet, Ann Arbor. Kalamazoo, Kent, Ottawa, St. Joseph Barry, VanBuren and Montcalm Counties.
42. Musk Turtle. *Aromochelys odoratus.*—Olivet, Ann Arbor. Kalamazoo, Van Buren, Montcalm and Barry Counties.
43. Map Turtle.—*Graptemys geographicus.*—Olivet. Kalamazoo, VanBuren, Montcalm, Barry, Kent and Ottawa Counties.
44. Common Pond Turtle.—*Chrysemys marginatus.*—Olivet, Ann Arbor. Marquette, Porcupine Mts., probably throughout.
45. Spotted Turtle.—*Clemmys guttatus.*—Olivet, Ann Arbor. Kalamazoo, Barry and Van Buren Counties.
46. Blanding's Box Tortoise.—*Emydoidea blandingii.*—Olivet, Ann Arbor. Kalamazoo and Van Buren Counties.
47. Carolina Box-Tortoise.—*Terrapene carolina.*—Montcalm, Kalamazoo, Barry and Van Buren Counties.

HYPOTHETICAL LIST.

1. Allegheny Hellbender.—*Cryptobranchus alleganiensis.*
2. Two-lined Salamander.—*Spelerpes bislineatus.*
3. Cave Salamander.—*Spelerpes longicauda.*
4. Red Salamander.—*Spelerpes rubra.*
5. Brown Salamander.—*Desmognathus fusca.*
6. Barred Salamander.—*Ambystoma opacum.*
7. Hoosier Frog.—*Rana areolata circulosa.*
8. Graham's Snake.—*Regina grahami.*
9. Diamond Water Snake.—*Natrix rhombifer.*
10. Corn Snake.—*Callopeltis guttatus.*
11. Bull Snake.—*Pityophis sp.*
12. Chain Snakes.—*Lampropeltis getulus.*
13. Rattlesnake.—*Crotalus horridus.*
14. Copperhead.—*Agkistrodon contortrix.*
15. Common Lizard or Swift.—*Sceloporus undulatus.*
16. Leather Turtle.—*Platypeltis mutica.*
17. Mud Box Turtle.—*Kinosternon pennsylvanicum.*
18. Masked Terrapin.—*Pseudemys hieroglyphica.*
19. Eastern Mud Turtle.—*Chrysemys picta.*
20. Muhlenberg's Turtle.—*Clemmys muhlenbergi.*
21. Three-toed Box Turtle.—*Terrapene triunguis.*

These species have all been reported at various times as occurring in Michigan, but the evidence is usually unreliable and no known Michigan specimens are extant. Who will be the first to present evidence which shall enable us to transfer a name from this list to the previous one.?

Olivet, Mich., March, 1905.

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THE OPHIDIA OF MICHIGAN WITH AN ANALYTICAL KEY.

F. N. NOTESTEIN.

CONTENTS.

INTRODUCTION.

The study of natural history as a part of a liberal education is becoming more and more desirable, and is leading to the preparation of manuals and helps along almost every possible line of study.

This report is taken from the author's manual of "The Ophidia of the United States," which was prepared not only for those who are now interested in natural history, but with a hope that it may stimulate others to the study of nature, wherever they come in contact with it.

It is also hoped that this report may interest some in this part of the animal kingdom, and help to correct the common prejudice which exists against these animals, so that the ruthless destruction of these much abused and slandered creatures may soon cease.

The author has carefully prepared an artificial key, founded upon the most obvious characteristics, for the ready determination of any snake in the State.

In making use of this "report," the reader must remember:

1. That the descriptions are those of types and that there are, as in the vegetable kingdom, variations, intermediate and abnormal forms which are more difficult to classify.

2. That the color markings vary with the habitat, season of the year and age of the specimen, usually being brighter and more distinct after shedding the skin and upon young specimens.

3. That the colors are often greatly changed when placed in spirits; thus orange, yellow and salmon become write or whitish; pink and red may become white or yellowish or the latter may become brownish; green often becomes bluish, blue may become reddish; white, black, brown and metalic tints remain unchanged for some time.

Let all who read this remember that the Crotalidae are the only snakes in the State that are venomous, and that all others are not only harmless but do positive good by destroying noxious insects and other vermin. They are the friends of the agriculturist and should be protected instead of being destroyed.

The author would recommend that those desiring to make collections use the "F. N. N. Ophidia Tubes," with rubber stoppers.

Alma, Mich., Feb. 15, 1905.

ANALYTICAL KEY TO THE GENERA.

Serpents with the maxillary fixed to the internasal and premaxillary: a pubis is present: usually of subterranean habits. The Blind Snakes. Catadonta, A.

Serpents with maxillary bone horizontal, in contact with the premaxillary, and provided with solid teeth. The Harmless Snakes—Asinea, B.

Serpents with channeled maxillary fangs and loreal pit. The Pit Venomous Snakes.—Solenoglypha, C.

Serpents with colubriform jaws, the anterior maxillary teeth grooved or perforated: pupil vertical. The Pitless Venomous Snakes. Proteroglypha, D.

A. *Catodonta,—Kat-o-don-ta.*

Serpents with head slightly depressed: rostral large: snout rounded, overlaping the lower jaw. Fam. 1. Glanconiidae.

B. Asinea—As-i-ne-a.

Serpents without premaxillary: with supraoculars and postoculars: peropods. Fam. 2.—Boidae.

Serpents without supraoculars and without cronoid bones: spur like appendages are present. Fam. 3. Chrinidae.

Serpents without loreal pit, upper surface of head covered with plates. Fam. 4—Colubridae. 8.

C. Solenoglypha—Sol-e-nog-li-fa.

Serpents with poison fangs in front part of mouth: with a deep loreal pit between the eye and nostril. Fam. 5.—Crotalidae. 9.

D. Proteroglypha—Prot-e-rog-le-fa.

Serpents with erect poison fangs in front part of mouth: loreal pit wanting: jaws not dilatable: pupil vertical. Fam. 6—Elapidae.

Note.—No representatives of families one, two, three and six, have been found in Michigan.

Fam. 4, Colubridae—Ko-lu-bri-de.

I. Dorsal scales keeled, a.
- a. Anal plate entire, b.
- b. Dorsal scales in 15-17 rows.—Storeria, 114.
- b. Dorsal scale rows not exceeding 23; two nasals.—Eutaenia, 114.
- b. Dorsal scale rows exceeding 23.—Pityophis, 115.
- a. Anal plate divided, c.
- c. Loreal absent, rarely present.—Storeria, 114.
- c. Loreal and one or more preoculars presented.
- d. Dorsal scale rows 17 or fewer.—Cyclophis, 116.
- d. Dorsal scale rows 19 or more, e.
- e. Head plates normal f.
- f. Dorsal scales in 19-33 rows, all keeled.—Natrix, 116.
- f. Dorsal scales in 23-35 rows, some smooth.—Coluber, 117.
- e. Head plates not normal, g.
- g. Muzzle produced; dorsal scales in 23-27 rows.—Heterodon, 118.

II. Dorsal scales smooth, h.
- h. Preocular absent; lorealocular present, i.
- i. Dorsal scales in 13 rows; one postocular.—Carphophiops, 118.
- h. Preocular usually one, rarely two, j.
- j. Anal plate divided, k.
- k. Dorsal scales in 15 rows; preoculars 1-2: color green. Liopeltis, 118.
- k. Dorsal scale rows not exceeding 25; superior lablials 7. Ophibolus, 118.
- k. Dorsal scale rows 25 or more; superior labials (7), 8-9. Coluber. 117.
- j. Anal plate entire, l.
- l. Dorsal scales in 21-25 rows; loreal 1, temporals (1), 2, 2, (3). Ophibolus, 118.
- n. Preoculars usually two, m.
- m. Anal plate divided, n.
- n. Usually with a cervical ring; rather small. Diadophis, 119.
- n. Without cervical ring; body elongated. Bascanium, 119.

Fam. 5, Crotalidae—Kro-tal-i-de.

Tail ending in a point witout a rattle. Agkistrodon, 32.
Tail provided with a rattle or button, o.
o. Top of head mostly covered with scales, plates few. Crotalus, 33.
o. Top of head covered with cephalic plates. Sistrurus, 34.

COLUBRIDAE.

The Harmless Snakes.

Genus 1, Storaria-Baird and Girard—Sto-re-ri-a.—Little Brown Snake.

Body small; dorsal scales in 15-17 rows, keeled; without pits; anal plate usually divided; head short and distinct; cephalic plates normal; loreal absent or rarely present; internasals two; nasals two; preoculars one or two; postoculars two; tail short; ovoviviporous; harmless.

* Dorsal scales in 17 rows.

1. Storeria dekayi-Holbrook.—Little Brown Snake.—Dorsal scales in 17 rows; reddish brown to grayish brown above, with a lighter dorsal stripe margined with dotted lines; grayish white to copper color on the abdomen. A dark bar extends from the occipitals to the angle of the mouth; head plates often mottled with brown: a dark spot below the orbit; preocular one; postoculars two; superior labials 7, fifth largest; temporals 1. 2, first extending to the middle of the last superior labial; exterior row of scales largest, smooth or weakly keeled. Sometimes there are traces of one or more series of stripes on the sides. Length 330-350 m. m. Common in Michigan. Throughout the United States east of the Rocky Mountains.

** Dorsal scales in 15 rows.

2. Storeria occipitomaculata-Storer. Red-bellied Brown Snake.—Dorsal scales in 15 rows all keeled except the inferior row which may be smooth; superior labials 5-6; inferior labials 6-7; oculars 2-2; nostril in anterior nasal; pregeneials longer than the postgeneials; chestnut brown to gray, bluish or olivaceious above, with a lighter dorsal stripe margined with dark dotted lines; abdomen red or salmon color to whitish. The salmon color fades in spirits to grayish white. The ventral color sometimes extends upon the flanks; lower jaw minutely dotted with brown; salmon colored spots on the superior labials and occipital region. Length about 340 m m. Habitat same as Storeria dekayi. Rare in Michigan.

Genus 2. Eutaenia-Baird and Girard.—U-te-ni-a.—Garter Snakes. Striped Snakes.

Dorsal rows of scales not exceding 23, more or less keeled; cephalic plates normal; two nasals; one loreal; preoculars 1-2; postoculars two; anal plate entire; terrestrial or sometimes semi-aquatic; ovoviviparous. The snakes of this genus seem open to every possibility of variation. They are the most common snakes in the United States and are perfectly harmless.

KEY TO THE SPECIES.

I. Lateral stripe at least on the third and fourth row of scales.
*Dorsal scales in 19 rows.
†Temporal scales 1, 1, (2); superior labials 6-7.
Laterals tripe on the second, third and fourth rows of scales, at least anteriorly. E. Butleri, 114.
‡Temporal scales 1, 2, (3).
Superior labials 7, (8).
Body slender; first row of scales longer than deep. E. saurita, 114.
**Dorsal scales in 21, (19) rows; temporals 1-2, 3.
Superior labials 7, (8). E. radix, 115.
II. Lateral stripe when present on the second and third row of scales.
*Dorsal scales in 19, (17, 21) rows; superior labials 7, (8); temporals 1, 2, (3).
Preoculars 1, (2); postgeneials longer than the pregeneials. E. sirtalis, 115.

1. *Eutaenia butleri Cope. Butler's Garter Snake. Short mouthed Snake.*

Dorsal scales in 19 rows, all keeled, inferior row widest; superior labials 6-7, (8), yellowish, maigined with black; inferior labials 8; oculars 1-3; temporals 1, 1, rarely 1, 2, first usually larger than the second and extends to the superior labials; loreal trapezoidal. Head conical, olive brown above, marked with black, with or without two yellowish, dark bordered, occipital spots; muzzle narrow and projecting a little; cleft of mouth short; chin white; throat yellowish; eye over the third and fourth superior labials. Body small to fairly stout, tapering towards both ends. Color above light to dark olive brown; marked with three yellowish longitudinal stripes; dorsal stripe corners, one and two half rows of scales, each lateral stripe covers more or less of the second third and fourth rows of scales, at least anteriorly, irregular in width posteriorly. Two rows of dark ill-defined spots above and one below the lateral stripe, which sometimes widens, on the side of the neck, into a yellowish blotch containing a black spot. Abdomen light olivaceous, more or less speckled with black. Tail short; total length 350-530 mm. This is a rare species found in eastern Illinois, Indiana, southern Michigan and western Ohio.

2. *Eutaenia saurita Linneaus. Swift Garter Snake. Ribbon Garter Snake.*

Body slender, elongated, tapering to a long pointed tail; superior labials 7, (8); inferior labials 9-10; geneials extending to the seventh inferior labial; frontal elongated, hexagonal; eyes large; preoculars usually whitish; color dark to chocolate brown above, with three stripes usually extending from the head to the tip of the tail; dorsal stripe sulphur yellow, usually margined with a narrow black band; lateral stripes occasionally speckled or margined with black; the labials, chin and gular region yellowish white; abdomen greenish white, without spots. The young are spotted. End of ventrals chestnut brown, which disappears in spirits; length 750-900 m m. East of the Mississippi River.

3. Eutaenia radix, Baird—Girard. Racine Garter.

Dorsal scales in 21, (19) rows, inferior row as deep as long, smooth or keeled; body moderately stout; head short; muzzle pointed; superior labials 7, (8), bordered posteriorly with black; inferior labials 9-10; temporals 1, 2, (3); internasals and prefrontals as wide or wider than long. General color above, various shades of brown, in the type dark brown to black, obscuring the spots. In some forms as light as light olive, so that the spots above and below the lateral stripes are distinct. The stripes are rather narrow and yellow. In young specimens, a narrow black stripe on each side of the dorsal stripe is common, which in age develops into a more or less distinct row of spots. The lateral stripes are on the third and fourth rows of scales. Abdomen dark greenish to lighter more or less spotted with black. Sometimes the spots on the ventrals are prolonged so as to form a more or less interrupted black stripe on each side of the abdomen. Rare in Michigan, but one of the most common species of the western plains.

4. Eutaenia sirtalis Linnaeus.

Body moderately stout; head distinct, oval in outline; dorsal scales in 17-21 rows; oculars 1, (2)-3, (4); temporals 1, 2, (13), 3; superior labials 7-8, (6); postgeneials longer than the pregeneials; inferior labials usually 10; geneials reaching back to the sixth or seventh inferior labial; nasals two. Color above varying from light green through olive brown to black; dorsal and lateral stripes, when present, brownish yellow to whitish. Abdomen yellow, greenish, copper color or black; stripes begin at the back of the head and gradually become indistinct on the tail; lateral stripes on the second and third rows of scales, when present. The type has two rows of alternating dark spots between the dorsal and each lateral stripe, which in some of the varieties may be more or less confluent with each other and thus become indistinct or disappear; ventrals black spotted in some varieties, without spots in others. This species in some of its forms ranges throughout the United States. It is the most common of the genus and the most variable in its scale formulae and the color markings. When handled it gives off an offensive odor. There are the following varieties in Michigan.

*Green to olivaceous, with or without spots; stripes indistinct or wanting.

Var. 1, Eutae nia sirtalis ordinatus Linnaeus. Green Garter Snake.

Dorsal scales in 19 rows; superior labials 7, usually with dark edges. Color above greenish to olive brown; dorsal stripe, if present, yellowish and indistinct; lateral stripe, if present, a trace on the second and third rows of scales; spots generally distinct occasionally obscure or wanting; abdomen greenish white, usually with a few of the ventrals spotted with black on each end of the scale.

Throughout the United States east of the Mississippi River. Rare in Michigan.

**Both spots and stripes present.

†Dorsal stripe yellowish not black bordered; no red on the sides.

Var. 2. Eutaenia sirtalis sirtalis Linnaeus. Garter Snake. Striped Snake.

Dorsal stripe yellowish to greenish yellow, not bordered with black but often quite narrow and encroached upon by the spots; lateral stripes onthe second and third rows of scales, a little lighter than the first row of scales, which is usually colored like the ends of the ventrals. Color very variable, but usually olive to dark brown ; abdomen greenish white to yellowish; spots usually in three series, sometimes they are small and indistinct and can be seen only on stretching the skin, more frequently they are large and distinct. The spots are more or less confluent, in some specimens even dividing the stripes into sections; usually numerous white lines will be seen on stretching the skin; ventral spots are usually present; labials yellowish or greenish, often with dark borders. This is especially the case in old individuals. This is one of the most variable varieties both as to its general color and markings. Eastern and Austroriparian region and as far west as central Kansas. One of the most common snakes in Michigan.

††More or less red in and about the lateral stripes.

Var. 3. Eutaenia sirtalis parietalis Say. Red Garter, Rocky Mountain Garter Snake.

Dorsal scales in 19, (21) rows; superior labials 7, (8), color above, greenish, brown to blackish; dorsal stripe variable in width and color, greenish white to yellowish brown; lateral stripe on the second and third rows ot scales, yellow to greenish; first row of scales and ends of the ventrals darker, often brownish; superior row of spots often very indistinct, seen only on stretching the skin, with which the inferior row sometimes connects above; first row of spots quite distinct, between the third and sixth rows of scales; second row, which may be distinct, is between the sixth row of scales and the vertibral line; skin an even the lateral margins and base of the scales between the dark spots bright brick red in western specimens, in eastern specimens, (Michigan,) the red is usually visible on the anterior part of the body, in and about the lateral stripe and inferior row of scales, sometimes visible only on stretching the skin. It forms the connecting link between the western specimens and Eutaenia sirtalis sirtalis of the east. Ventral spots few and small or none; abdomen bluish green to yellow; top of head olive brown to reddish yellow; occasionally a superior labial will have a narrow dark border. From Michigan to the Pacific coast and from Montana to Mexico.

Genus 3. Pityophys Hallowell—Pi-ti-o-fis.—Bull or Pine Snakes.

Body rather large and robust; head elongated; epiglottis veritical, laminiform; rostral plate high, projecting backwards; nasals two; internasals two; prefrontals 4-6; preoculars 1, (2); postoculars 3-5; one loreal; dorsal scales in 25-35 rows, scales pitted, and more or less keeled; anal plate entire; terrestreal in habits, preferring dry and sandy regions; length 1,500-2,000 m m.

*Head bands distinct; spots numerous.

1. Pityophys catenifer Blainville.

Dorsal scales in 25-35 rows, 3-12 lower rows smooth; preoculars 1, (2); postoculars 3, (4); temporals 3, 4, (5); superior labials 8-9; rostral varying from low and broad to high and narrow above, sometimes penetrating between the internasals but not extending to the prefrontals; prefrontals 4, (6); dorsal spots 40-70 in number; lateral spots in three series, which are more or less distinct. Head with dark bands, one between the orbits, one from the orbits downward across the superior labials and one from the orbits to the angle of the mouth.

†Rostral high, narrow above, penetrates the internasals about two thirds of their length.

Var. 1. Pityophys catenifer sayi Schlegel. Prairie Bull Snake.

Head subelliptical, distinct; frontal broad, muzzle pointed; preoculars one or two; postoculars three or more, interprefrontals rather narrow; loreal trapezoidal; superior labials 8-9; second and third posterior ones largest; inferior labials 12-13; sixth and seventh largest; labials margined with dark brown or black; head bands usually distinct; dorsal scales in 27-33 rows, usually five to nine rows smooth. Ground color yellowish or reddish brown with three series of dorsal black blotches, 40-70 in number, from the head to opposite the anus. The medium series of blotches largest; lateral series alternating with the medium series; abdomen dull yellow with a small dark spot on the end of each alternate scutella; throat yellowish. From Illinois to the Rocky Mountains and from the northern to the southern boundaries of the United States. Rare in the southwestern part of Michigan, Indiana and Ohio.

Genus 4. Cyclophis Gunther,—Si-klo-fis.

Body long and slender; dorsal scales in 17 rows, keeled, head distinct and moderately large; cephalic plates normal; prefrontals and internasals each a pair; nasals one, nostril in the middle of the nasal; oculars 1-2; anal plate divided.

1. Cyclophis aestious Linnaeus—Summer Green Snake. Hammock Snake.

General color above greenish to reddish green, bluish in spirits; abdomen yellowish to greenish white; loreal long, rarely absent; preoculars 1, (2); postoculars 2, (3); temporals 1, 2; rostral broader than high; superior labials 7, sixth largest; inferior labials 8, fifth largest; labials, chin and throat white or yellow. From New Jersey south to Florida, west to the Mississippi River and southwest to New Mexico. Very rare in the southern part of Michigan.

Genus 5. Natrix Laurenti—Na-triks.—Water Snakes. Queen Snakes.

Body often rather stout and large; head distinct; dorsal scales in 19- 33 rows, keeled and pitted; cephalic plates normal; loreal present; preoculars 1-2; pastoculars 3, (2); labials and geneials large; anal plate divided; viviparous.

KEY TO SPECIES.

I. Temporal plates 1, 1, (2); superior labials 6, (5).
Oculars 1, 2; dorsal scales in 19, (21) rows; size small.—N. kirtlandii, 116.
II. Temporal plates 1, 2, (3).
*Body usually with stripes; scales in 19, 21 rows.
†Preoculars 2, (1).
Brown with three black stripes on the back.—N. leberis, 116.
Light brown or clay color, usually with four stripes on the back.—N. grahamii. 116.
**Body usually with spots or cross bands.
†Dorsal scales in 23-25 rows.
Superior labials 8, (9); preoculars one.—N. fasciata, 116.
‡Dorsal scales in 27-29 rows,
Dorsal scales in 27 rows; without true circumorbital scales. N. rhombifera, 117.

1. Natrix kirtlandii Kennicott.—Little Red Snake.

Body slender, about 450 m m. long; dorsal scales in 19, (21) rows, all keeled; superior labials 6, (5); inferior labials 7; oculars 1-2; nasal one with a mark giving it the appearance of two; one loreal; anal plate divided; general color above, pale purplish brown; with a dorsal series of large dark spots and an alternating series of spots on each side; abdomen pale brick red, fading in spirits, with a black spot near the end of each ventral plate. It is terrestrial in its habits, usually found in the woods under logs. Illinois, Indiana, Michigan, Ohio and Wisconsin.

2. Natrix leberis Linnaeus. Willow Snake. Yellow-bellied or Leather Snake.

Head small, tapering anteriorly; dorsal scales in 19 rows; nostral low, nearly twice as wide as high; preoculars two; postoculars 2, (3); superior labials 7, fifth and sixth largest; inferior labials 9-10; loreal large; temporals 1, 2, (3), first large; internasals usually wider than long; color dark chestnut or chocolate brown above, with three narrow black stripes; a yellowish stripe on the two inferior rows of scales; abdomen yellowish with dark bands which sometimes fuse making the abdomen quite dark. Length 575-590 m m. United States east of the Mississippi. Not uncommon in Michigan.

3. Natrix grahamii Baird and Girard. Graham's Snake. Prairie Water Snake.

Head elongated, flattened above; dorsal scales in 19, (21) rows; oculars 2-2, (3); temporals 1, 2; superior labials 7, fifth and sixth largest; inferior labials 10, fifth and sixth largest; internasals longer than wide; rostral nearly as high as wide; loreal slightly elevated anteriorly. In old individuals the colors are darker and the appearance is more like that of a brown snake with three narrow black stripes on a side. In younger specimens there is a light brown or clay colored dorsal stripe, about one and a half scales wide, bordered by a narrow black line Next to this is an olive brown stripe about three scales wide bordered by another black line on the fourth row of scales; next a straw colored band, on the first, second and at least part of the third row of scales, which passes along the side of the head to the end of the nose, and this in turn is bordered below by a narrow black line along the juncture between the first row of scales and the ventrals; abdomen light straw colored, frequently with one or two narrow dark medium lines. Length 875-885 m m. The Mississippi valley from Michigan to Texas.

4. Natrix fasciata Linnaeus. Banded Water Snake.

Size moderate to large and stout; dorsal scales in 23-25, (27) rows, all keeled scales of the first row larger than the others; superior labials 8, (9); eye above the fourth and fifth superior labial; oculars

1-3, (2); temporals 1, 2, (3); pregeneials nearly equal to the postgeneials; head distinct, widening posteriorly. General color above grayish, reddish brown to bluish black, spotless or marked with large transverse spots; abdomen yellowish or reddish with or without reddish brown to bluish black spots.

†Abdomen spotted with bluish spots.

Var. 1. Natrix fasciata sipedon Linnaeus. Water Adder. Mud Moccasin.

Size moderate, dorsal scales in 23, (25) rows; superior labials 8; inferior labials 10-11, sixth largest; dull black to grayish or brown with three series of darker, more or less, distinct quadrilateral spots margined with brown or black; dorsal spots much the largest and anteriorly fuse with the lateral spots which have their sides nearly parallel; anteriorly they are often obscure or wanting; no distinct postocular bands in adult specimens. In old dark individuals the general appearance is that of a dark brown snake, crossed onthe middle of the back with narrow light lines margined with black; top of head brown; abdomen yellowish white with blotches of light reddish brown to grayish, margined with black or brown, often a fine mottling. All markings less distinct in adult specimens. This is not only the common water snake of Michigan but of the eastern and middle states. From Maine to Georgia west to Wisconsin and Kansas.

††Abdomen red or reddish.

Var. 2. Natrix fasciata erythrogaster Shaw: Red-bellied Water Snake.—Copper-belly.

Body large and stout; head elongated, narrowing anteriorly;dorsal scales in 23, (25) rows; oculars 1-3; temporals 1, 2, (3), first largest; loreal rather large; superior labials 8, sixth and seventh largest; inferior labials 10-11; geneials large and nearly equal. General color above bluish black to reddish brown, sides often lighter; abdomen light color, in young specimens, to a deep dark copper red in old individuals, without true spots but often speckled with small dark spots and the ventrals are often marginal with dark, especially at the ends which are dark like the scales of the first row. The color of the abdomen fades in spirits. Young specimens sometimes have indications of three series of blotches. Length 1200-1800 m m. From southern Michigan, south and southwest.

5. Natrix rhombifera Hallowell. Diamond Water Snake.

Large dorsal scales in 27, (25) rows, all keeled, first row larger and slightly keeled; head distinct; rostral nearly twice as wide as high; oculars 1-3, (2-4); temporals 1, 2, (3); superior labials 8, sixth and seventh large, centers yellowish olive, sutures dark bordered; eye above the fourth superior labial and the lower postocular; inferior labials 11, sixth largest, all usually dark bordered. General color above yellowish brown to reddish brown, with a vertebral series of 30-40 black spots, 2-5 scales long and 3-7 wide. The dorsal spots are more or less connected, at the corners, with the rectangular lateral spots, thus enclosing, more or less well defined, diamond shaped spots. The lateral spots extend down, in triangular points, upon the ventrals. There are also semi-circular spots on the other ventrals a little nearer the median line. Gular region and anterior part of abdomen yellowish, posterior part usually more or less spotted. Length 1100-1200 m m. Illinois, Indiana, Louisiana to Texas. Rare in southwestern Michigan.

Genus 6. Coluber Linnaens.—Kol-u-ber.

Body large; dorsal scales in 23-25 rows, partly keeled or smooth; anal plate divided; cephalic plates normal; loreal present; head distinct; mouth deeply cleft; labials large. A row of large dorsal spots and one or more of smaller lateral spots are usually present. Colors much lighter after sheding the skin and spots more distinct. Harmless to man but destructive to birds and small animals.

*Dorsal scales with 9-15 rows, moderately to strongly keeled.

†Grayish yellow to brownish, with distinct spots.

1. Coluber vulpinus Baird—Girard. Fox Snake. Pilot Snake.

Dorsal scales in 25-27 rows 9-11 keeled sometimes but slightly; internasals smaller than the prefrontals; inferior labials 10-12, sixth largest; superior labials 8, seventh largest; occipitals large; frontal bell shaped; temporals 2, 3, 4; form stout, large to the base of the tail. General color brown or brownish to grayish yellow, with a dorsal row of large, dark brown, quadrate spots, 4-7 scales long and 11-15 wide. Interspaces about two scales long and 3-5 wide. All series of spots continue on the tail but are smaller. Head light yellow to brownish or copper color:: abdomen checkered with bluish or black spots, some of which extend upon the flanks. Adults 1200-1500 m m. long. From Mass. to Minn. and southwestward.

††Black or bluish with spots sometimes obscure.

2. Coluber obsoletus Say. Black Snake, Pilot Snake. Racer.

Dorsal scales in 25-29 rows, 9-21 rows keeled; oculars 1-2; temporals 2, 3, (1, 3) or (3-3) superior labials 8, orbit over the fourth and fifth; inferior labials 11-13; ventrals 220-260. Color above, black to grayish, with dark spots; lateral spots, when present, more or less elongated; size medium to large and stout. There are three varieties in the United States.

‡Black or bluish above, sometimes with spots indistinct.

Var. 1. Coluber obsoletus obsoletus Say. Black Racer. Black Snake, Pilot Snake, Sleepy John.

Dorsal scales in 25 to 29 rows, 9-17 rows keeled, becoming more decidedly so towards the medium line. Color above dark to black, brownish on young specimens; spots often distinct and color quite light after shedding the skin, but normally blackish and spots indistinct in adult specimens, sometimes the spots are margined with yellowish specks; throat and chin yellowish white; abdomen yellowish, at least anteriorly, and more or less marked with black spots; posteriorly usually bluish black; labials yellowish, margined with black. In some specimens there is more or less red on the flanks and brownish red on the back; length from 4-7 ft. From Maine to Illinois southwest to Mexico.

Genus 7. Heterodon Latreille.—He-ter-o-don.

Blowing or Puffing Adder. Hog-nosed Adder or Snake. Adders.

Dorsal scales in 23-27 rows, more or less keeled; anal plate divided; loreals one or more; preoculars 2-4; postoculars 3-4; suboculars 1-3; temporals (2), 3, 4) in first row; cephalic plates not normal. The trowel shaped rostral plate is prominent, with a well defined keel above. Neck and anterior part of body capable of being greatly dilated by inhalation of air which it emits with a hissing sound; snout short with an azygous plate behind the rostral, with or without accessory scales.

*No accessory scales about the azygous plate.

1. Heterodon platyrhinus Latreille. Blowing Viper, Hog-nosed Snake, Deaf, Blowing and Spreading Adder are some of the names by which this species is known.

Dorsal scales in 25, (23) rows; 1, (2) azygous plates separating the internasals; frontal longer than broad; prefontal extending down to loreals; superior labials 8, (9); temporals 3, 4; 4, 4, (5); one pair of geneials; body stout, 800-820 m m. long; tail short tapering. General color very variable, from yellowish gray, brown or reddish brown to black in variety niger, usually with a series of 20-30 quadrate brown or black spots separated by narrow interspaces; lateral series of spots, when present, alternate with those of the dorsal. In young specimens a second series of spots is visible. Abdomen greenish white, yellowish or reddish, often clouded and either with or without browinsh spots; two dark spots on the nape; head usually banded. There are three color varieties in the United States but none of these varieties are found in Michigan. The type is quite common in Michigan. It is harmless.

Genus 8, Carphophiops Gervais—Karfo--fi-ops.

Body small; head flat and not distinct; dorsal scales in 13 rows, all smooth, one nasal; internasals 0, 1, 2; no preocular; one loreal-ocular ; one postocular; anal plate divided. These snakes are usually found under stones, bark or logs.

1. Carphophiops amoenus Say.—Red Snake, Ground or Worm Snake.

Head small and depressed; frontal hexagonal; supra-oculars very small; superior labials 5, fifth largest; inferior labials 6, third largest; occipitals large; temporals 1, 2; chestnut brown above, opalescent; abdomen salmon color. The light color does not extend to the third row of dorsal scales. Tail short, tapering to a point. Northern Austroriparian region westward. Possibly within the state.

Genus 9, Liopeltis Cope.—Li-o-pel-tis.

Body rather small; head distinct; tail long; cephalic plates normal; preoculars 1-2; postoculars 2, (3); temporals 1, 2, elongoted loreal (0), 1; dorsal scales in 15 rows, all smooth; anal plate divided.

1. Liopeltis vernalis DeKay. Green or Grass Snake.

Color above yellowish green to light pea green, lighter on the flanks abdomen, yellowish green to whitish; cleft of mouth deep and slightly curved; superior labials 7; inferior labials 7-8, fifth largest; loreal, when present, rather small; length about 500 m m. Blue to bluish in spirits; perfectly harmless. Throughout the United States except the Pacific and Sonoran regions. Common in Michigan

Genus 10, Ophibolus Baird & Girard—O-fib-o-lus.

Milk Snake, Corn Snake, King Snake.

Head slightly distinct; cephalic plates normal; temporals (1), 2, -2, (3); loreal one; preocolar one; postoculars 2-3; superior labials 7-8; two pair of geneials; dorsal scales in 21-25 rows, smooth with two apical pits; anal plate usually entire.

*Dorsal scales in 21, (19, 23) rows.

†Dorsal spots black, brown or red with black borders, or with ring around the body.

Ophibolus doliatus Linnaeus.—Milk Snake, Corn Snake.

Size medium to small· dorsal scales in 21, (19, 23) rows, rather wide; loreal small, longer than high; oculars 1-2; temporals 2, (1)-2, (3); superior labials 7, fifth largest; head from red to black, variously marked with brown or yellow or both. This species is found, in some of its forms, from the Atlantic coast to the central plains and south to Mexico.

‡With an oblique streak or band behind the orbit.

Var. 1. Ophibolus doliatus triangulus Dandin—Milk Snake, House Snake, Chicken Snake, Adder.

The largest of the varieties; dorsal scales in 21, (19, 23) rows; superior labials 7, fifth largest; ventrals 185-215; muzzle rather broad and head rather depressed; temporals usually 2, 2; length 1000.1100 m m. Ground color above, yellowish gray with a series of 40-50 grayish brown to chocolate brown spots on the body. The dorsal spots are black bordered in adult specimens and red or reddish in young ones. The spots are about 13 scales wide and rarely extend below the third row of scales; 10-13 black half rings on the tail. There is a second smaller alternating series on the sides, which does not reach the ventrals, alternating with these spots is another series of smaller irregular black spots which involve the ends of the ventrals; abdomen whitish, blotched with black. The first dorsal blotch is elongated and irregular covering the posterior half of the frontal and enclosing a triangular or heart shaped figure and the V. A dark prefrontal band is present, also a dark band from the orbit to the angle of the mouth , which is bordered above with a light band. This is the well known Milk snake of the Middle States. It is harmless. From the New England States west to Wisconsin and south to North Carolina and Texas. Quite common in Michigan.

**Dorsal scales in 21-23, (25) rows.

†Large; black with more or less yellow or white.

2. Ophibolus getulus Linnaeus. King Snake.

Body large and stout; muzzle slightly compressed; head not very distinct; dorsal scales in 21-23, (25) rows; oculars 1-2, (3); superior labials 7; inferior labials 9-10, fifth largest temporals 2, 2, (3, 4); color above, black or brownish black with white or yellow markings.

‡Top of head yellow spotted; scales with yellow centers.

Var. 1. Ophibolus getulus sayi Holbrook.—Say's King Snake.

Dorsal scales in 21-23, (25) rows; loreal trapezoidal, about as high as long; postgeneials small; dorsal and lateral scales usually lustrous black with white or yellow centers. The color pattern is very variable; often the spots of the body collect into narrow transverse bands leaving large black spaces with a trace of yellow spots; sometimes about seven of the lower rows of scales are spotted, while on the dorsal region the spots collect into narrow bands uniting the spots of the sides; head black with yellow spots; abdomen yellow or white with black blotches which are more numerous posteriorly. From Indiana to Louisiana and western Texas. Possibly in Michigan.

***Dorsal scales in 25 rows.

3. Ophibolus calligaster Say.—Say's Chain or King Snake. Milk Snake.

Head elongated, rather flat; oculars 1-2; temporals 2, 3; loreal longer than high; superior labials 7; inferior labials 9; fifth largest; dorsal scales in 25 rows; anal plate entire or divided; length 1180-1200 m m. Light olivaceous brown to grayish brown with a series of subquadrangular, dark chestnut brown, black bordered blotches, and two similar alternating lateral series. The dorsal spots are about three scales long and 8-10 wide; the latteral about two long and 3-4 wide; the inferior series, which are smaller and alternate with the lateral, cover the first row of scales and the ends of the adjacent ventrals; abdomen light yellow to white with or without square black or bluish blotches along the medium line; head banded; labials yellowish; nape banded. From central Ohio to Minnesota south to Texas. Possibly in Michigan.

Genus 11, Diadophis Baird & Girard—Di-ad--o-fis.—Ring Necked Snakes.

Dorsal scales in 15-17 rows, smooth; body slender, elongated; head rather short and distinct; cephalic plates normal; loreal one; oculars 2 (1)- 2; rostral normal; usually with a cervical ring; anal plate divided; tail short; abdomen yellow or orange to whitish, or pinkish, with or without black ventral dots.

*Dorsal scales in 15 rows; superior labials 8 (7).

1. Diadophis punctatus Linnaeus.

Dorsal scales in 15 rows; superior labials 8 (7); inferior labials 8-9; oculars 2 (1)-2; temporals 1, 1; loreal quadritaleral; head slightly depressed; snout rounded and slightly over-laping the lower jaw; ventrals 135-160; tail tapering; length 350-360 m m. Adults bluish black or brown above, which color extends like a bar upon the ends of the ventrals; young specimens are reddish brown or even salmon color above; abdomen yellowish orange to whitish or pink, with or without a series of black transverse spots on the middle of each ventral; color on nape one half to one scale wide, yellowish; inferior labials and lower half of superior labials yellow, usually without small black dots. This species is found about logs, stone or bark; harmless; lives on insects and batrachins. The United States east of the Mississippi.

Genus 12, Bascanium Baird & Girard,—Bas-kan-i-um.—Raeer Snakes. Whip Snakes.

Body elongate; head distinct; cephalic plates normal; dorsal scales in 15-19 rows, smooth; preoculars two, lower one small; two nasals; one loreal; labials and occipitals usually large; mouth deeply cleft; anal plate divided; color, black, blue black, olive green or yellowish, sometimes quite dark. Coloration of the young usually quite different from the adult, being marked with spots, transverse bands or longitudinal stripes; harmless.

*Adult not striped; dorsal scales in 17 (19) rows; young spotted.

†Superior labials 7, (8); black, bluish or slate color to green.

1. Bascamium constrictor Linnaeus.

Body rather slender; tail long; cephalic plates normal; two nasals; one loreal, oblique trapezoidal; oculars 2-2; temporals 2, 2, (3); superior labials 7, (8); inferior labials 8;-9; length 1100-1500 m m.

‡Black or bluish above; abdomen slate color, whitish in young specimens.

Var. 1. Bascanium constrictor Linnaeus.—Blue Racer, Black Snake.

Lustrous black in the eastern part of its range to bluish or olive black in the western part, without spots or stripes in the adult; gular region white to whitish with dark spots. Top of head and back in young specimens yellowish to greenish gray, banded and spotted with darker colors; abdomen white or whitish; spots disappear when the specimen is 45-50 m m. long. This species will climb trees in search of eggs and young birds. It is harmless to man and useful in destroying insects and small animals. Throughout the United States east of the 100th meridian.

CROTALIDAE.

The Pit Venomous Snakes.

Genus 13, Agkistrodon Beauvais. Ang-kis-tro-don.—Moccasins. Copper heads. Cotton-mouth.

Body and tail subcylindrical; dorsal scales in 21-27 rows, keeled; head very distinct, triangular, covered with 9-12 plates which extend posteriorly beyond a transverse line between the eyes, a few auxiliary scales are often present; two prefrontals; two preoculars, elongated longitudinally; two postoculars; one or more suboculars; loreal 0-1; pupil vertical; anal plate enitre; tail short, tapering and without a rattle.

*One or more loreals; no true post-occipitals.

1. Agkistrodon contortrix Linnaeus.—Cotton-mouth, Highland Moccasin, Rattlesnake Pilot, Red-eye.

Dorsal scales in 23-25 rows; loreal present, partly bounding the pit on the front; two preoculars, the lower bounding the pit posteriorly; two postoculars; two or more suboculars; often a subloreal is present, which with the second superior labial bound the loreal pit below; temporals smooth, lower row largest; superior labials 8, (7); inferior labials usually 10; postoccipital plates; length 800-1000 m m. Color grayish to light hazle or reddish brown mottled with small dark points. On each side is a series of 15-25 darker chestnut colored blotches resting upon the ventrals and abruptly contracting about the middle of the sides. These blotches extend to the vertebral line where they may end abruptly or be more or less rounded or even confluent. Top of head often bright copper colored, without stripes, except the postorbital bands; sides of the head cream colored; chin and throat yellowish white, often mottled but not spotted; abdomen light copper color to yellowish, with a series of distinct black spots on each edge; tail terminating in a long point, often yellowish or greenish in young specimens. Eastern, Austrariparian and eastern part of the central regions. It is very doubtful if it is in the state.

Genus 14, Crotalus Linnaeus—Kro-ta-lus.—Rattlesnakes.

Body robust, cylindrical; dorsal scales in 21-31 rows; head more or less triangular and distinct, usually covered with scales and plates; loreal pit very distinct; temporals and labials numerous, pupil vertical; tail terminating in a button or rattle. This genus is found chiefly in North America. The rattlesnakes are rather slow in their movements and not quick to bite. They coil up, raise the head, give a warning with the rattle and spring at their enemy. They can spring forward a distance about equal to two-thirds the length of their own bodies. They are all venomous, and seem to thrive best in rocky regions.

*Top of head covered with numerous small scales or plates; supraoculars normal.

‡Tail black; dorsal spots chevron-shaped cross-bands

1. Crotalus horridus Sinnaeuc.—Banded Rattlesnake.

Dorsal scales in 23-25, (27) rows; head very distinct, triangular; rostral high; anterior nasal large and in contact with the rostral; cephalic scales small and numerous; two rows of small plates behind the nasals; 4-8 rows of scales between the subraoculars; 2-4 rows of scales between the suboculars and the superior labials; superior labials 12-16; inferior labials 13-15; loreals two; temporals numerous. General color variable, from light yellow and reddish gray to dark brown or black, crossed by twenty or more irregular chevron-shaped black bands. These bands are often broken into angular spots on the sides, but they always form zigzag cross-bands; a postocular band passes above the angle of the mouth; tail of adult specimens uniformly black; length 900-1500 m m. From Maine to Florida, west to Iowa and Texas. Rare in Michigan. Found in the Au Sable region and Kalamazoo county.

Genus 15, Sistrurus Garman.—Sis-tru-rus.—Ground Rattlesnakes. Massasaugas.

Body small to medium stout; dorsal scales in 21 -25, (27) rows, mostly keeled, with apical pits; top of head covered with large plates which extend posteriorly beyond a transverse line between the eyes; rostral moderately large; nostril between two plates; labials and temporals rather small; one pair of geneials; gular scales small; pupil vertical; loreal pit and rattle present; anal plate entire.

*Postnasal usually in contact with the upper preocular; light band, to the angle of the mouth, begins at the nasal plate.

1. Sistrurus catenatus Rafinesque.—Massasauga.

Dorsal scales in 23-25, (27) rows; one or two inferior rows smooth; rostral higher than wide, irregular hexagonal; preoculars 2-3, upper larger, usually in contact with the nasal, anterior end oblique upwards, usually covering the loreal; superior labials 12-14; inferior labials 11-14; no large loreal, occasionally a small upper one; one row of scales between the suboculars and superior labials. Gray, brown or even black, with a dorsal series of dark brown blotches, anteriorly often crescent shaped, posteriorly subcircular. There is a second series of roundish, indistinct spots, more or less alternating with the dorsal spots; a third series opposite the dorsal spots and a fourth series on the inferior rows and ends of the ventrals; top of head with a light band across the anterior end of the frontal; also a light line extends from the postnasal plate below the orbit to the angle of the mouth; usually two dark bands from the subraoculars to the first dorsal spot; abdomen yellowish to black. The color varies with age, season of the year and habitat.

†Dorsal scales in 25, (23-27) rows; dorsal spots usually fewer than 40.

Var. 1. Sistrurus catenatus catenatus Rafinesque.—Black or Prairie Rattlesnake. Massasauga, Swamp Rattlesnake.

Body rather stout and short; tail short; rattle rather large; dorsal scales in 23-27 rows, usually 25 rows; cephalic plates normal; scutellation is that of the species; dorsal spots usually from 35-41, 3-5 of which are on the tail; colors usually darker and the lateral spots more distinct than in the other varieties; occasionally a specimen is found which is entirely black; abdomen yellowish to entirely black; length about 850 m m. From New York to Kansas and north into Canada. Quite common in some of the swamps of Michigan.

GLOSSARY.

Anal. Pertaining to or situated near the anus.

Anal plate. The plate immediately in front of the anus.

Anus. The opening at the posterior extremity of the alimentary canal.

Apical pit. The small pit at or near the end or apex of a scale.

Austroriparian region. In general that part of the United States south of the isothermal of 77 degrees F, and east of longitude 102 degrees.

Azygous. Having no fellow, not one of a pair. Single.

Caudal. Pertaining to the tail.

Central region. The plains west of the Mississippi and east of the Rockies.

Cephalic plates. The plates on the top of the head.

Cervical ring. A color ring or collar on the neck.

Colubriform. Having a long serpent like form.

Dorsal. Pertaining to the back.

Eastern region. The region north of isothermal 77 degrees F and from the Atlantic coast to the Central region.

Epiglottis. The leaf shaped lid at the base of the tongue.

Frontal. The central plate on the top of the head.

Gastrosteges. See Ventrals.

Geneials. The large plates on the under surface of the chin.

Gular. The region around and back of the geneials.

Internasals. The plates between the nasals.

Iridescent. Glittering with colors which change in different lights.

GLOSSARY WITH ILLUSTRATION.

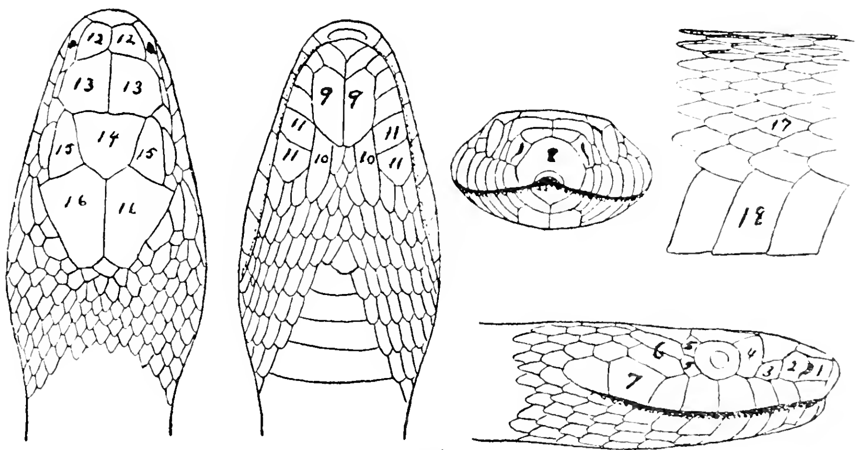

Fig. 1

COLUBER VULPINUS BAIRD AND GIRARD.

Fig. 1.—A harmless snake.

1. Prenasal. 2. Postnasal. 3. Loreal. 4. Preocular. 5. Postoculars. 6. First row of temporals. 7. The largest superior labial. 8. Rostral. 9. The pregeneials. 10. The postgeaneials. 11. The largest inferior labials. 12. The internasals. 13. The prefrontals. 14. The frontal. 15. The supraoculars. 16. The occipitals. 17. Smooth scales. 18. Ventrals.

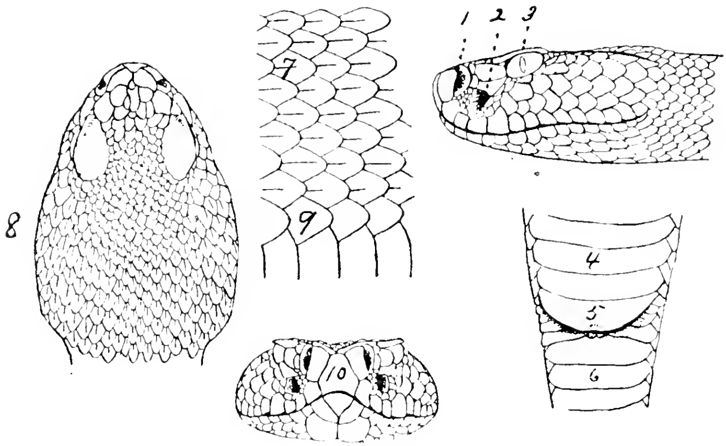

Fig. 2.

Crotalus horridus Linnæus.

Fig. 2. A venomous snake.

1. Nostril. 2. Loreal pit. 3. Vertical pupil. 4. A ventral scale. 5. Anal plate. 6 Subcaudal. 7. Keeled scales. 9. Smooth scales. 10. Rostral. 8. A distinct head with small scales between the supraoculars.

Glossary.

Keel. A little ridge on the median line of a scale.
Labials, inferior. The first row of scales on the lower lip.
Labials, superior. The first row of scales on the upper lip.
Labials 8-10, and similar notation, means that there may be 8 to 10 plates or scales of the class named.
Laminiform. Anything thin or plate like.
Loreal. The plate between the postnasal and preocular.
Loreal pit. A small pit between the eye and nostril of venomous snakes.
Lorealocular. An abnormal loreal which takes the place of a true loreal and a preocular.
Maxillary. The upper jaw or pertaining to the upper jaw.
Muzzle. The front end of the head of an animal, the snout.
Nasals. The plates in contact with the nostrils.
Occipitals. The large plates on the back part of the head.
Oculars, 1-2 or 2-2, means one preocular and two postoculars or two preoculars and two postoculars
Ovoviviparous. Animals that are oviparous but hatch the egg within the body.
Parenthesis, figures within, as (3) or (25), means that they occur rarely.
Peropodes. Animals with imperfect or abortive feet.
Postocular. One of the small scales bounding the orbit posteriorly.
Prefrontal. One of the plates immediately in front of the frontal.
Prehensal. Having an organ adapted to seize or grasp.
Preocular . One of the small scales bounding the orbit in front.
Rostral plate. The vertical plate on the end of the nose.
Sonoran region. Southern New Mexico, Arizona, Nevada and Northern Mexico.
Suboculars. The small scales below the eye or orbit and above the labials.
Supraoculars. The large plates above the eyes.
Suture. The seam where two scales or plates unite or meet.
Temporals. The scales between the occipitals and superior labials posterior to the postoculars.
Temporals 1, 2, 3, means that there is one temporal in the first row, two in the second and three in the third.
Urosteges. The plates on the under surface of the tail.
Ventral. Belonging to the belly or abdomen.
Ventrals. The scales or plates on the abdomen.
Vertebral. Pertaining to the back-bone or region of the back-bone.

Names of Authorities and their Abbreviations.

Allen,—A.
Baird,—B.
Beauvais,—Beau.
Bibron,—Bib.
Blainville,—Blain.
Blumenback,—Blum.
Bocourt,—Boc.
Boice,—Boice.
Bonapart,—Bon
Boulenger,—Boul.
Brown, A.—Br.
Catsby,—Cat.
Cooper,—C.
Cope,—Cope.
Cones,—Cones.
Cuvier,—Cuv.
Daudin,—Dau.
DeKay,—DeK.
Duges,—Dug.
Dumerile, Dum.
Fitzinger,—Fitz.

Fleming,—Flem.
Garman,—Gar.
Gervais,—Ger.
Girard,—G.
Grulen,—Gru.
Gray,—Gray.
Gunther,—Gun.
Hallowell, —Hall.
Halran,—Har.
Holbrook,—Hol.
Hutt,—H.
Jordan,—J.
Kennocott,—Ken.
Kirtland,—Kir.
Lacepede,—Lac.
Latreille,—Lat.
Laurente,—Lau.
LeCauntis,—LaC.
Linnaeus,—Lin.
Lockington,—Lock.
Merrem,—Mer.
Michaello,—Mich.
Notestem, F. N.—N.
Peters,—Pet.
Rafinesque,—Raf.
Reuss,—R
Say,—Say.
Schlegel, —Schl.
Schneider,—Sch.
Shan,——Shan.
Smith,—Smith.
Stejneger,—Stej.
Storer,—Stor.
Streets,—Str.
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PLANT DISTRIBUTION IN A SMALL BOG.[1]

EDITH E. PETTEE.

The bog studied is about four miles southeast of Ann Arbor, Mich., in one of the many morainal depressions of that region. It is about thirty-nine rods long and seventeen rods wide, and is surrounded by steep banks which are forty feet high at the west end, sloping down on both sides to within three feet of the swamp level at the east end. On the north side there is a depression in the hillside, and a consequent widening of the swamp at that point of at least fifty feet. The area drained is very narrow on all sides and there is no definite channel draining into the swamp.

The bog is undrained except for excess of water, which is taken off in times of flood by a shallow ditch at the east end. The surface of the swamp is nearly level and there is no evidence of its ever having stood at a higher level than at present.

The underlying soil is heavy blue clay. Borings show a slope of the bottom on all sides toward the center, as indicated in the diagram. The dotted lines show estimated depths which have yet to be determined.

The hills around the bog seem to have been covered by an oak-hickory forest which has all been destroyed except on the high west hill and its east facing slope. On the top of the hill are found:—

Quercus rubra, Quercus velutina, Quercus alba, Hicoria ovata, Hicoria alba, Acer saccharinum.[2]

There is no underbrush and few herbs except grass.

On the east facing slope we find

Quercus rubra, Quercus velutina, Quercus alba, Hicoria ovata, Hicoria minima, Hicoria alba, Juglans nigra, Prunus sp. (cherry), Juniperus communis, Prunus Americana, Rubus occidentalis.

Rubus nigrobaccus, Hamamelis Virginiana, Crategus 2sp., Corylus Americana, Cornus stolonifera, Rosa Carolina, Galium sp., Vagnera racemosa, Celastrous scandens, Vicia sp., Dioscorea villosa, Parthenocissus quinquefolia, Thalictrum dioicum, Asclepias Syriaca, Linaria Linaria, Falcata comosa, Podophyllum peltatum, Pyrola elliptica, Impatiens biflora Geranium maculatum, Cnicus Lanceolatus,

The south bank is occupied by a second growth of young trees and shrubs. We find here:

Quercus rubra, Quercus velutina, Quercus alba, Quercus coccinea, Hicoria alba, Hicoria ovata, Rubus occidentalis, Rubus nigrobaccus, Populus grandidentata, Populus tremuloides, Carpinus Caroliniana, Hamamelis Virginiana, Corylus Americana, Aronia arbutifolia, Acer saccharinum, Crategus (several species), Vaccinium vacillans, Rhus glabra, Vitis sp., Smilax sp., Hepatica Hepatica, Antennaria plantaginifolia, Mitchella repens, Penstemon sp., Rudbeckia hirta, Achillea Millefolium, Viola pubescens, Mitella diphylla, Vicia sp., Carex sp., Thalictrum dioicum, Polytrichum commune, Prunella vulgaris, Aster cordifolius, Prunus sp.

On the north side there is a cultivateded field with patches of this young-tree-and-shrub zone fringing the swamp as shown by the presence of

Hamamelis Virginiana, Corylus Americana, Prunus, etc.

The bog proper is divided into three very distinct regions:—

1. A Marginal zone. 2. An intermediate zone. 3. A central area.

The marginal zone averages about twenty-five feet wide and has a distinctly different vegetation from the rest of the swamp. Ten of the thirteen plants given by Transeau[3] as typical of drained swamps are found here. The ones not found are

Scirpus lacustris, Polygonum emersum and Fraxinus Americana.

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[1] This work was done in the summer of 1904 under the direction and with the assistance of Dr. G. P. Burns.

[2] The names used are those of Britton's Manual of the Northern States and Canada, 1901.

[3] Transeau, E. N. On the Geographic Distribution and Ecological Relations of the Bog Plant Societies of Northern North America.—Botanical Gazette, December, 1903.

The following plants are found here: (The first ten are the ones in Transeau's list).

*Carex riparia, *Juncus effusus, *Polygonum sagittatum, *Typha latifolia,* Cornus stolonifera, *Cornus candidissima, *Salix discolor, *Ulmus Americana, *Cephalanthus occidentalis, *Acer rubrum Scirpus atrovirens, Impatiens biflora, Polygonun 2 sp., Erechtites hieracifolia, Spathyema foetida, Panicularia nervata, Osmunda regalis, Osmunda cinnamomea, Onoclea sensibilis, Dryopteris 3 sp., Spirea salicifolia, Rosa Carolina, Naumbergia thyrsiflora, Rumex verticillatus, Koellia Virginiana, Monarda fistulosa, Roripa Armoracia, Salix lucida, Salix petiolaris, Salix sericea, Salix 2 sp., Ilex verticillata, Oxalis stricta, Viburnum Lentago, Viburnum acerifolium, Sambucus Canadensis, Prunus Virginiana, Prunus sp., Ribes floridum.

The characteristic plants of this zone are the sedges and shrubs which are intermingled except along the west end where the shrubs are lacking. Next to the open field there is a much greater number of genera and species than anywhere else. Impatiens is abundant at the shaded southwest corner and the polygonums at the more sunny north west corner.

The intermediate zone is the main area of the bog and here are found:—

Rhus Vernix, Vaccinium corymbosum, Acer saccharinum, Acer rubrum, Larix laricina, Aronia arbutifolia, Ilicioides mucronata, Viburnum Lentago, Sambucus Canadensis, Rubus strigosus, Rubus occidentalis, Populus grandidentata, Populus tremuloides, Osmunda cinnamomea, Dryopteris 3 sp., Unifolium canadense, Coptis trifolia, Sphagnum, Mosses, Typha latifolia, Solanum Dulcamara, Monotropa uniflora, Naumbergia thyrsiflora

Both red and black raspberries are found in open spaces where trees have been cut out; but the red ones are frequent while the black ones are rare. On the hillside the reverse is true. In the dense shade of the larger maples and thick patches of Vaccinium corymbosum the undergrowth of herbs is very scanty.

The plants in the central region are

Chamaedaphne calyculata, Sarracenia purpurea, Cypripedium acaule, Oxycoccus oxycoccus, Vaccinium corymbosum, Sphagnum, Larix laricina, Carex trisperma, Rhus Vernix, Bidens sp., Mosses.

This seems to be the only place where the Sphagnum is really thriving. Carex trisperma is very abundant here and is not found to any extent in any other place in the swamp. Examination of the rings of wood on the stumps of half a dozen tamaracks showed an unusually slow growth between the years 1880 and 1890.

The marginal zone and the central region have *no* plants in common and are separated from each other by a region which has some of the plants from each and some from the surrounding hillside together with others found in none of these places.

These marked zones of vegetation and examination of the soil conditions show this bog to be not at all a homogeneous habitat, but decidedly heterogeneous.

Cattle are at times allowed free access to the swamp and have frequented the margin at the west end more than anywhere else. They may have had much to do with keeping the shrubs from getting a foothold here. Possibly they have had some influence in aerating the margin—thus making it more like a drained swamp.

MacMillan[1] describes the formation of plant atolls in lakes in Minnesota: Shaw[2] found a marginal ditch around bogs near Woods Hole due to falling leaves smothering out vegetation in that region; and Atkinson[3] suggests the same condition in New York may be due to shading of the margin of the bog. It is not clear how this marginal region could have originated in any of these ways.

Davis[4] finds this marginal zone common in bogs in Michigan and believes it is caused by fluctuating water supply in this shallow part of the bog due to variation in annual rainfall and temperature. Then we would expect to find the marginal zone widest in the shallowest part of the basin, but much to our surprise we found the widest part of the zone deeper and wetter than any other part.

The west end of the swamp is deeper and has more water in the soil than the east end Here we find poison sumac and huckleberry thriving best while at the shallow east end maples predominate and poplars are coming in, and the huckleberry bushes are dying out in the dry coarse leaf mold in the shade of the maples. The tamarack is the only plant of the central region which is still thriving in the rest of the swamp.

Livingston's[5] determination of the osmotic pressure of bog waters shows that we can no longer consider the presence of humous acid a physical cause for the xerophytic character of the plants of the central region. A few preliminary thermometer readings seemed to indicate that the soil is colder here than at the same depth in other parts of the bog.

The distribution of the vegetation seems to have a definite relation to the height at

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[1]MacMillan, Conway. On the Occurrence of Sphagnum Atolls in Central Minnesota.—Minnesota Botanical Studies, I. No. 9, 1894.

[2]Shaw, C. H. The Development of Vegetation in the Morainal Depressions of the Vicinity of Woods Hole.—Botanical Gazette, June, 1902.

[3]Atkinson, G. F. Lessons in Botany.

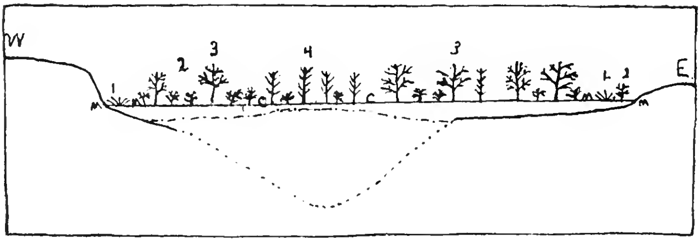
[4]Davis, C. A. An article yet unpublished.

[5]Livingston, B. E. Physical Properties of Bog Waters.—Botanical Gazette, May, 1904.

which the ground water stands. The broken line in the diagram shows the approximate condition of affairs during the summer of 1904. It comes almost to the surface in the center and is nearer the surface at the west end and north side than at the shallow east end. It seems to be held at the surface by the sphagnum which is very little disintegrated in the center, while the soil in other parts of the swamp is physically in a very different condition. This varying physical condition would greatly affect its moisture holding capacity.

We have here a dying tamarack swamp bounded by a marginal zone which seems to have been influenced by other factors than the rest of the swamp. The distribution of the swamp plants seems to have a definite relation to temperature, the physical character of the soil, depth of the bog, and level of the ground water. The investigation of these subjects is being continued and a fuller report will appear later.

University of Michigan.



Profile of bog from west to east.
Scale: Horizontal 80.4 cm=1mm, vertical 61 cm=1mm.
1. Sedges.
2. Shrubs.
3. Maples.
4. Larix laricina.
C—C. Center.
M—M. Margin.

RAVINES IN THE VICINITY OF ANN ARBOR.

BY ALFRED DACHNOWSKI.

(An Abstract.)

Preliminary to more extended work in the field in experimental physiology, the attempt is made to give a brief ecological summary of the various ravines in this vicinity. For convenience four phases are emphasized in ravine processes, corresponding to relatively dominant ecological factors. They are:

(1) A locally typical ravine.
(2) A ravine influenced by man.
(3) A ravine of arrested development due to captured territory.
(4) A rejuvenated ravine.

The results obtained show that in each ravine the vegetation, though more or less similar, is decidedly influenced by conditions of soil, light, water-content, temperature, etc., as determined by geology, topography, man, the plants themselves, or the combination of these with other agencies. Concrete cases make it obvious that no ecological factor can be cited as exclusively determining the character of the local flora. Many changes in kind and arrangement of vegetation are independent of dominant ecological agencies. They are results which arise from the united action of these factors and, in turn reacting upon the conditions present, thus lead to changes in habitat and consequent distribution of plants not to be attributed either to topography alone, water-table, or character of soil. The main stress must be laid on process, i. e., the varying causes actively at work which bring about the modifications in ravine life, if we are to avoid inconsistencies in definite classification of plant societies. But equally important is the fact that such data must be reinterpreted by the physiological condition of the plants growing in the environment.

University of Michigan, Botanical Laboratory.

THE SCIENTIFIC NECESSITY OF COMPLETE REGISTRATION OF VITAL STATISTICS.

CRESSY L. WILBUR.

The place of vital statistics among the divisions of scientific knowledge may be briefly considered.

In practice, we find that vital statistics chiefly relate to the leading vital events or conditions affecting human lives, namely, births, deaths, sickness, marriages and divorces.

These studied in their mass-relations, as pertaining to large numbers of persons associated in communities, form the chief subject-matter of vital statistics or *demography* taken in connection with the basic data of population derived from the census upon which all other demographic data depend and to which the vital statistics proper must be referred in order to be rendered fully intelligible.

It is interesting to note that the general subject, demography, was classed under the department of sociology in the arrangement adopted for the International Congress of Arts and Science at St. Louis last year, sociology forming with psychology the two divisions under *mental science* according to the following scheme:

Division D—Mental Science.
- Department 15—Psychology.
  - Section a.—General Psychology.
  - Section b.—Experimental Psychology.
  - Section c.—Comparative and Genetic Psychology.
  - Section d.—Abnormal Psychology.
- Department 16—Sociology.
  - Section a.—Demography.
  - Section b.—Social Structure.
  - Section c.—Social Psychology.

Other sections with which demography bears close relations are biology and anthropology, classed under physical science (Division C), public health, preventive medicine, pathology, pediatrics, and perhaps other branches of medicine coming among the utilitarian sciences (Division E), and perhaps national and colonial administration under politics and the family, urban and rural communities, etc., belonging to social science under social regulation (Division F).

As the section on demography failed to meet at St. Louis as planned, owing to an unfortunate miscarriage of arrangements, I was unable to learn the reasons governing its classification, but without passing upon the satisfactory or unsatisfactory nature of the scheme, the very important relations of this branch of science may be clearly inferred.

Dealing with man as an animal, many facts of biological importance relating to his productiveness under various conditions, his development, his vital history, the duration of life, and the causes bringing about his death can only satisfactorily be known through the averages obtained from the study of many individuals, that is to say, by the statistical method.

The function of vital statistics as a branch of sanitary science is such an important one that it has practically dwarfed the proper development of the science as an independent, although numerously correlated, study of the statics and dynamics of population for its own ends, namely, pure knowledge of the nature and causes of the phenomena displayed, without ulterior purposes of "practical" application to hygienic problems. I think I may appeal to this Academy to take a broader view of the matter, and without disparaging the useful applications of vital data to the preservation and improvement of the public health, as well as the protection of the legal rights of individuals, we may consider some of the valuable scientific results that would come from a more adequate and complete knowledge of the people of the State and country.

"The noblest study of mankind is man," and the most patriotic study of an American is that of the American people. In no other country is there a greater field, presenting more variety, or better displaying the movement and swing of social forces whose destiny it is to write the future history of the Republic. The native American, whatever that term may be taken to represent, the negro, the oriental element, and, most important of all foreign sources, the various nationalities constituting the recent European immigration, with their immediate descendants—these are the factors of a demographic problem whose solution is infinitely important to the human race.

Complete and accurate vital statistics are the necessary materials for the study of these questions. It is not to our credit as a nation that the subject of demography has been greatly neglected in certain respects. We have, it is true, a longer history of national censuses than can be found in most countries, and so far as this basis of demographic investigation is concerned, we may point with pride to the achievements of American official statistics. But when we come to the records of births and deaths, marriages and divorces, which fill in the picture of national demographic change, we are more at a loss, and for certain important departments of study we find that materials are entirely wanting.

The only laws regulating the registration of vital statistics are those authorized by the various States. The Federal Government may utilize the results of the State registration laws, and from time to time has done so, but the primary collection of the data is solely under State control. As a result, statistics have been collected in many different ways, some of them most inefficient in character, and for a very large part of the country there is practically no effective registration of vital statistics whatever, even for the most essential item, that of mortality. Not a single state in the Union at the present time has a fully efficient registration of births, and many states fail to properly register their marriages and divorces. As for sickness, important as this is in its relation to sanitation and economic effectiveness of population, we are not so much behind the rest of the world since this important branch of vital statistics is only in its infancy.

How do we compare in this respect with other civilized countries? As an example I shall take Japan, which, although not a European country, I have no doubt you will pronounce one of the most civilized nations of the earth. In this connection I may refer to a conversation said to have occurred with a Japanese diplomat, who complained that Western opinion had been very tardy in recognizing the status of the Japanese people. "We sent you exquisite paintings for many years, enamels, porcelain and works of art, and you merely considered us as somewhat advanced barbarians. Now we have killed forty or fifty thousand Russians, and all Christendom hastens to admit us among the highly civilized nations! As if progress was proved alone by systematic slaughter of enemies." A higher basis of comparison would be the wonderful record of sanitary efficiency of the Japanese medical service in the present war, which stamps the awful death rates of American troops at Chicamauga and of the British troops at the Cape from preventable diseases as quite unnecessary and marks of defective sanitary organization. In Japan the surgeon goes ahead with and co-operates with the line officer, knowing that typhoid is usually more deadly than bullets in a campaign.

When the Japanese sent representatives forth among the Western nations to learn what was best in our culture for adoption as the foundation of a new Japan, she could find little of value in America in the line of vital statistics. European and especially German models were taken in demography as in war, and the thoroughness with which the ideas were assimilated in both cases have been shown to the world, in the one case by the splendid publications of the General Bureau of Statistics of the Imperial Cabinet of Japan, in the other by the victories of Oyama and Togo. Both of these achievements are magnificent triumphs of national organization, but in the long run I am not sure but that the quiet work of the statistician will prove as sure a foundation of national greatness as the more thrilling deeds of the soldier and sailor.

On the importance of adequate statistics for national guidance we may quote from the reports of Major J. W. Powell, the late Director of the Bureau of American Ethnology:

"Statistics are compared for different conditions to exhibit important relations of social life as causes of good or evil effects. The comparison is made of numbers taken at different periods in the history of a people for the purpose of exhibiting the evolution of social conditions. This leads to the consideration of statistics in verification.

So common is this use that it would not be a bad definition to say that statistics is the science of the verification of sociologic inferences. The statesman, whose vocation is the study of practical government, deals largely with statistics, and the sociologist, whose theme is the social structure and its functions, resorts to statistics for the verification of his doctrine. In this use of statistics the greatest care is necessary in order that unsound doctrines may not receive apparent confirmation.

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Causes are multitudinous, much of demotic invention is exercised for the purpose of discovering the particular cause most easily modifiable in the interest of human purposes. In the multitude of such devices the causes are examined in a multitude of ways by a multitude of people who naturally seek verification for their inferences as to the best methods of modifying causes. In sociology this verification is by statistics, and any arrangement of figures which appears to verify an hypothesis may easily be believed to indicate the true or modifiable cause of the effects considered.

In all the field of human thought there is no region in which verification is more important than in sociology, nor is there any field in which pseudo-verification entails more misery on mankind. Men may claim to verify their speculations about motors, and arrive at conclusions in which perpetual motions are supposed to be involved in mechanical constructions; but only the deluded persons themselves who are engaged in such enterprises as inventors, promoters or capitalists, are deceived. But when social inventions which are supposed to accomplish "perpetual justice" are adopted by men as bodies politic, calamity for the multitude is the result.—Twentieth Annual Report of the Bureau of American Ethnology to the Secretary of the Smithsonian Institution, 1898-99, p. lxi.

Let us consider how this country "sizes up" with Japan in presenting adequate statistics as a basis of social study and legislation. Besides the convenient yearly handbook (*Résumé statistique de l'Empire du Japon*), containing the most important demographic tables in a form readily accessible to all, we have a special volume of tables on the Movement of Population, the scope of which I may show by the table of contents:

All of these tables present the data for each district (do, fu and ken) in Japan, and the facts are given with a precision and definiteness much greater than we are accustomed to. There are also a few subsidiary tables showing omitted registration of births, deaths, stillbirths and marriages for previous years, and incidentally illustrating the thoroughness with which the system is kept up.

In the United States we have mortality statistics alone for a few of the states. In 1900 there were only nine of these registration states whose returns of deaths were accepted by the U. S. Census Bureau on the very low standard of 90 per cent of accuracy. No states and no cities had complete registration of births, and few states had satisfactory marriage and divorce statistics. We are thus far behind Japan in this essential function of government.

Not only do our vital statistics lack in scientific completeness in regard to the scope of subjects included, but the degree of completeness of individual items is also very far from satisfactory. There is a lack of that scientific conscience, if I may so call it, that feeling for and application of accuracy for its own sake in registering the various details. In every department there are depreciations of data or variations from full perfection of statement. A few marriages are not recorded owing to negligence of the clergymen in making their reports; a few divorces in one county or another are "suppressed" or otherwise omitted from the record; in some places a combination of a careless undertaker and a negligent local registrar may be responsible for the omission of certain deaths; everywhere the laws for the registration of births are inefficient or are poorly enforced. For these reasons, vital statistics in the United States must be taken with a considerable degree of allowance for imperfections. But the great bulk of these imperfections are not necessary, but simply marks of careless or negligent administration. What we need is a fuller appreciation of the importance of the correctness of vital data and the cultivation of a higher ideal of official honor and precision in their treatment.

It is for this reason that I have read this paper before the Academy, as I believe that the interest and intelligent aid of the members of this scientific association scattered throughout the State might be a valuable aid in securing more creditable results. It is important for the purpose of reliable legal records that each birth and death, marriage and divorce in Michigan should be recorded with scrupulous fidelity to details; it is necessary for practical sanitary uses that every birth and death, and more particularly the causes of each death should be registered; but in addition to these valuable uses, it is indispensable as a contribution to the scientific study of human life in Michigan that all of these vital data should be observed with all possible precision. Guesswork and estimates are of little value; What we must demand are facts, and they should be subject to no discount for careless or negligent observation. What was created in Japan by the intelligent action of a centralized imperial government, we must bring about by the cultivation of an enlightened public opinion. In the end we can trust America to press to the front rank among nations of the earth, but for the present we are left to the individual action of the various states, and until their efforts shall be correlated and unified, little will be accomplished in the way of creditable vital statistics for the nation. I am glad to say that Congress has expressed an interest in this work, and the U. S. Census Bureau has already made considerable progress toward the introduction of approved methods of collecting and presenting vital statistics in co-operation with the state authorities.

What is our most pressing duty in Michigan? At present it would seem to consist (1) in the maintenance of our present system of immediate registration of deaths in unimpaired efficiency, and (2) in the substitution of a modern system of registering births for the antiquated and ineffective system now employed. I am not going to discuss the necessity and principles of birth registration in the present paper. I have here some reprints of a paper recently printed in the Detroit Medical Journal on this subject, and will merely say that with an enlightened public opinion supporting the movement all or practically all births in this State could be promptly registered and returned in substantially the same manner and by the same officials as deaths are at present. When this is done we shall have the four branches of vital statistics in Michigan upon a solid foundation, admitting of progressive improvement in efficiency, so that the Michigan system will form a worthy part of the great national system of vital statistics which we shall some day possess—when we have advanced as far in this respect as Japan.

Lansing, Michigan.

"AM I MY BROTHER'S KEEPER?"

HENRY B. BAKER.

Modern sanitary science makes it appropriate that each one of us repeat the question asked by Cain; also it answers the question in the affirmative.

The person who spits infected sputum where it is likely to be breathed in by an innocent person whose life is thus endangered, does not kill his brother with a club, but, if it is done knowingly, is morally guilty of contributing to the death.

The person who knowingly permits his infection of typhoid fever to reach a source of drinking water, a milk supply, or in any way to enter the body of an innocent person, must now be classed with Cain.

Furthermore, there are few, if any, of the diseases that kill our brothers and sisters which they, by their own unaided efforts, can avoid or control. Their lives are at our mercy, collectively, that is, at the mercy of the public. Beginning with the disease which causes most deaths in Michigan, pneumonia, there is no way known whereby a human being may with any certainty avoid that disease through his own unaided efforts. There are a few precautions which, under favorable circumstances, may serve to lessen the danger of contracting the disease; but it may attack any person. The germs of the disease are now so commonly scattered about by careless spitters that no person who goes freely in public places can avoid taking them into nose or throat. Whether or not a person shall contract disease thereby depends upon conditions most of which no person acting alone has power to control. Yet, I believe the disease is preventable by restrictive measures through public health administration. If that is a fact, and experience in Michigan seems to prove that it is, then whoever is responsible for the continuance of the disease is morally guilty. If we fail to do our utmost for the full support of the public-health service without the action of which this disease and the other communicable diseases cannot be restricted, we are morally guilty, we may well ask, "Am I my brother's keeper?"

The old-time belief that by personal hygiene individual health may be maintained is not sustained by the facts of modern sanitary science. True, many minor illnesses may thus be avoided, and something can be done by the individual to guard against contracting the diseases which cause most deaths; but the great truth which should be taught to the people is, that those diseases, if controlled at all, are to be controlled by governments, by reason of wise legislation.

A prudent person may avoid wetting and chilling the feet, may avoid exposure to cold winds, may avoid eating or drinking injurious articles of food or drink, may practice physical culture, may boil the drinking water, in fact, may, in his own home, fulfill every known law of personal hygiene, and yet if the public water supply contains the germs of typhoid fever, that person may contract typhoid fever and die. If such a person attends a church, a theatre, or even a social party at a residence where a person infected with one of certain dangerous communicable diseases, is or has been and the place not disinfected, such person may contract that disease, however much care has been devoted to personal hygiene and physical culture.

The most dangerous diseases are the communicable diseases, and no amount of personal hygiene or physical culture is proof against them. Their restriction is a *public* duty, the most important duty that a public officer can perform. Every public officer should know this. And every public officer who does not perform that duty to the utmost of his power and ability may repeat the question asked by Cain, but the answer is, "Yes; you *are* your brother's keeper, and if you do not do your utmost that preventable diseases shall be prevented, you are as guilty as Cain."

Among the many classes of officials whose attention should especially be called to this subject are boards of supervisors who refuse to allow bills for the restriction of typhoid fever, on the pretense that it is not what every sanitarian knows that it is—a dangerous communicable disease. No such official should consent to act without first informing himself as to what diseases are dangerous and communicable. In Michigan there is no excuse for ignorance on this point, because the law requires that the facts shall be taught in every year in every public school in the State. And such facts have been taught in many of the schools for several years.

Nothing can be done for the restriction of any such disease except in accordance with some law. No law can get on the statute book without legislative action. Therefore, members of the Legislature are the officials who, of all others, should be held most responsible for deaths from communicable diseases not restricted. They are elected to represent the people of the State in caring for their highest interests. I know of no higher interest than those of life and health. Yet, at every recent session of the Michigan Legislature bills prepared with great care by sanitarians who have given years of study and observation to the subject of the restriction of the most dangerous diseases, are ignored or pushed aside as if of no consequence, while at the same time bills, of local importance only, are passed under suspension of the rules and given immediate effect by a vote of two-thirds of all of the legislators.

In Michigan, public-health administration has had the commendation of the people, and of many outside of Michigan who have known of the work accomplished. Yet, in Michigan, public health *legislation* has fallen far behind that in other progressive states. Is it not time that members of the Michigan Legislature were chosen for their interest in and prospective efforts for the highest interests of the people of the State? Is it not time that members of the Legislature put to themselves the question asked by Cain, "Am I my brother's keeper?" Not that a legislator may be supposed to be familiar with the facts in chemistry, bacteriology, etiology, and the other sanitary sciences, any more than in the science of electricity or any other science, but he may be supposed to accept the facts from experts in those sciences much as he would accept established legal principles from an expert in law, or as all intelligent persons accept the dicta of a jeweler as to the facts relating to their watches.

The State Department Bulletin of Vital Statistics states that the numbers of deaths in Michigan during the year 1904 from some of the dangerous communicable diseases, which are not being restricted as they should be, if the law made complete provision therefor, were as follows:

Pneumonia	2,685	
Tuberculosis	2,648	
Typhoid fever	633	
		5,966

A total of nearly six thousand deaths from these three diseases.

It is not enough that, during that year by public work, hundreds or even thousands of lives have been saved from preventable diseases, these other thousands were not saved, and they should have been, if there had been some such law as for years I have advocated—a law to require that local health officials shall be promptly informed of the occurrence of any disease officially declared by the State Board of Health, the highest official authority in the State, to be dangerous and communicable.

In every year there die in Michigan thousands of our loved ones from preventable diseases not restricted. How long are we to continue to observe this and not arouse ourselves to such a degree as to act our part for reform in governmental affairs? We, the people, elect our representatives. Have we not a duty to perform in that regard? Do we not each and every one of us need to ask ourselves the question, "Am I my brother's keeper?"

Lansing, Michigan.

COUNTY SCHOOLS OF AGRICULTURE.

W. J. BEAL.

Although the time of opening the oldest agricultural college in America was 48 years ago next May, there are now fifty-nine agricultural colleges in the United States, not counting a few agricultural schools of a lower grade.

The State of Wisconsin was the first in the Union to encourage the establishment of schools for the teaching of agriculture, manual training and domestic science of the rural classes. County schools of agriculture and domestic economy were created by act of the Legislature of Wisconsin in 1901. Two counties, Dunn and Marathon, erected buildings and purchased furniture, apparatus, machinery and stock, the state aiding each school to the extent of $4,000 a year to apply on the running expenses.

In 1904 these schools were so successful that the previous Legislature offered to help two more counties that should build and equip buildings for that purpose. The purpose of these schools is to train young men and young women for life on the farm.

A great change is taking place in American country life. So many new principles are being introduced that persons who have been off the farm only a few years have no idea of the modern ways of doing things by up-to-date methods. Agricultural education in some regions is coming right to the front and all progressive farmers are glad to see it.

Dunn County also has a school for the training of teachers for rural schools. By an interchange of classes the agricultural school teaches the rural teachers to handle these subjects in their schools in a very creditable manner.

Course of study in the county schools of agriculture and domestic economy, in Dunn and Marathon counties, Wisconsin. The course covers two years of eight months each, beginning in October and closing in May.

REGULAR COURSE OF STUDY.

Young Men.

First Year.

First Term—Work with soil *5; carpentry, d. 5; English and library reading, 5; business arithmetic, 5.

Second Term—Soils and fertilizers, 5; dairying, d. 2; carpentry, d. 3; English and library reading, 5; farm accounts, 5; rural architecture, d. 2.

Third Term—Plant life, 5; vegetable, flower and fruit gardening, 5; poultry, 3; English and library reading, 5.

Second Year.

First Term—Plant life, 5; blacksmithing, d. 5; economic insects and diseases, 5; English and library reading, 5.

Second Term—Animal husbandry, 5; blacksmithing, d. 5; United States history, 5; English and library reading, 5.

Third Term—Animal husbandry, 5; vegetable, flower and fruit gardening, 5; English and library reading, 5; civil government, 5.

YOUNG WOMEN.

First Year.

First Term—Cooking and sewing, d. 5; English and library reading, 5; business arithmetic, 5.
Second Term—Cooking and sewing, d. 5; home economy, 5; English and library reading, 5; laundry, 2.
Third Term—Cooking and sewing, d. 5; plant life, 5; poultry, 3; hygiene, 5; English and library reading, 5.

Second Year.

First Term—Cooking and sewing, d. 5; English and library reading, 5; economic insect and diseases, 5.
Second Term—Cooking and sewing, d. 5; chemistry of foods, 5; United States history, 5; English and library reading, 5.
Third Term—Cooking and millinery, d. 5; home nursing and emergencies, d. 2; vegetable, flower and fruit gardening, 5; English and library reading, 5; civil government, 5.

* The numerals denote the number of recitation periods per week; d. signifies double period.

The probable number of students that could attend the county agricultural school at any one time is about 125.

These schools are well equipped for giving instructions in the courses which they have adopted. Besides teaching students of the agricultural school, officers and students help conduct many farmers' institutes or similiar meetings.

In these two Wisconsin schools it is believed that a pupil will be more useful in after life if he writes a composition on "How to Fill a Silo," than if he writes about "Spring". If he is set to weaving a basket, his time will be better employed than if he is stood in the corner for whispering. If he is allowed to do these useful things when his study is fininshed, he will be much more apt to not whisper at all. They believe it is better for a pupil to know the composition of feed for growing stock than to be able to name the battles of the Revolution. It is better for him to know the meaning of protein and nutritive ratio than to know what is meant by the least common muntiple.

Agricultural College, Michigan.

TOPICS IN HORTICULTURE FOR COMMON SCHOOLS.

U. P. HEDRICK.

PROPAGATION OF PLANTS

Place seeds in a simple germinator and study daily until germination is completed.
Determine the increase in volume of various seeds during imbibition.
Prove that increase of heat hastens imbibition.
How much does soaking seeds hasten germination as compared with those planted out of doors?
What are the effects of mechanical injuries on seeds? Try with weevil-eaten peas.
Soak seeds of one of the former for several hours. Is the mucilaginous substance beneficial?
Show that heat is produced in germinating seeds.
Will seeds grow after alternate drying and sprouting?
Show the influence of light on the germination of potatoes.
Show the necessity of oxygen for germination.
Study the reproduction of plants from cuttings, especially as to the several kinds of cuttings and requisites for each.
Propagate flower and shrubs for the school grounds in various ways.
Have pupils graft and bud plants, using the simple processes.
Examine root-stocks, corms, tubers, bulbs, and all underground parts used in artificial propagation. Compare with buds.
Study runners, stolons, tips, and methods of artificial propagation by them.

VEGETABLE GARDENING.

Sow short rows of vegetables and have students make notes as they pass through various stages of growth
Give pupils practice in sowing seeds, transplanting and cultivation.
What causes seedlings of vegetables to damp off?
Study effects of food elements in sand or water cultures?
Make sections of cabbages, Brussels sprouts, and compare with buds of trees.
Examine flowers and note peculiarities, especially in regard to cross-pollination.
What are the weeds that infest the garden?
Will the various cucurbits mix?
Study the structure of the fleshy-rooted vegetables.
Study the foliage and habit of growth of tomatoes.
Compare varieties of tomatoes as to color, shape, flavor, structure of fruits.
Study the arrangement of eyes on the potato. Examine sprouted tubers as to what eyes give strongest shoots.
Do tubers of different varieties of potatoes bear the same number of shoots?
Teach pupils to distinguish vegetables by their seeds.
Study variation in garden plants, and especially with regard to plant-breeding. Call attention to sports
Study varieties of vegetables. What constitutes a variety?
Make observations as to ideal specimens of vegetables of the various kinds.

POMOLOGY.

Study the various types of fruits, as pomes, drupes, berries.
What are the differences between the fruits of the several pomes? Of the several drupes?
Classify the several fruits as to season, flavor, color, etc.
Study the bloom on fruits. Of what use is it?
Compare perfect and imperfect flowers of the strawberry.
What fruits have stems and what ones do not? Shall we leave the stems on, and why?
When are fruits ripe and how long will they keep?
Give talks on the evolution of native fruits.
Become familiar with injurious insects and fungi.
Make a study of the callus at the edge of wounds made in pruning.
Study injuries resulting from pruning and deduce rules for making the cut and covering the wound.
Discuss and illustrate the training of trees and vines.
Wild fruits are often borne in clusters, and but singly in cultivated varieties of the same species. Why?
Study relations of cultivation to seedage by comparing seeds in wild and in cultivated fruits of same species.
Observe what becomes of all floral organs in fruits.
Note peculiarities of floral organs as related to cross-pollination.
Study buds and bearing wood of all fruits with regards to kinds of buds, where borne, fruit spurs, long and short shoots, age of wood, etc.
Study the unfolding of leaf and flower buds
Make notes on the development of fruits from flowers to maturity.

Agricultural College, Mich.

SYLLABUS FOR A FOUR-YEAR COURSE IN HORTICULTURE.

For Graduates of a Good High School.

U. P. HEDRICK, AGRICULTURAL COLLEGE.

FALL TERM.

Freshmen		Sophomores.		Juniors.		Seniors.	
Subjects.	Hours.	Subjects.	Hours.	Subjects.	Hours.	Subjects.	Hours.
Stock judging..........	10	Agricultural physics.	10	Pomology...........	5	Plant breeding.....	10
Chemistry..............	7	Rhetoric...........	5	Systematic pomology..	10	French or German...	5
Botany................	10	Physics............	7	Parasitic Fungi.......	10	Three electives.....	15
Algebra................	5	Chemistry..........	7	French or German.....	5		
Military drills...........	3	Zoology............	7	Bacteriology.........	5		
		Military drill.......	3	Military drill.........	3		

WINTER TERM.

Freshmen.		Sophomores.		Juniors.		Seniors.	
Subjects.	Hours.	Subjects.	Hours.	Subjects.	Hours.	Subjects.	Hours.
Work in wood shop and forge shop............	10	Farm crops........	10	Floriculture..........	5	Plant evolution.....	10
Drawing...............	5	Agricultural chemistry.............	5	Laboratory work in greenhouses........	10	French or German..	5
Geometry (solid)........	5	Plant histology.....	10	English..............	5	Three electives.....	15
Chemistry..............	10	Zoology............	7	Bacteriology.........	10		
Anatomy..............	6	Forestry...........	5	French or German....	5		
Military drill...........	3	Military drill.......	3	Military drill.........	3		

SPRING TERM

Freshmen.		Sophomores.		Juniors.		Seniors.	
Subjects.	Hours.	Subjects.	Hours.	Subjects.	Hours.	Subjects.	Hours.
Study of soils...........	10	Plant propagation..	7½	praying plants.......	5	Experimental work..	10
Botany................	5	Vegetable gardening	7½	Work in orchard and Garden..............	10	French or German..	5
Drawing...............	5	Entomology........	8	Landscape gardening..	5	Three electives.....	15
Physics................	7	Ecology...........	......	English	5		
Trignonmetry and surveying..................	7	English............	5	Military drill.........	3		
Military drill...........	3	Military drills......	3	French or German.....	5		

ANIMAL HUSBANDRY—FOUR-YEAR COURSE.

For Graduates of a Good High School.

R. S. SHAW.

FRESHMAN YEAR.

Fall term.		Winter term.		Spring term.	
Subjects.	Hours.	Subjects.	Hours.	Subjects.	Hours.
Study of breeds	10	Forge work ½ term	4	Soils	5
Elementary chemistry	5	Bench work ½ term	4	English	5
English	5	Drawing (freehand)	5	Systematic botany	3
Algebra	5	Geometry	5	Trigonometry	3
Botany (Fruits and seeds)	5	Chemistry (Analytical)	10	Surveying	4
Hygiene	2	Anatomy	6	Physics	5
		English	5	Drawing (Farm buildings)	5

SOPHOMORE YEAR.

Fall term.		Winter term.		Spring term.	
Subjects.	Hours.	Subjects.	Hours.	Subjects.	Hours.
Study of breeds	5	Farm crops	5	Dairying	10
Agricultural physics	5	English	5	English	5
English	5	Agricultural chemistry	5	Vegetable gardening	10
Physics	5	Plant histology	5	Entomology	7
Organic chemistry	7	Stock breeding ½ term	5	Geology	3
Zoology	7	Vet. Science ½ term	5		
		Zoology	7		

JUNIOR YEAR.

Fall term.		Winter term.		Spring term.	
Subjects.	Hours.	Subjects.	Hours.	Subjects.	Hours.
Live stock experiments	10	Live stock experiments	10	Live stock experiments	10
Botany, fungi	8	Physiological chemistry	5	Animal feeding	10
Breeds of poultry	5	Bacteriology	10	Methods of sanitation	5
Bacteriology	5	Feeding, care, management of	5		
Political science	5	poultry	5	Dairying	10
		Physiological botany	5		

SENIOR YEAR.

Fall term.		Winter term.		Spring term.	
Subjects.	Hours.	Subjects.	Hours.	Subjects	Hours.
Advanced stock judging	10	Slaughtering and meat cutting	10	Animal nutrition	10
Bacteriology	5	Registry associations and methods of registration	2	Veterinary science	5
Veterinary science	5	Legislation effecting animal industry	5	Meteorology	5
Zoology	5	Bacteriology	5		
		Veterinary science	5		
		Economics	5		

This outline of a four-year course in Animal Husbandry is merely tentative, its practicability has not been tried out in actual practice and doubtless many changes would have to be made in putting it into use. So few special four-year courses in Animal Husbandy have been devised that guides in preparing a syllabus of this kind are scarce.

Aside from those subjects treating directly on animal husbandry, crop production, botany, chemistry and bacteriology should be strong features.

In this course 380 hours are devoted to the study of breed types of horses, cattle, sheep, swine, and poultry, and the judging of these classes. This includes a brief consideration of the origin, history and characteristics of the various breeds as well. This is considerably more time than is usually allotted to this work in the four-year courses in agriculture. It is highly desirable that this work be distributed throughout the four years. It is absolutely necessary, too, that numerous typical specimens are available for study in the class room, as little can be accomplished from the text book alone. As first impressions are frequently lasting, poor specimens should not be presented before classes except following a critical study of the best for purposes of comparison.

Thirty-five hours only are devoted to the subject of animal breeding. Most features of this subject are still shrouded in mystery and more scientific investigation is needed to clear up this extended theoretical field.

It is important that much of the chemistry and botany precede the 140 hours' stock feeding work in the spring time of the junior year as planned. Note that Physiological Botany and Physiological Chemistry come in the same term with Poultry Feeding, Care and Management, and precedes the spring term work in animal feeding. This particular botany and chemistry is extremely essential to a course of this nature.

Ten hours per week throughout one year has been assigned to live stock experiments. During the first term the instructor should review with the student all the methods employed and results secured in live stock investigation work by leading American institutions. Modern methods and recent discoveries are factors which tend to qualify some of the results on record. The second term should be given up, if necessary (in part), to a continuation of the first terms' work and the planning of a live stock experiment to be conducted by the student during the spring term.

The work in slaughtering and meat cutting is not intended to train students for butchering, but rather to give them an opportunity to study questions of quality in meat production. In this work a feeding record is kept in the preparation of the animals; they are judged and scored in the class room and estimates made as to the probable quantity and quality of the carcasses; at the killing, slaughter records are secured and finally the carcasses are cut up on the block by students who secure the per cents of the various cuts and note the quality, thereby determining whether their estimates of the animal on foot were correct or not. This system of laboratory work with living animals and the carcasses produced from them, fills in the links omitted by the old system whereby animals are judged and scored and then turned away without securing proof of the accuracy of the estimates.

Every distinct breed of live stock has a registry association and some have three or four. Some of the separate associations are weak and some are strong; in some cases transfers can be made from one to another and in some they cannot. The prospective breeder should know about the history, location and standings of these registry associations. Some associations have rules governing applications and registry in common with others, while others again adopt requirements suited to their peculiar or special needs. It is desirable to study these rules somewhat carefully.

A study of legislation, both home and foreign, in connection with its effects on the development of the live stock industry, is essential. This includes international, federal and state inspection laws, quarantine regulations, control of contagious diseases and laws concerning transportation. Special attention is given to legislation of foreign countries effecting American trade. The great foreign markets of the world and their sources of supply are also studied. This work is usually preceded by a consideration of the development of the live stock industry in America.

It may appear that two such closely related subjects as physiological chemistry and animal nutrition overlap, and in fact it may be impossible to set a dividing line. The first, however, is intended to embrace a series of lectures on chemistry of the animal body and the last some lines of experiments along the line of nutrition.

Veterinary science is necessarily represented in this work quite fully, not with the intention of educating men for veterinarians, but rather with the object of preparing them to properly care for animals, thus preventing disease, injury, etc., and to know what to do in emergency cases.

Two terms' work are considered necessary in dairying even for those who may not intend to specialize in this division. The work would impart some knowledge relative to methods of handling milk and cream, milk testing, and the manufacture of milk and butter.

Both botany and bacteriology should be strongly represented in a course such as this because of the close association of the former with plants which constitute such a large percentage of animal foods. Today some knowledge of bacteriology is necessary in the consideration of soils, plant growth, plant and animal diseases, and all processes of dairy manufacture and in many cases in the preparation of stock foods.

Agricultural College, Mich.

A STUDY OF SOILS BY YOUNG STUDENTS.

J. A. JEFFERY.

In preparing an outline for the study of soils in rural schools, it is borne in mind that the pupil, the condition and the teacher will each have a bearing upon how closely any outline shall be followed.

The following short outline is one which I would suggest, subject, as indicated above, to modification. The time required for the work will depend on the time at the teacher's disposal. In the ordinary country school the work would have to be done largely during the spring and fall terms.

Apparatus Required.

Little can be done without some apparatus.

It would be desirable, of course, to have a laboratory with a lot of good apparatus, but even with simple and crude tools, one is often enabled to obtain excellent results.

A torsion balance weighing to 1-10 gram, glass tubes, glass funnels, glass jars, filter paper, graduates and evaporating dishes are desirable.

This article is written for a laboratory supplied with apparatus as follows:

One kitchen scale with dial, weighing from one ounce to 24 pounds, price 90 cents.
One dozen gallon jars—of the deep sort.
One dozen common glass tumblers.
One and one half dozen quart tin fruit cans (tomato cans) with open end melted off by placing can, open end down, on a hot kitchen stove for a few minutes.
One dozen tops of baking powder cans.
One common eight ounce graduate such as can be bought in most grocery stores.
A few dozen screw cap bottles, seven-eights inch by five and one-half inches, or thereabouts.
One small bottle of ammonia.
One small alcohol lamp.

A Soil Collection.

(a) Have each member of the class bring a quart sample of soil. This sample should be obtained by digging a hole with perpendicular walls to the depth of the plowed soil, or, in virgin soil, to the depth of the soil proper as indicated by the darker color due to the presence of the larger quantities of organic matter. In muck soils take sample to depth of six inches. Mix thoroughly before taking the quart sample.

(b) These soils should be air dried, thoroughly mixed, and smaller samples taken from these to preserve. A screw cap homeo, 7 inch by 5½ inches, makes a very convenient receptacle in which to preserve samples.

(c) Have the pupils place these samples in groups so far as they may be able to on the basis of appearance, feel, etc. If they have any difficulty in this let the teacher suggest and later, if necessary, complete the classification.

There are likely to be in this lot of soils, sandy soils, loams, clays, and muck soils with intervening modifications. In some cases sub classifications on the basis of color, might be required. Or some special form of soil, such as an alluvial, might be brought in.

(d) If these vials of soil could now be mounted in some permanent form, for reference from time to time, say upon heavy cardboard with light copper wire, it would be helpful.

(e) Have samples of the sub-soils brought in the same manner for a depth of six inches below the depth of the first sample. Dry, bottle, and place each with its soil.

(f) It would be well to carefully save the remaining soils after bottling the samples.

Composition of Soils.

(a) Have each pupil study a sample of the soil he has brought. (and later, samples of soil brought by the others) and let him as far as possible determine what materials compose it.

(b) In a qualitative way the relative amounts of organic matter, fine material, and sand of each soil may be determined:—

1. The organic matter, by burning a quantity of each soil. The soil may be placed in a can cover and the cover and contents placed over the alcohol flame or on a bed of hot coals or upon a hot stove top.
2. The coarse, sandy material may be determined by placing a quantity (about one ounce) of soil in an ordinary glass tumbler. Fill the tumbler half full of water, add a few drops of ammonia and allow to stand for twenty-four hours stirring from time to time. After twenty-four hours fill the tumbler nearly full of water, stir well and after standing one minute, pour off the water with everything left in suspension, repeating till nothing is left in suspension at the end of one minute.
3. The finer clayey material would be estimated by difference.

By the use of the 90 cent kitchen scale this work could be done quantitatively with aproximate accuracy, though larger quantities of material should be used. This would require, also, that the material be air dried before and after separation before weighing.

Soil History.

It would be possible at this point to give some attention to the manner in which some of the soils have been formed. The alluvial soils and the muck soils are especially suited to give the pupil an opportunity, under the direction of the teacher, to develop something of their history for himself. The teacher might give a few of the simpler facts concerning the formation of all the soils brought in by the pupils. Visits might be profitably made, at times, to soil deposits.

Physical Characteristics.

Simple experiments may be performed to illustrate some of the more important qualities of soils such as:

(a) Water holding power. If funnels of glass are not at hand a quart tin tomato can as described above, will do. With a nail or other tool, punch a small hole in the bottom close to the side.

1. Weigh the can.
2. Weigh in one pound of air dry soil, first placing a moistened piece of old fine muslin over the hole punched in the bottom.
3. Now introduce more than sufficient water to saturate the soil.
4. Place the can with its contents in a tilted position with the hole down, and allow to drain until water ceases to drip
5. Weigh and determine the amount of water retained in the soil.

It is best to use two to several kinds, or types of soil at the same time. Cans are not expensive to obtain.

(b) The rate at which soils give up moisture.

1. Fill two one gallon jars even full with a soil containing about the amount of moisture it would require in the field to plow well. Pack the soil reasonably well. Number the jars.
2. Weigh jars and contents and record weights.
3. At the end of one week, weigh again, record weights, and estimate losses.
4. Add water sufficient to bring weight of jar back to original weight.
5. At the end of another week, weigh again and proceed as in (4).

It would be well to carry this work through a number of weeks using three or more lots of soil.

(c) Effects of standing water.

1 Place in bottom of a glass tumbler a piece of moistened paper large enough that when fitted well down against the bottom it will reach half way up the sides of the tumbler.
2. Introduce into the tumbler one ounce of air dry soil.
3. Cover with water and allow to stand twenty-four to forth-eight hours.
4. Without stirring, pour off excess of water and allow tumbler to stand in a warm place till the soil in the bottom becomes thoroughly dry.

Soils of different kinds should be so treated at the same time for convenience in comparison.
Compare effect of this treatment on different soils.

5. Have pupils observe whether field soils in the neighborhood are made hard by heavy rains or by water standing on the field, and how such a condition of field soil effects the crop.

Effect of Cultivation on Moisture Losses.

1. Fill full four one gallon jars of the deep sort, with any good soil in well moistened condition. Pack well. "Strike off" the surfaces with a straight edge. Number the jars, 1, 2, 3 and 4.
2. With a table fork, thoroughly stir the surface soil of jars 3 and 4 to a depth of an inch, and "strike off ' with straight edge.
3. Weigh all four jars and record weights.
4. Place jars either in open room or out of doors, but not where rains may strike them.
5. At end of one week weigh again and record weights, estimate and compare losses from the jars cultivated with those not cultivated.
6. Add sufficient water to each jar to bring it bach to its original weight and after a little time stir the surface of the jars 3 and 4 again.
7. Repeat (4) and (5).

WATER USED BY PLANTS.

1. Fill four one gallon jars to within one inch of the top with a well moistened soil.
2. Number jars 1, 2, 3, and 4 and weigh and record weights.
3. Plant eight good plump kernels of oats, or four good kernels of corn in each of the jars 3 and 4. Place all jars where rain will not reach them.
4. When plants are three inches high, thin the oats to six plants, or if corn, to three plants. Add sufficient water to bring each jar to its original weight.
5. In one week, weigh again, record weights, estimate losses, and with jar on the scale, add water sufficient to bring it up to its original weight. Note losses from jars with plants as compared with losses from jars without plants.
6. Repeat (5) for several weeks noting how, as the plants grow larger, larger quantities of water are used.

It will be necessary when the plants are well started, to add water oftener than once per week to the jars having plants in them.

7. Have pupils examine cultivated fields and observe, if possible, whether any difference in appearance exists between the crops in well cultivated fields and those of poorer cultivated fields, keeping in mind this experiment and the one above.

With a little effort, this scheme may be considerably enlarged. Experiments with field soils and crops are entirely feasible.

Agricultural College, Michigan.

COURSES IN SOME PHASES OF RURAL ECONOMY.

OUTLINE FOR A COURSE IN FARM MANAGEMENT.

PREPARED BY PROFESSOR F. W. CARD, RHODE ISLAND COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

Introduction.

Evolution of farming.
- Ratio of population to productive area.
- Changes in farming methods.

Capital.

Fixed.
Circulating.
- Relationship and relative proportion of each.

Labor.

Relative proportion to capital invested.
Manual labor.
Team labor.
The labor problem.
Winter labor.
Contract labor.
Profit sharing.

Ownership or Rental.

Share rental.
Money rental.
Ownership.

Choice of a Farm.

Location.
- Surroundings.
- Market facilities.

Character.
- Land, buildings, orchard, etc.

Farm Balance.

(Proportionate division of crops.)
Influenced by
1. Rotation.
2. Farm consumption.
3. Distribution of labor.
4. Money return.

Systems of Farming.

Special vs. mixed.
- Advantages of mixed farming.
- Advantages of special farming.

Extensive vs. intensive.
- Demands of extensive farming.
- Demands of intensive farming.

Syndicate farming.
- Favorable factors.
- Unfavorable factors.

Marketing Problems.

Price.
Transportation.
Wholesale vs. retail.
General vs. special.
Home vs. distant.
Direct sales vs commission.
Varieties, packing, and grading.

Records and Accounts.

Business accounts.
- Requisites.
- Inventory.
- Cash-book.
- Bank accounts.
- Personal accounts.

Farm records.
- Time-cards.
- Production records.
- Family consumption.

Implements and Equipment.

Items of cost in owning.
Cost and efficiency of labor with and without machine.
Profit or loss in owning.
Capacity of machines.

Farming compared with other Lines of Business.

Investment.
Returns.
Limitations.
Advantages for the working investor.
Opportunities for the passive investor.

Advertising

Methods.
Cost.
Returns.

Miscellaneous Problems.

Fencing.
Economy of time.
Shape of fields.
Location of buildings.
Economy in farm operations, etc

Legal Questions.

Law of contracts.
Leases.
Landlord and tenant.
Master and servant.
Trespass.
Fence laws.
Control of live-stock.
Water rights.
Overhanging trees, etc.

Cooperation.

Cooperative production.
Cooperative manufacture.
Cooperative marketing.
Cooperative buying.

Specific Types of Farming.

Mixed farming.
(Inventory, farm balance, probable expenses, probable returns.)
Dairy farming.
Beef farming.
Sheep farming.
Grain farming.
Grass farming.
Terry rotation.
(Wheat, clover, potatoes.)
Fruit farming.
Poultry farming.
Truck farming.
Farming under glass.

OUTLINE FOR A BRIEF COURSE IN AGRICULTURAL ECONOMICS.

PREPARED BY PRESIDENT K. L. BUTTERFIELD, RHODE ISLAND COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

I. Characteristics of the agricultural industry.
  Dependence upon nature.
  Capital and labor as applied to agriculture.
  The laws of rent and of decreasing returns in agriculture.
  Relation of agriculture to other industries and to the welfare of mankind.
II. History of the Agricultural Industry.
  In ancient times.
  Status in Europe prior to the eighteenth century.
  The struggle to maintain its standing after the advent of commerce and manufacture.
  In the United States.
    The pioneer stage.
    Development of commercial agriculture.
    The new farming.
III. Present status of the Farming Industry.
  The world's food supply.
  Agricultural resources of the United States.
    Geographical factors.
      Soils, climate, fertility, natural enemies, etc.
  Statistics of farms, farm wealth, production, etc.
  Leading sub-industries, cereals, stock, etc.
  Distribution of production.
IV. The agricultural Market.
  Description of the market,—local, domestic, foreign.
  Mechanism of the market.
    Banks and local exchange facilities.
    Middlemen.
    Boards of trade.
  Prices of agricultural products.
    Movements of prices.
    Agricultural competition.
    Depressions of agriculture.
    Influence of "options".
  Transportation of agricultural products.
    Primary transportation—wagon roads and trolley lines.
    Railroad and water transportation.
      Facilities.
      Rates.
      Discriminations.
      Delivery methods.
    Incidents of the transportation system—elevators, etc.
    Imperfect distribution of agricultural products.
  Development of the market.
    Increase of consumption of products—Manufacture of farm products as a factor.
    The factor of choicer products.
    The factor of better distribution of products.
    The local market as a factor.
    The foreign market as a factor.
V. Business Cooperation in Agriculture.
  Historical sketch.
  Present status.
    Production.
    Marketing.
    Buying.
    Miscellaneous business cooperation.
  Difficulties and tendencies.

VI. Agriculture and Legislation.
- Land laws and land policies of the United States.
- Agriculture and the tariff.
- Taxation and agriculture.
- Food and dairy laws.
- Government aid to agriculture.

VII. General Problems.
- Agricultural labor.
- Machinery and agriculture.
- Interest rates, indebtedness, etc.
- Tenant farming.
- Large vs. small farming.
- Business methods.
- Immigration and agriculture.

OUTLINE FOR A BRIEF COURSE IN RURAL SOCIOLOGY.

PREPARED BY PRESIDENT K. L. BUTTERFIELD, RHODE ISLAND COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

INTRODUCTION.

1. Definitions.
2. Relation of the sociological to the economic, the technical and the scientific phases of agriculture.

Part I.

THE RURAL SOCIAL STATUS.

Chapter I.

Movements of the Farm Population.

1. Statistical survey.
2. The movement to the west.
   History, causes.
3. The movement to the cities.
   a Growth of cities.
   b Depletion of rural population in certain localities.
4. Causes of the movement to the cities.
   a Industrial, social, and psychological causes.
5. Results of the movements of the farm population.
   a Results both good and bad.
   b Resume of industrial and social results.

Chapter II.

Social Condition of the Rural Population.

Nativity; color; illiteracy; families; health; temperance; crime; morality; pauperism; defectives; insanity; etc.

Chapter III.

The Social Psychology of Rural Life.

1. Isolation and its results.
2. The farm home and its environment
3. Traits of family life.
4. Traits of individual life.

Chapter IV.

The Social Aspect of Current Agricultural Questions.

1. Tenant farming.
2. Large vs. small farms.
3. Farm labor.
4. Irregular incomes.
5. Farm machinery.
6. Specialization in farming.
7. Immigration.

Part II.

SOCIAL FACTORS IN RURAL PROGRESS.

Chapter I.

Means of Communication in Rural Districts.

1. Importance and status of rural communication.
2. The new movements for better rural communication.
   a. Highways.
   b. Rural free mail delivery.
   c. Rural telephone.
   d. Interurban electric railways.

Chapter II.

Farmers' Organizations.

1. Value of.
2. Difficulties in organizing.
3. Forms that organizations may take.
4. History and work of farmers' organizations in the United States.
5. General deductions from study of farmers' organizations.

Chapter III.

Rural Education.

1. Distinction between rural and agricultural education.
2. The country school.
   a. Its importance, organization, maintenance, instruction, and supervision.
   b. The rural school as a social center.
   c. The township unit, the consolidated school, the centralized school.
3. High school privileges for rural pupils.
4. The rural library.
5. Other agencies for rural education.

Chapter IV.

Means of Agricultural Education.

1. Historical
2. Research in agriculture.
3. Agricultural instruction to resident students.
   a. Higher education in agriculture.
   b. Secondary education in agriculture.
   c. Primary education in agriculture.
4. Extension teaching in agriculture.
5. Miscellaneous agencies for agricultural education.
   a. Farmers' societies.
   b. The farm press.
   c. The county paper.
   d. Industrial departments of steam railways.

Chapter V.

The Rural Church.

1. Present status.
2. Difficulties in country church work.
3. The awakening in the rural church.
4. The institutional rural church.
5. The Y. M. C. A. in the country.
6. The rural Sunday School.
7. The rural social settlement.

Chapter VI

The Social Ideal for Agriculture.

1. The importance of social agencies.
2. The preservation of the "American Farmer" essential.
3. Relation of this ideal to our American civilization.
4. The federation or cooperation of rural social agencies.

THE PREPARATION OF TEACHERS FOR THE RURAL COMMON SCHOOLS.

By Ernest Burnham.

The greatest service at the least cost, which is largely determined by organization, is a fundamental school problem just as it is a fundamental problem in the management of any industry or institution. Another fundamental question has been clearly defined by the late Dr. B. A. Hinsdale, one of the greatest American students of education, in these words: "The provision of good teachers will be the vital educational question of the twentieth century as it has been of the nineteenth century."

The question of good teachers, for country schools repeatedly recurs in Grange, Farmer's Club and Farmer's Institute programs and in general public and press discussions. The discussion of this problem is increasing and it will continue to do so until the American instinct for doing justice is given full expression in the provision of at least as many trained teachers for country children as are provided for any other children.

When it is known that at present 75 per cent of the teachers in graded schools in the villages and cities of this state have had some professional training by the state, while less than 2 per cent of the teachers in the country schools have had such training, the fact is patent to all that the campaign for professionally trained teachers for rural schools is hardly begun.

Before such a campaign can proceed there must be developed a sufficient demand, on the part of the patrons and supporters of country schools, for trained teachers. A sufficient demand will induce an increasing number of ambitious and worthy young people to seek that particular kind of training which will prepare them for successful work in country schools. Such a demand has been created in recent years, by farmer's institutes and other agencies, in many districts in various parts of Michigan; in fact this new demand has outrun the supply and as a result, a study of the whole question of trained teachers is being made.

The brief study of this question here attempted is based upon the confident belief that all honest, patriotic citizens, whether they happen to live in the city or in the country, when they know the facts, will unite in the demand that our proud American boast of equal rights to all and special privileges to none be made as true to children as to older people. Public sentiment, the drawn sword of Justice in this country, will enforce the demand for trained teachers for all boys and girls.

A trained teacher is: First, one who has fullness and accuracy of knowledge in the subjects which are to be taught and who is determined to become intimately familiar with all the sources at his command to which he may go or send for the increase of his knowledge and the proof of its accuracy; and secondly, he is one who by patient teaching under competent criticism has been shorn of careless, haphazzard, slovenly, weak and wasteful methods and has by observation, instruction and practice acquired efficient, time-saving methods. Thirdly, a trained teacher is a manly man or a womanly woman who, by association with nature and humanity through books and by personal contact, has grown into a compelling soul-power sufficient to interpret, to cultivate, to vivify, to individualize, to inspire in children and youth the best ideals of life in general and of the humanity and nature about them in particular; to banish laziness and self-satisfying stagnation by giving the conscience a better grip on the will.

Progress in the training of teachers for country schools must find its starting point in existing conditions. There must be systematic study of these conditions. The facts which underlie the present status of the matter must be discovered, correlated and proved. This is too vital a question to find a basis for action in mere theory or speculative opinion. The necessary facts may be known and only in so far as they are known can there be any safe basis for the reasonably permanent, constructive work which the spirit of the times demands. This work is sure to be done because the conditions are being provided which insure to this great work the necessary able, trained, experience-proven constructive leadership.

Teacher training has been carried on successfully at state expense in Michigan for more than fifty years and the agricultural population has cheerfully borne its 5.13 or more of the taxation which has been necessary for the support of normal schools, without ever demanding with sufficient unanimity and emphasis that these schools try at least to solve the problem of doing equal justice to both urban and rural population.

It has evidently been thought by those in authority that the rural districts did not want trained teachers, and that even if they did they could not afford to have them. This may have been true of many districts and it is possibly still true of some districts which, recognizing their financial inability to maintain an up-to-date school, take no advantage of a convenient law enabling them to better their financial condition.

It has doubtless been the purpose of administrative officers to do the best for all concerned, but they have been baffled until recently by the circumstances hedging in the country schools. As a consequence, the whole normal school machinery has been largely adapted to the work of providing teachers for graded schools in particular.

The natural consequences of this plan of work needed but the additional circumstances of the better organization and better wages of village and city schools to make it yield the present unbalanced, unjust and un-American status of 75 per cent of State-trained teachers in the urban schools and less than 2 per cent of State-trained teachers in the rural schools.

Fortunately for country children normal school training, while it ought to be the best, has not been the only training available for young people desiring to become teachers. The method of practically unguided, experimental practice in real schools has been in operation throughout the years. The time honored, experimental method to which the State is indebted for 98 per cent of its rural teachers has been in a measure successful. This method is familiar to all. By it, at least one-fourth of the total number of country teachers enter the teaching force every year.

These new teachers are entirely without professional training and a majority of them have never before tried to carry independently any responsibility. They have come up to a minimum standard of scholarship; but their qualifications in general culture and physical and moral tone, if estimated at all, are largely guessed at from clothing, figure, face and manners. Careful investigation in one county, Calhoun, shows that of fifty-five beginners in one year, twenty-two were graduated from city high schools, nineteen were graduated from village high schools, eight had had part of a high school course and six were graduates of the eight-year common school course.

During one term of the same year in the same county, the active teaching force of 155 rural teachers consisted of fifty beginners, thirty-seven who had had one year, eleven who had had two years, nine who had had three years and forty-eight who had had four or more years of teaching experience.

There has been a slight increase in the proportion of beginners to the whole number in recent years, but approximately these proportions persist in the county studied; one-third of the rural teaching force with neither special training nor practical experience, one-third who have had from one to three years of largely unobserved and undirected trial; and one-third who have had four or more years of the same sort of training.

Five years of almost daily observation of the work of these teachers, establishes the conviction that this independent and largely uncriticised experience may produce a first-class teacher and again it may be practically worthless. The balance turns on the health and temperament of the teacher and his attitude toward his work. The vital element here is the spirit of the teacher. This is the open door through which walk into the school the disorganizing and dissipating power of low ambition and indefinite ideals or the pride invoking, self arousing power of clear ideals and ennobling ambitions.

Observation seems to prove that weak and time-wasting work anywhere in the public school system tends to reproduce its kind, but with lessening vitality; while definite and efficient work anywhere in the public school system tends to reproduce its kind with ever increasing vitality and power for good.

If this is a true general principle its application to the question under discussion is far-reaching. The poorly trained, undeveloped teacher is handicapping, for all time, the plastic lives he fails to bring to their best possibilities. In like manner the developed, skilled teacher is expanding and re-creating in larger mould the lives before him every day.

In concluding the discussion of this most used method of preparing teachers for country schools, ignoring the mass of failures and all that these failures have meant in dwarfed and stunted human souls; it is but justice to state the truth that this method supplemented by county supervision, associations, institutes and reading circles has brought into the service of the State very many noble men and women, some of whom although in the service but a few years have aroused and safely started in life many of the best men and women in the country's history.

A better method, better because it keeps the merits of the old method and makes definite additions to them, is now provided in the County Normal Training Classes. Through the great public interest and the activity of the Department of Public Instruction this plan, although only in its second year of application has become fairly well understood throughout the State.

The eight county classes in operation last year graduated 96 teachers and the twenty classes now at work have a total enrollment of about 300, nearly all of whom will receive certificates next June. There will be thirty of these classes next year with a total enrollment of about 500; and there is good reason to believe that the next ten years will see a County Normal Training class in every Michigan county which has a large corps of country teachers and which is not conveniently near to a State Normal School.

This plan is new and will be strengthened and perfected by trial under the constant watchful care of men and women of experience-proven good judgment. The essential features of its organization include its establishment by the State Superintendent after a favorable vote by the district and the board of supervisors in the county applying for it; its financial support—one-half by State appropriation and one-half in equal proportions by the county and district it serves, and its management by a county normal board consisting of the State Superintendent, the County Commissioner and the Superintendent of Schools where the class is located.

These classes now offer one year of work to which applicants are admitted who are at least 17 years of age, possess good moral character, declare their intention of completing the course and becoming teachers in rural schools, and who have successfully completed 10 grades of public school work or hold a second grade certificate or have had two years of successful experience in teaching.

The course of study includes reviews in all the common school branches with suggestions as to the best methods of teaching these subjects and, in addition, psychology, pedagogy and school management, algebra, general history, drawing, manual training, music, primary methods, elementary agriculture and practice teaching.

The time given to this course is short; but the admission requirements insure for it pretty well matured and instructed young people who, working with a fixed purpose under sympathetic and wise guidance for a year are sure to be very much more likely to succeed in their first schools than they could possibly be without this special training.

The benefits of the County Normal Training Class course do not consist in the amount of added knowledge so much as in an attempt to classify and organize the whole fund of information and put it at the instant command of the one possessing it. The results of a course of this kind are not all carried away in note books and a memory overloaded with special methods and devices which may be lost or forgotten; but to formal and particular work of these kinds there is added a partial understanding, at least, of fundamental principles upon which it will be safe to form judgment and base action.

Having discussed the good old method and the better new method, attention may now properly turn to the State Normal Schools where the best method of training teachers for country schools should be found. By force of the statutes establishing State Normal School courses and by force of the good faith and purpose of the State Board of Education, now entirely responsible for these courses, the State Normals have in process of evolution what is intended to be the best possible method of training teachers for service in rural schools, under present and immediately prospective conditions.

At Mount Pleasant, where the training of rural teachers has been in progress for nine years, nearly 500 teachers have been graduated and many others have had the benefits of one year of the two years' course offered. A very large percentage of these teachers have gone out and proven the worth of their training in country schools.

All of the State Normal Schools are now making more or less effort to serve the rural schools. But the fundamental problem of the Normal Schools in dealing with this question is not yet solved. It is a difficult and perplexing problem.

The Normal Schools must first differentiate the training of teachers for ungraded schools in rural communities from the training of teachers for graded schools in urban communities in so far as a differentiation is necessary. Having done this, the public conscience, through the worthy men to whom it delegates its functions will not stop short of providing with equal enthusiasm and liberality both kinds of training in all State supported Normal Schools.

The very few people who are working seriously at this great problem of State wide importance have made little real progress. Their thought and study is centered about three fundamental elements of the problem. First, what difference, if any, should there be in the academic requirements? Secondly, what differing provisions for observation and practice teaching are required for these two classes of teachers? Thirdly, what are the possibilities for social service by the rural teacher and how may the Normal Schools inculcate a spirit of enthusiasm for such service?

None of these questions have been satisfactorily answered. No one has advanced any proof that less scholarship is required for successful teaching in rural schools than in urban schools. It must be concluded that the fact that lower standards are now set for rural teachers is due to circumstances beyond human control. It is clear that for the present, equal academic standards cannot be required for urban and rural teachers; but it must be resolutely determined that these standards will not be allowed to differ in the quality as well as the quantity of work required.

Many agencies are now at work hastening the day when the teachers of all the elementary schools of the State, whether in city or county, will be held to the same standards of scholarship. Then all teachers will be required to have a general knowledge of the whole industrial fabric of the community, State and nation. It is now thought necessary for all teachers to have in addition to a general knowledge of industrial matters a more detailed and applied knowledge of the particular industries establishing the conditions in which their children live. This demand of up-to-date education opens great possibilities to the rural teacher whose children live largely by the one industry of agriculture. A veteran Michigan teacher has suggested that all teachers graduated from county normal training classes and the rural school courses of the State Normal Schools be required to spend at least a summer term in residence at the State Agricultural College for the purpose of getting an introduction to agriculture.

Men who have directed the observation and practice work of teachers in preparation for service in the ungraded country schools say that part if not all of this work demands a separate and characteristically different training school. Dr. W. T. Harris, the U. S. Commissioner of Education, says that a distinct difference should be made between training teachers for a school having a few large classes all within one or two grades and a school having many small classes scattered through six or eight grades.

Dr. Henry Barnard, of Connecticut, after 50 years of close familiarity with the development of Normal School work, looked upon the raising up of teachers adapted to country service as an unsolved problem. There is at present a growing conviction that observation and training in the practice school should, as far as may be possible, be carried on under the same general conditions which the teacher will find in the real school where his service is to be rendered.

One of the Michigan Normal Schools is making a definite, studied attempt to inculcate the spirit of social service in all the students who are taking the two years' rural school course. This work is not fully developed; but a beginning has been made by organizing what is called a Rural Sociology Seminar. This organization meets for a two hours' session one afternoon in each month. The programs for two meetings each term consist of music, recitations and papers by students. The papers are reports of progress in the historical and current industrial, social and spiritual phases of rural life.

The third and last meeting of each term affords an opportunity to invite experienced rural teachers, county commissioners, grange and farmers' club leaders, and normal school and Agricultural College professors to talk to the students.

The work of this seminar will be supplemented near the end of the course by a regular course in rural sociology and a trip to the State Agricultural College. It is believed that the students will by this means discover in advance many ways in which they can make their schools, the rural schools in which they are to teach, serve the communities in which these schools are located.

Furthermore, it is believed that devoted and enthusiastic leadership for two years in this seminar will qualify and inspire these young people to be privates, corporals, lieutenants and captains in the developing campaign for rural progress.

There is great reason for encouragement in the matter of trained teachers for rural schools. The prospective graduation of rural teachers this year from the twenty Normal Training Classes and the State Normal Schools offering the rural school course is 425. This is two and one-half times as many teachers as were prepared for rural schools last year.

This is the beginning of that glad time for which multitudes of Michigan's best men and women have worked, paid and waited. The accumulated investment by rural communities of more than $1,000,000 in the State Normal School system is a matter of great pride, and it is becoming a source of intelligent satisfaction because these schools are returning to rural communities an increasingly respectable annuity of service.

Better even than this is the prospective working out in rural schools of this fundamental principle of real progress: "It is impossible to develop an expert of high efficiency without raising the general plane of excellence in the class to which he belongs." This time proven general principle makes positive promise that out of the present accelerating movement for trained teachers in rural schools there will emerge expert students of rural conditions, then from this vanguard of experts there will arise a man or a woman with the inspiration and the condition mastering constructive ability to found a distinct profession of rural school teachers, and through the life long services of such a body of teachers the rural schools will accomplish their full fruition.

Kalamazoo, Mich.

EXPERIENCES IN SCHOOL-GARDENING.

J. B. DANDENO.

In the early eighties the writer commenced teaching in a country school about ten miles from the city of Guelph, Ontario, and continued in the same school for three years. This country school was in a district where the quality of both farms and farmers was of a very high grade. The farmers were prosperous and progressive, and they took much interest in their school and all things which might concern it; consequently, it was easy to carry out such plans as might tend toward the betterment of the condition of the younger children. It is necessary to mention something of the nature of the surroundings in this school section, in order to make clear the conditions bearing upon the school-garden, about which it is proposed here to speak. From my considerable experience, and my observations in various places since then, I may say that the school district referred to, its surroundings and building, were far superior to any I have seen since in Michigan, even at the present time, excepting perhaps in the large towns and cities. This might be said of about any school in South Wellington, the county in which said school was situated.

In these schools the average yearly attendance was about 37 to 40—that in the winter being somewhat higher than that in summer, because of the fact that the older pupils were required at home during the summer season to do various kinds of manual labor. Some ten or fifteen years before this time—in the early seventies—the attendance in many of the same schools reached, in the winter season, one hundred and over. I have a personal experience of such an instance in my boyhood days. Today in the same schools, as far as I can learn, the attendance is about twenty to twenty-five. If this progression is kept up it is not difficult to figure out the time when the attendance might approach the zero mark. At first sight this might appear to have but little to do with the proposition, but it really furnishes a basis for the right understanding of the whole situation.

The school building in which my experience was gained was of stone and fairly well adapted to good school work. The grounds were about three-fourths of an acre, and situated on a good site. It was well fenced with a high board fence on all sides. The turf was what might be called natural sod. Water was supplied from a well in the school yard, though it required the constant engineering skill of the teacher to keep the pump in good order. The same may be said of the fences and other details of out-buildings and walks.

I propose to describe this work of plant culture under two headings: (1) House plants, (2) Garden plants.

I commence with house plants because these suggested the other.

HOUSE PLANTS.

A few of the more common house plants had been, in summer time, kept in the school previous to my time there. (I entered upon my duties there Jan. 1.) This I undertook to extend by asking each pupil to bring one or two plants to the school. By buying three or four dozen pots, the number of specimens was considerably increased by making cuttings from the other plants at noon hour, or recess periods, but particularly after school closed in the afternoon. The main reasons for commencing this, I suppose, was the suggestion received from the fact that a few plants had, in previous years, decorated the window ledges. Another reason, probably, was the desire to improve upon my predecesor, and to furnish the means by which my store of surplus physical energy might be applied.

These plants were placed in the room on the window ledge—this being quite wide because the wall was of stone and very thick. Some we placed in a circular bed outside in the front of the building. They were placed there from the pots in spring. In summer vacation it was possible to get a neighbor, sometimes past school years, to attend to the plants. This work was gratuitous, but the results were always excellent. In winter the plants were taken to the house of a neighbor—the same party each year—and the best sepcimens were taken care of during the winter. Some were taken by individuals, here and there, to their homes, but I found that when individuals brought, in all, about twenty-five plants, not five of these would be taken home in the fall. Consequently, our supply would increase from year to year, both in pots and in specimens. I found it always easy to borrow a horse and wagon to take the plants from the school in the fall, and similarly to the school in the spring.

The labor in taking care of the specimens, at the building, and of the transportation of them to and fro, fell upon the teacher quite largely. Watering was often done by the pupils, but after the novelty of the thing wore off, the pupils looked upon the matter as a bore. They would do it if asked, but only in the same spirit as they would carry in wood or any other work which might be required of them.

The main difficulties in connection with the matter were as follows: It was impossible to keep plants over winter in the building owing to the fact that the temperature over nights and during days when there was no session, would often fall very low and the plants would freeze. The work had to be done by the teacher, unless pupils were ordered to do it.

The re-potting under conditions existing was very difficult, both as to a convenient place and to a supply of good earth. The pupils were too young to appreciate the work and many of them had too much manual labor to occupy their spare time at home. Anything in the nature of work became, after a time, a bore, and I do not blame them. Lastly, the summer vacation made an enormous gap in the work. This gap, as you see, together with the winter season, occupied a large portion of the year.

The advantages to be gained from having such planting are these: It makes the school home-like and cheerful, and it develops a certain amount of refinement in the pupils directly and indirectly. It furnishes illustrative material for many of the common branches of study in the school, e. g., literature, composition, geography and elementary lessons in natural science; and lastly, it furnishes healthy exercise and interest for the teacher.

Now, the inside plants suggested outside planting; and this developed what might be indicated in three divisions: (1) the summering of winter plants, (2) tree-planting, (3) regular outside gardening in a small scale. The plans for the first of these was to place out in the front circular flower-bed certain of the plants which had been wintered inside in flower pots and plant them carefully, and in order, as best we might. Pupils were able to help in this work, to some extent, because everything was clear and definite before their eyes, and they were able to see the result of their work at once, without waiting till plants would develop from seeds.

The plans for tree-planting were comparatively simple. One spring day—a regular school day—was selected for the purpose of choosing, digging out (plenty of good trees could be had in the woods), and hauling to the school premises a number of suitable trees. Few of the pupils were able to help very materially in this part of the work. It is true that they could supply axes, spades and the like, and in this way take some part in the work, but the brunt of all the heavy labor fell upon the teacher. While the digging was going on, some of the larger boys were busy making holes for the trees in the school yard. The trees are then—in the afternoon—planted in holes made in the forenoon by those selected to do this work. After planting, these trees were each given to a certain pupil to care for, and water, and have a sort of general supervision over, with a view to the welfare of the tree. We had no protecting frames for the trees, so the pupil had something to do to keep children from shaking and otherwise injuring them.

This day was called "Arbor Day," and it was the only day, or, I may say, the only time, of the school hours which could be taken for the work. The trees were planted inside the fence and about three feet from it. Most of these trees lived, and they are now a monument to the blistered hands and tired backs of those who engaged in the work.

I found, however, that these trees seriously interfered with the playground, as a playground, for it cut off a good slice on the edges of a large portion of the ground, which was originally none too large, and in games of foot-ball, and other chasing games, it was natural for a boy to grab the tree as he ran round and give it a shake as he attempted to steady himself while he ran. This was, of course, hard on the trees.

The regular garden for flowers, weeds and the like was placed along a fence on its south side. Then came the work. The ground was almost all sod, and the digging was tremendous. All this fell to the teacher as the only person connected with the school who was physically capable of digging it up. The pupils helped in raking, in the planting of seeds, in the watering and other minor details.

This space was also a serious inroad upon the playground, and I often regretted it. As for barnyard manure, we were not able to secure any, though, of course, had this planting been kept up for several years, it would be required. During the time of planting, and for some time afterwards, the students took a real interest in the matter, and aided materially in pulling weeds, and, to a small extent also, in cultivating the beds. I might note that grass is a hardy weed in a bed recently dug from sod. To mention this may seem a small thing, but it was really no unimportant matter, for it seriously affected the garden for one year out of the three. We neglected to collect seeds the first year and we were therefore dependent upon what we could purchase from the stores. The second year we collected seeds of wild plants and weeds, and from these we had the best success. Pupils were more interested in growing canada thistles and burdocks and such plants than in growing flowers. I believe there is more, much more, educative value in such a garden than in a garden in which nothing but what are commonly called flowers are grown.

The main difficulties were serious. The pupils were too young to do the work, and they had not sufficient interest to abandon play for this sort of labor—of hoeing, watering, weeding and the like. It encroached upon both the *space* for play and the *time* for play. Only small boys attended in the summer. This might be said also of girls. Then the summer vacation nearly killed the outside gardens. Pupils have too much of this sort of thing at home—cutting weeds and thistles, hoeing and the like. Change of teachers would probably kill what was left.

In an ungraded school, such as a rural school is, there is always a lack of time, and pupils can not be expected to remain after school hours to do this work. They are not to be blamed. Then, lastly, all the work falls upon the teacher, and he may not have the necessary knowledge of plant life to develop a garden that would be of much interest in any school section. Schools are changing rapidly in the personnel of the teacher. In my boyhood days a female teacher was unheard of. In my teaching (rurual school) days, there were a few. Now the male teachers in that community, or district, are not numerous. As I pointed out before, the attendance has decreased very much. In regard to a few schools which I know had attempted school gardens, I may say that as soon as the female teacher came on the scene the garden disappeared. The fences became dilapidated because the trustees left that matter to the teacher as they had been accustomed to. The grounds showed also that some change had been brought about, because sticks, stones and rubbish had been allowed to collect here and there over the yard.

In several places in the same township, and in two or three of the neighboring townships, attempts had been made to use part of the grounds in a way to help beautify the premises and to encourage the children in the cultivating of plants. I am informed that the advent of the female teacher sounded the dying knell of those gardens.

The female teacher is, therefore, the first and strongest draw-back, in my judgment, towards a successful development of these school gardens, and for the following reasons: Female teachers are physically incapable of undertaking the manual labor necessary. Their term of incumbency in any school is usually very short, about from one to three years, often only one year. They have not sufficient knowledge of such things, because many of them are city girls having no experience whatever in such matters and care nothing at all about it. Moreover, they, like the male teachers, have not time to spend upon the work.

The introduction of consolidated schools may supply a remedy, but there are new difficulties introduced by the consolidated schools which may, or may not, be counterbalanced by the advantages; but the proper way to introduce the school gardens upon a firm basis would be to return to the conditions such as existed in Ontario twenty or twenty-five years ago, by appointing only male teachers, and, if possible, married teachers; provide dwellings for them and keep them for twenty or thirty years in a given school. There are a few such schools near Guelph to-day, and in one of these is a very fine school garden. The man resigned a few months ago, after nineteen years' service in that school. But it may be said that there are not now enough children to warrant the expenditure involved in the employment of such a teacher. This may be true. And for my part I think the main tendency now is to teach children at home and abandon the public school altogether. And why should it be considered necessary to send a child away to learn to read, to write and to do some arithmetic any more than it is to teach the child to talk good English and a host of other things at home?

At this point I might ask why is this matter of school gardens brought to the notice of the public to-day? Partly because of the agitation in large cities for such things to supply for the city boys and girls that which they have not because they are city people. In short to supply country to the city. This is largely, of course, a fad, and the absurdity of it has attached itself to the rural school. Now, just imagine the average city girl, a high school graduate of about eighteen or twenty years of age, assuming a rural school, digging garden, planting trees, wheeling manure and the like. Besides, what good would it do? As far as my experience goes, it would give the teacher good healthy exercise; and a number of the pupils as well as many of the ratepayers would think her a fool for her pains. School gardens in the rural schools, as they now are, will never succeed. They may, if undertaken by consolidated schools.

This leads to another fad born of the former and nourished by a name, a mere name—agriculture. Some contend that agriculture should be taught in rural schools. Many, if not all, of those who do so contend have never had any experience as teachers, and do not in any way appreciate the situation. It would be about as rational to place banking, civil engineering, shoe-making, tailoring, etc., on the curriculum, and it would be just as easy to teach them; and it would probably be more useful. Agriculture is purely and necessarily an art, not a science at all; and to teach the arts of stock-raising, fruit-growing, grain, hay and grass crops, is beyond the boy of ten or twelve, or even fourteen years of age.

In the schools of Ontario, for some time past, an attempt has been made to introduce agriculture into the rural schools with the results as indicated in the following quotation:

"Prior to the issue in August, 1904, of the revised course of study for public schools in Ontario the teaching of agriculture was compulsory in rural schools only in the last two forms, IV. and V. The work in Form IV was largely conversational—and somewhat discursive. In Form V. the text book was introduced, but the study was limited to the first 73 pages. As a large number of rural school pupils leave school before the Fourth Form is reached, and nearly all leave at the conclusion of Form IV., the work hitherto done has been of the most desultory and aimless character and has affected but a small proportion of the rural pupils. Moreover, in the absence of any preliminary systematic course of training in observation, the work was purely empirical."

This shows that with pupils of the fourth and fifth forms (8th and 9th grades of common schools in Michigan), the teaching of agriculture in schools in country districts has proved a failure and the reason assigned is this: the absence of a preliminary course in the systematic training of the powers of observation.

Notice the advance made upon the former plan:

"Under the revised code, from the very beginning of his public school course, the pupil is systematically taught to observe and explain the natural phenomena which daily present themselves to his notice. The courses are begun in the First Form, are continued throughout every form, and are obligatory on all pupils, whether rural or urban."

This applies to girls as well as boys, to all alike. The following quotation gives the general idea the framers of the program had when they drew up this portion of the course of study:

"The daily systematic study of the phenomena will, during the first three or four years, give the pupil not only a large fund of useful information, and this is of even greater importance, it will train him to observe carefully, describe accurately, and interpret correctly—the most suitable preparation for the formal study of agriculture or horticulture or the many and varied occupations connected with the farm."

The general plan of the matter is given as follows; and it must be remembered that it is for the first three or four years of the school life of the pupil, i. e., from eight to eleven years:

"Soils are to be examined, classified and their utilities determined with reference to various kinds of plants. The adaptations of animals and plants to their habits and surroundings come under observation. All the sciences—physics, chemistry, botany, zoology, geology, mineralogy—are laid under contribution to supply suitable phenomena for study. All this knowledge is directly contributory to the scientific study of agriculture, and indeed is basal to it."

The way this is to be brought about is as suggested in the following paragraph:

"Provision is further made in the revised courses for the establishment of a special agriculture course in the high school. The high school undertaking this course must be specially equipped. It must have experimental plots, a school garden, an aboretum, and a science laboratory. This course is practical and technical, and aims to give the farmer's son who wishes to be a farmer the same opportunity that is afforded a farmer's son who wishes to enter one of the professions."

It all resolves itself into this: It was not possible to teach pupils of the 8th and 10th grades (12 to 15 years) the subject of agriculture, therefore teach it to pupils of the grades below the 8th (8 to 11 years), and these are the subjects: Botany, zoology, chemistry, physics, mineralogy and geology, in addition to the other common subjects, namely, reading, writing, composition, arithmetic, history, geography, drawing, English grammar, dictation and spelling. This is a fairly good load.

Now, one of the strongest arguments in favor of teaching agriculture in the rural schools is that it would inculcate in the farmer's boys and girls a love for farm duties, a love for farm life. This is an important point, and if it does serve the purpose of retaining to any extent farmer's sons and daughters on the farm, it deserves the most favorable consideration. But does it? Does any advocate of agriculture for rural schools really believe this? To understand this we have to look a little at the conditions existing both in the school and on the farm.

What could a teacher do, actually do, of farming operations? She might grow some plants, perhaps, recognize some weeds, study the life histories of some insects, dig a little, hoe a little and rake a little. But is this farming? Is it any very serious part of farming? Let us ask oureslves for what purpose people carry on the operations of farming. What is the main purpose? What are the subordinate purposes? Are they not all to make a living, to make money? Where then would be the proper place to gain some useful knowledge about this? Surely there can be no place that can at all approach the home and the farm in the matter of acquiring a knowledge of such things. I am convinced that very many of those who urge that school gardens be introduced, that agriculture be placed upon the public school curriculum, have not had the experience which some of us have had. What are some of the duties which the farmer's boy has to do at home as *he* learns farming in the ordinary way? Allow me to enumerate a few. He carries swill to the hogs twice a day. He drives cows to and from the pasture-fields and many a time in the fall of the year in his bare feet when the frost is still on the ground in the morning he seeks a warm spot where the cows have lain during the night to warm his feet. He has occasionally, in the summer, when cattle or horses break through into the grain fields, to wade through grain or hay all wet with dew or rain till he is wet all but his hat. He has to wheel out manure from the cow-stable or the horse-stable daily for many months. In the summer he has weeds to pull, thistles to cut, potato bugs to pick, hoeing to do, fences to fix and a hundred other things to do which none could realize except those who had experience in such things. Now, send such a boy to school to a female teacher who, the boy is certain, knows absolutely nothing of farming as it really is, as he knows it. Ask this teacher to teach this boy to farm scientifically, to inculcate a love in the boy for the work of the farm, for farm life. The situation is sufficiently plain that little further explanation is needed.

These were some of the difficulties with which I met in carrying on the operations of my school garden. The boys who might be of any use to work in the garden, or to understand the operations or the results to be obtained from them were such as had too much of such things to do at home, and I knew fairly well what each boy had to do at home before he started to school in the morning, and also in the evenings and on Saturdays and other days when he did not go to school—vacations and the like.

People say that the present high school education tends to draw the boy away from the farm. It is certain that it opens the door to other things, and I often think that this is one of the great blessings of the high school. Would the addition of agriculture to the high school curriculum be likely to induce the farmer's boy to choose agriculture? Not at all. He soon learns that not every boy has to get up in the morning at half-past four to go out in the wet grass to bring home cows for the milking, to carry swill to the hogs, to split wood, pump water, wheel out manure until the very smell of the farm is odious to the boy. Why, the high school shows his emancipation from his slavery days. There are probably many men now living in this State who are inwardly congratulating themselves on the opportunity the high school offered them to break away from the farm, from the delightful chores of farm life.

But now we see a way to develop a love for farm work and farm life in the farmer's boy, and to develop it in him scientifically. Just send him to school to a female teacher of twenty years of age or so, to learn the operations, to have him taught (as the Ontario Government is about to do), physics, botany, chemistry, zoology, geology, mineralogy, etc. Talk about there being no royal road to learning. Why, knock out the bung and let the "SCIENCE" liquor flow that the farmer's boy may drink freely.

Agricultural College, Mich.

OUR SCHOOL MUSEUM.

HON. CHARLES W. GARFIELD.

Picture to yourself a lad of seventeen in charge of a country school of 81 pupils, the school-house having a seating capacity of only 68, two upon a seat. It was in the old days when there was little arrangement of the course of study. There was absolutely nothing done in the way of grading; there were 38 recitations in a day, covering all the ground from the A, B, C little ones to a class in quadratics in algebra. In those days there were two terms, the winter term and the summer term. This photograph is taken in the summer term, about two weeks after it had been opened. The compensation of the teacher was $30.00 a month. This was to be used as a fund to help through college, so, notwithstanding all of the untoward conditions, hope was high, for the net earnings meant a wider opportunity for education.

At nearly the end of the first fortnight there was a languishing period, the nerves of the teacher and children had been overwrought, the temperature inside and out was too high for comfort. The teacher was at his wits' end what to do with this lot of uneasy children. It was three o'clock in the afternoon when the strain was very near the snapping point, the teacher stopped short in his work and asked that all books be put away, and he said to the wondering children: "We are all hot and tired and nervous, and I am certain we shall not accomplish very much in this last hour, so I have concluded to have a little talk with you, and if you agree with me we will plan something that will give us all a good time. You are sent here to school and I am hired by this district, having in view the acquirement of knowledge which we are expected to get out of our text books. We must not disappoint our parents in this regard. We must do our level best to satisfy their ideas of what we ought to learn; if we can do this, however, and have a real good time, I do not think anybody will find any fault with us, and I have a plan that it would take all of us to carry out, and I want you to take hold of it with me, and if my thought is well carried out, this term of school will be one that you will always remember. I find that we do not any of us know very much about the things in our own neighborhood. We are studying the geography of the world and we are spending a great deal of time on arithmetic and algebra and natural philosophy, but I want each one of us should learn all we can during this term about the things we can see in our own school district, and in order to have something to show for the knowledge that we will thus acquire, I propose that we form a museum and that we begin tomorrow; that now, at the close of school, you go out from here with your eyes open to find something that is curious that you would like to know more about and bring it in tomorrow morning, and with the things that we will thus have together, if our lessons are perfectly learned by three o'clock tomorrow, we will spend the last hour of school in talking about the things that are brought in to start our museum. I will have a case of shelves made and we will try and classify the things as they are brought in, and you shall each one of you have something to do with the formation of this museum." There was a great deal more to this talk and as the young man developed his idea he became enthusiastic, and while the older scholars looked rather incredulous the youngest were ready to start out at once and find something that was worthy of a place in the museum.

The experience of the next day was not altogether reassuring. The conglomeration of material that was gathered upon the piazza was somewhat disheartening to the young teacher, for if the truth must be told, a good many of the older boys were inclined to poke fun at the whole business, and their contributions had been of a character to throw cold water upon the scheme rather than to support it. There were boulders as large as two boys could lift; there were sticks of cordwood and bundles of grass, live mice, a chipmunk, a dead woodchuck, and, worst of all, a dead black cat. The teacher was good natured through it all and during the noon hour made his classification, arranging with the aid of the larger boys, all of the heavy material where it could be seen by the school; the dead cat was slung over the fence, but the mice and the squirrel and the woodchuck were utilized. The school was all expectation. Lessons were never more glibly recited, and at three o'clock everybody was on a quiver.

You must remember the teacher was only a mere lad; he had not any very great amount of knowledge along natural history or scientific lines, but he did know enough to classify all of the things into the three kingdoms. He had an interested and enthusiastic audience. He told them something about how these boulders got into this region and gave them a little account of the wonderful ice period, in which our drift was ground up and landed here. He told them something about how they could add to the museum by finding all sorts of specimens in the sands and gravels of this drift in their own neighborhood that would add great value to the collection. From the specimens of wood and bark and twigs he awakened an interest in them to know the names of all the trees in the neighborhood. From the bunches of grass and grain he had assorted a little collection and outlined to them a plan of making this part of the museum attractive. There were numerous bugs and butterflies of which he knew very little, but he explained to them the way in which they could be preserved and mounted, and gave them also a lesson in taxidermy, very simple, to be sure, but interest-awakening in its purport.

The hour passed swiftly away, and as the little people were dismissed, for a wonder, they did not grab their dinner pails and run for home, but they almost all of them lingered and wanted to know more and wanted to know what kinds of things to bring; the boys who had brought the big boulders even stopped and begged pardon for bringing such large stones when smaller ones would have answered the purpose. There was a good feeling and wholesome interest that was inspiring to the teacher.

The next morning when the children came, the museum had been started. It was organized along scientific lines, and there were a lot of other things to be added to it from the second day's gathering. In the course of a week the whole neighborhood was talking about the school museum. The record of visiting attendance was extraordinary. I have had occasion within the last few days to look up a little book having that record, and the average number of parental visitors during the last half of that term was eleven per day. It was a pretty crowded place to entertain visitors, but they were interested, and every day there was some factor in this museum which was used in connection with the school work. The children forgot the heat. They neglected to be nervous. They did not think it a cross to go to school. They were wonderfully prompt in attendance at the opening of the school because every day a little talk from the teacher about the new things brought into the museum was the feature of the morning exercises. In addition to his usual school duties the teacher had his hands full gathering information to render his museum useful.

At the close of the term there was a great day and one long to be remembered by the entire neighborhood. A picnic gathering under the trees in a neighboring yard, and exercises which did not exhibit proficiency in reading or spelling or arithmetic or grammar or any of the other things connected with the books; but an account of what the children had learned about the things in their neighborhood in which every individual in the school took some part, made a program of wonderful interest. Every household in the district was represented, and at the close of the school there was a distribution of the museum to the different homes in the school district.

The interest awakened in that one short term of school has not lost itself to this day. The youngest boy, a little fellow of five years old, who did his part in helping to grow the museum, is now director in this same school district, and his daughter is a successful teacher in the school. In that household are specimens which are considered heirlooms and which formed a part of this school museum. The awakening of a desire, not only on the part of the children, but on the part of their parents and older brothers and sisters, to know more about the things with which they had to deal every day, has been a characteristic of this community to this day.

To my own mind, there is nothing truer than that the most important education we can possibly give to the students in the rural schools is that which acquaints them thoroughly with their environment and gets them into sympathy with the things that shall be the largest factors in their lives. I am impressed with the importance of doing this kind of work in connection with rural schools because of the greater opportunity of success than can be secured in connection with city schools; and, further, because the city boy or girl is handicapped from the outset, and we must recognize the importance of dealing in the best possible manner in our educational methods with the boys and girls upon whom we shall most largely depend for our supplies of strong, influential characters in all phases of our developing life.

I have thus briefly given an abstract of a bit of history. Its lesson would be incomplete unless I should give my view that the value of a rural school museum, while it lies largely in the gathering, is intensified and increased with the continuous maintenance of this museum as a permanency in connection with the machiery of the school room. Fortunate indeed is that rural school community which has a well classified and well housed museum of the commonest kind of things to be found in the neighborhood and which can be continuously employed in impressing upon the plastic minds of the pupils the great lessons connected with the processes of Nature in constant operation about them. In the hands of a wise instructor these simple, common lessons may be utilized to enforce and crystallize moral and spiritual qualities which should be inseparably connected with any education of developing children.

Grand Rapids, Mich.

WINTER FIELD WORK IN BOTANY.

J. HARLEN BRETZ.

Under winter conditions, perennial plants face a very different problem than in summer. With the oncoming of winter, marked changes in the environmental conditions take place, of which the most pronounced occur in the factors of temperature and water supply. Low temperature indirectly and lack of water very directly force the plant into suspension of activity. Endurance becomes the test of fitness to survive.

To meet these changes, the plant becomes xerophytic, taking many precautions to prevent escape of water by evaporation since it can secure none to replace any loss. It might be said that plants of temperate and colder regions become pseudo-xerophytes in winter. Xerophxtes, they of course are not because the true xerophyte *works* under its conditions.

One response to the changed conditions is the formation of winter buds and in these the endeavor of the plant to prevent evaporation is clearly shown. It is on these buds that a great deal of the work of plant identification must be done.

A few instances will show that this work is not so difficult as at first it might appear. The four species of Hicoria most commonly found present no difficulty in identification from winter buds. Hicoria ovata, the shagbark hickory, has a large, oval, yellowish brown bud with two dark outer scales that shag off, Hicoria alba lacks the outer scales, Hicoria glabra has a smaller bud than H. alba though similar otherwise and Hicoria minima, the swamp hickory, has a long, flattened, winter bud of a bright orange yellow. Again it would be difficult to distinguish between the two species, Viburnum Lentàgo and Viburnum prunifolium, in winter were it not for this mark of identification. The buds of V. Lentàgo are long and acute while those of V. prunifolium are shorter and thicker and are often covered with a rusty pubescence. It may be necessary occasionally to secure both species for comparison before one can be definitely certain. Another example may be found in the genus Fraxinus. The only two species commonly found in southern Michigan, Fraxinus Americàna and F. nigra, are distinguishable at a glance for the buds of F. nigra are a dark brown, almost a black, and could hardly be mistaken for those of Fraxinus Americàna, the white ash.

If there is not sufficient differentiation in the bud, it is a simple matter to carry a twig home and force the bud into expansion. A beaker of water and a south window will bring it out and often enough additional data will be afforded by the leaf which will partially develop, to decide the species.

We, of course, can not deal with annuals in this use of winter buds. But, except for this restriction, the annual is not barred from the scope of winter work in identification. Nearly every annual plant whose bare skeleton stands through the winter has some withered, wrinkled leaf still clinging to it. More often it will be found near the base of the plant, perhaps covered by the snow. Steaming or a brief immersion in water will unfold the contorted leaf and admit the determination of its shape, marginal and base form, venation, attachment to stem, whether sessile or with a long petiole and many other marks which may characterize a species.

Melilotus officinàlis and Melilotus alba, the common sweet clovers of every roadside, are not to be distinguished in winter without examination of the leaflet. That of M. officinàlis is narrowed at the base, that of M. alba is oblong.

Suppose all the leaves have been lost, yet their arrangement on the stem is still to be easily observed, from the leaf scars.

Still more data are afforded by a study of the culm of the annual. Is it terete, quadrangular, triangular, flattened, grooved or ridged? Hollow or solid? Glabrous or pubescent?

The stem or twig of woody plants gives a like latitude for specific variations. Hicoria minima can be distinguished across a field, with no examination whatever of its bud. Its slender, graceful twigs and branches are almost feminine beside the angular, roughened, thicker branches of the other hickories.

Modifications of the epidermis are more common. The vivid red bark of the osier, Cornus stolonifera, is easily distinguished against the snow from the kinnikinnic osier, Cornus Amonum, whose bark is dull and brownish. A terminal twig of C. stolonifera is glabrous, one of C. Amonum is finely pubescent. Drawing it across the lips will demonstrate this.

Smilax hispida, its stem thickly set with long, slender prickles, as its name indicates, can hardly be confused with Smilax rotundifolia, the prickles of which are stout and scattered.

Yet another important mark of identification to use in winter field work is the fruit. The seed and seed case offer a great many variations in form for generic determination. Berries, drupes, pods, capsules, acorns, nuts, achenes, awns, cones and many other forms can usually be obtained in winter. The only other means of differentiating the two Viburnums, Lentàgo and prunifolium, in winter, is a comparison of their seeds. The stone of prunifolium is oval and slightly convex on one side, that of Lentàgo is flat on both sides and oval or circular.

In winter field work, the collection of plants standing above the snow, the only ones available, has none of the disadvantages of summer collection. There are no delicate parts to preserve from crushing or wilting until the laboratory can be reached. There are no dense tangles where the foliage conceals a possible way of entrance or passage and where the very species you seek may hide quite securely. Instead, every plant stands silhouetted clearly against its background of pure white.

The extent of such a society as winter work can deal with, a society of plants above the snow, can be seen from one viewpoint and very quickly. If, in summer, much tramping about through masking foliage would be necessary to get the same idea of a society's area.

Bog floras, swamp floras, the littoral and marginal societies of lakes and rivers are as accessible in winter as the society growing about a stone pile in the open field. Places, which in summer are inaccessible by boat or by foot, are easily visited in winter. And it is practically only the lowest stratum of plants, mosses, lichens, algae and prostrate annuals, which is denied the winter field worker.

A system of recording field observations is of immense value to a class in botany. I hardly need state that the knowledge which the student discovers for himself is impressed on his mind with a vividness that cannot be approached by the second-hand method of a text book. Notes taken in the field on field observations about double the value of the work. And systematized recording is, on the face of it, still more valuable.

A system for recording ecological data which we use at Albion College is this. For each species, when identified, there is a sheet of paper 8 1-2x11, in an index alphabetically arranged. On the side of the sheet are tabulated, one below another, the various factors which might enter into any plants' environment; such as water, soil, light, wind, etc., in their varying forms. For example, under water comes its relation to the plant, its condition, its supply. Phases of water relation are dry, moist, wet, littoral, amphibious, floating, submerged; of water condition—running, still, clear, turbid, ooze, stagnant, putrid, impregnated with acids or salts. The sheet is ruled vertically and horizontally. Each vertical space is numbered across the top. Now by a system of abbreviations, the environment of about twenty different individuals of this particular species can be quite accurately noted and, thus tabulated, the normal environment of the species and variations from this normal can be easily determined by the student who collects and tabulates the data.

A separate record is kept of the environments themselves, a folio being necessary for this. About the same data are collected for a selected locality where all conditions seem to be equal throughout as for the species record with the addition that the blank provides a vertical column for recording *changes* that may be taking place in any factor and whether this change is seasonal or permanent. Thus the record is rendered dynamic. Record is made of succumbing species in the society of this locality, of dominant species, with reason if apparent, and of any promising successor to the present dominant species.

A list of the plants forming the society which inhabits the selected environment is also made. Of course such a system as this is just as applicable to summer as to winter field work.

There are obstacles to botanical work afield in winter. But in any undertaking that is worth while there are difficulties. If one's zeal is high enough, obstacles will be overridden and almost unnoticed in their insignificance when facing a real purpose.

And what can compare with the pleasure of a winter cross-country tramp when the pulse is stung into fiercer pounding by the stimuli of a winter atmosphere and a winter sun?

In conclusion, I have endeavored to point out some of the possibilities in systematic and ecological botanical field work in winter. Different obstacles might be met, different results attained than I have mentioned. This paper is presented simply as a pregnant suggestion.

Albion, Mich.

SPECIES RECORD

Scientific Name.. Number............

Common Name.. Herb No............

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.
Environment..............																		
Environment Record No......																		
State..............																		
Tp. R..............																		
S. ¼..............																		
Frequency..............																		
Water Relation..............																		
Water Condition..............																		
Water Supply..............																		
Drainage..............																		
Ground Slope..............																		
Temperature..............																		
Wind Relation..............																		
Light Relation..............																		
Soil Relation..............																		
Soil Condition..............																		
Soil Origin..............																		
Physiographic Form..............																		
Plant Relation..............																		
Animal Relation..............																		
....																		
....																		
....																		
....																		
....																		
....																		
Date of Observation..............																		
Initials of Recorder..............																		

ABBREVIATIONS

For both card index and environment record sheets, except where otherwise noted.

FREQUENCY—R-rare, F-frequent, C-common, D-dominant, Conquering a-by grouping, b-singly, Losing-c. Order of frequency indicated by sub. 1, 2, 3, etc., (for Envir. Rec. Sheets).

WATER RELATION—X-xerophytic, D-dry, M-moist, W-wet, L-littoral, A-amphibious, F-water surface, S-submerged. Figures after S give depth of water in feet.

WATER CONDITION—R-running, S-still, C-clear, M-muddy, O-ooze, S-stagnant, P-putrid. Ex. SC=still clear Water.

GROUND SLOPE—N. E. Down toward northeast. Give degree of slope.

DRAINAGE—R-water removed before percolation, G well drained, P-poorly drained, N-no removal of water from soil, N'no change of water in soil.

LIGHT RELATION—S-shade, W-open woods, B borded, O-open.

SOIL RELATION—C-clay, T till, L-loam, S-sand, G gravel, H-humus, P-peat, C′-calcareous, R-rock, A-alluvium. Ex SL-G=Sandy loam over gravel sub-soil.

SOIL CONDITION—Covered by L-dead leaves, P living plants, U-uncovered.

SOIL ORIGIN—C-lake clays, S lake sands, S′-dune sands, M morainic, G-outwash gravels and sands, D-glacial drainage channels, T-till plains, A-stream alluvium, R-soil *in situ*.

PLANT RELATION—S-symbiont, S′-saprophyte, P-parasite, H-host, 1-partially, 2-wholly (for Card Index only). An environment may be limited, for example, to the bark on the north side of a tree. In such a case, give details. (for Environment Record sheets only).

ANIMAL RELATION—S-symbiont, S′-saprophyte, P-parasite, I-insectivorous, 1-partially, 2-wholly. (Card Index only.) Defended by a-spines, b-thorns, c-resistant epidermis, d-hirsuteness, e-pubescence, f-acridity or acidity, (for Card Index only.) Give animals committing noticeable ravages in selected environment. (for Environment Sheets only.)

ENVIRONMENT RECORD FOLIO.

State..........................County..........................Tp.....R....S....¼....

Locality..

Recorder..Envir. Rec. Sheet No.........

Environment Factors.		Changing To.
Water Relation..........	....	....
Water Condition..........	....	....
Ground Slope	....	....
Drainage................	....	....
Light Relation	....	....
Soil Relation............	....	....
Soil Condition...........	....	....
Soil Origin..............	....	....
Plant Relation...........	....	....
Animal Relation..........	....	....
	....	....
	....	....
	....	....

Date of Observ.	Dominating Species.	Changing To.

Date of Observ.	Fre-quency.	Native Species.		Fre-quency.	Date of Observ.

Date of Observ.	Fre-quency.	Native Species.	Foreign Species.	Fre-quency.	Date of Observ.

THE USE OF TRYPTOPHAN IN CULTURE MEDIA FOR DETECTION OF INDOL PRODUCTION.

S. F. EDWARDS.

The object of the investigation was to contribute to our knowledge of the source of indol as produced by micro-organisms in their action on proteids, and to prepare, if possible, a medium which would give more uniform and more satisfactory results than the media commonly employed for the determination of indol production.

From the results obtained by Hopkins and Cole, (Jour. Phys., 27, 1901-02), working with the end products of proteid digestion, they conclude that the source of indol is the tryptophan group of the proteid molecule. They showed that the characteristic Adamkiewicz reaction could be obtained only when the acetic acid employed contained glyoxylic acid, and that the reaction is not a furfurol reaction, as was previously supposed, but is due to the presence in the proteid molecule of the tryptophan body.

In our isolation of the tryptophan, we followed the method of these two workers which briefly is as follows: commercial casein is digested with trypsin in a dilute solution of sodium carbonate until the test shows a maximum reaction for tryptophan, when the mixture is heated, filtered, and treated with sulphuric acid, the precipitate of calcium sulphate being filtered off. Mercuric sulphate is now added in excess, the resulting bulky precipitate is filtered off, washed with dilute sulphuric acid, and decomposed with hydrogen sulphide, after removal of which, the substance is re-precipitated by again adding excess of mercuric sulphate, and the mercury compound is removed in the form of sulphide as before. The sulphuric acid liberated on decomposition of the mercury compound is removed by precipitation with barium hydroxide, and the tryptophan is crystallized from alcohol.

The substance separates in the form of fine pearly white plates which are moderately soluble in cold water, and freely soluble in hot water. Aqueous solutions are markedly acid to litmus. It is sparingly soluble in absolute alcohol, cold or hot. In moderately strong aqueous solutions, if sufficient glyoxylic acid be present, the addition of pure sulphuric acid produces a deep indigo color, a greenish zone being seen next the acid if the latter is allowed to remain subnatant. With weak solutions the color is exactly the same as that produced by the original proteid. A solution of one part to ten thousand gives a well marked color.

The gyoxylic acid is prepared by adding to a saturated solution of oxalic acid in a tall cylinder about sixty grams per litre of sodium amalgam. When all the hydrogen has been evolved, the solution is filtered, and diluted two or three times, and used in exactly the same way as the glacial acetic acid in the Adamkiewicz test.

Bromine water, in aqueous solutions of tryptophan, excess being avoided, produces a fine rose-red color, and if the mixture be shaken with amyl alcohol, the colored product is taken up by this reagent.

Solutions of the substance give the pine slip reaction, evidence of the presence of the indol nucleus in the original molecule.

The constitution of tryptophan, as determined by the original workers with the substance is skatol-amido-acetic acid.

In our own work, in the first series of bacterial cultures, four different media were used, viz.: sugar-free bouillon, sugar-free bouillon having added to it one-tenth gram of tryptophan per one hundred c.cm. Dunham's solution, as ordinarily prepared, and Dunham's solution plus tryptophan in the same proportional amount as the beef-tea received. The media, after sterilization, were inoculated from the laboratory stock cultures and incubated at 30° C.

The indol test used was ten drops of a one-hundredth per cent. solution of sodium nitrite, and six drops of sulphuric acid, sp. gr. 1.84, added to one c.cm. of the cultures. The results of twenty-four hours incubation are shown in Table I, the amount of indol being expressed in grams per c.cm. of the cultures.

TABLE I.

Comparative amounts of indol produced in media as ordinarily prepared, and media having tryptophan added. Indol in grams per c. cm. of the culture.

Organism.	Dunham's solution.	Dunham's solution plus tryptophan.	Sugar-free bouillon.	Sugar-free bouillon plus tryptophan
B. acidi lactici......	Trace.	0.0001	0.0001	0 0001
B. proteus vulgaris......	0.00015	0.0004	0 0001	0.0002
B. fluorescens putidus.	None.	0 0003	Trace.	0 0001
Bact. zopfii	None.	0.0001	None.	Trace.
B. ruber of Kiel........	None.	0.0001	None.	Trace.
B. butyricus..	None.	0.0003	None.	Trace.
B. rubidus.	None.	0.0002	None.	Trace.
Sarcina aurantiaca ..	None.	Trace.	None.	None.
B. prodigiosus........	None.	0.0001	None.	0.0001
B. violaceus........	None.	None.	None.	None.
B. cyanogenes	None.	None.	None.	None
B. mesentericus vulgatus....	None.	None.	None.	None.
B. subtilis.........	None.	None.	None.	None.
B. megaterium	None.	None.	None.	None.
Sarcina lutea	None.	None.	None.	None.
B. typhosus.	None.	None.	None.	None.
B. coli communis....	0 0001	0 0003	Trace.	0 0002
V. Finkler-Prior.....	0 0001	0 0002	None	0 0002
B. pyocyaneus......	None.	Trace.	None.	None.
B. anthracis..........	None.	None.	None.	None.
V. cholerae Asiaticae......	0 0001	0 001	0 0004	0 0008
Diplococcus pneumoniae......	None.	Trace.	None.	Trace.
B. Metchnikovi......	Trace.	0 0001	Trace.	0.0001
B. cholerae suis.....	None.	0 0001	None.	0 00015
B. cholerae gallinarum .	None.	Trace.	None.	Trace.
B. icteroides....	None.	None.	None.	None.
Staphylococcus pyogenes aureus..	None.	None.	None.	None.
B diphtheriae . ..	None.	None.	None.	None.
B. mallei........	None.	None.	None.	None.
B. pneumoniae (Friedlander)...	None.	None.	None.	None.
M. tetragenus.....	None.	None.	None.	None.
B. dysenteriae....	None.	None.	None.	None.
Control............	None.	None.	None.	None.

Thus out of thirty-two organisms, nine non-pathogenic and eight pathogenic organisms showed indol production, and in every case the cultures in Dunham's solution plus tryptophan showed more indol than the cultures in ordinary Dunham's solution; and of the same cultures in sugar-free bouillon with, and without tryptophan respectively, all gave similar results with the exception of the lactic acid bacillus, which gave an equal amount in both.

The organisms were next cultivated in proteid-free media. Uschinsky's medium was prepared, a portion being tubed plain, and another portion receiving one-tenth gram of tryptophan per one hundred c.cm. of solution. Cultures in these two media were incubated at 30° C. for 24 hours, when indol tests were made with the results shown in Table II.

TABLE II.

Comparative amounts of indol produced in twenty-four hours in Uschinsky's medium with, and without tryptophan added. Indol in grams per c. cm. of the cultures.

Organism.	Uschinsky's medium.	Uschinsky's medium plus tryptophan.
B. acidi lactici	None.	0.0002
B. proteus vulgaris	None.	0.0004
B. fluorescens putidus	None.	Trace.
Bact. zopfii	None.	0.0001
B. ruber of Kiel	None.	None
B. butyricus	None.	None.
B. rubidus	None.	None.
Sarcina aurantiaca	None	None.
B. prodigiosus	None	None.
B. violaceus	None.	None
B. cyanogenes	None.	None.
B. mesentericus vulgatus	None	None
B. subtilis	None.	None.
B. megaterium	None.	None.
Sarcina lutea	None.	Trace.
B. typhosus	None	None.
B. coli communis	None.	0.0002
V. Finkler-Prior	None.	0.0002
B. pyocyaneus	None.	0.0001
B. anthracis	None	None.
V. cholerae Asiaticae	None.	0.0001
Diplococcus Fraenkel	None.	0.0001
V. Metchnikovi	None.	0.0002
B. cholerae suis	None.	None.
B. cholerae gallinarum	None.	None
B. icteroides	None.	None.
Staphylococcus pyogenes aureus	None.	None.
B. diphtheriae	None.	None.
B. mallei	None.	None
B. pneumoniae (Friedlander)	None.	None.
M. tetragenus	None.	None.
B. dysenteriae	None.	None.
Control	None.	None.

Here again the results shown in the table give positive evidence that the tryptophan is the source of the indol.

The next step was to prepare some medium in which this principle might be utilized without resorting to the long process of isolation of the purified tryptophan. A portion of casein was digested with trypsin until a strong glyoxylic reaction could be obtained, when the fermenting mixture was heated and filtered, yielding a clear, dark amber solution. A portion of this solution was tubed directly and sterilized, while another portion was used as the basis of a modified Uschinsky solution of the following composition:

Sodium chloride	5 grams.
Dipotassium phosphate	2 "
Ammonium lactate	6 "
Asparaginic acid	3 "
Casein tryptophan solution	1000 c.cm

The medium was rendered alkaline to litmus, tubed, sterilized and inoculated as before.

The results in these cultures were unsatisfactory. In the first place, the media proved unfavorable for some of the organisms, eight of which showed no growth in 24 hours, and others only slight growth. Furthermore the dark color of the media prevented a sharply marked reaction, even in the most active indol producers, and in cultures in which only a trace of indol was present its detection would be practically impossible. Again, the more abundant growth generally, in the tryptophan Uschinsky medium, indicated that the tryptophan solution alone is not a favorable medium for the cultivation of different types. This fact alone served to thwart one of the first objects of the research, that is, to prepare a medium in which efficacy and simplicity of preparation would be combined.

In a more extended comparative study of the use of Dunham's solution and sugar-free bouillon, the results obtained indicated that upon the whole, there was little advantage in either medium over the other. Under the same conditions some organisms produced more indol in shorter time in Dunham's solution than in sugar-free bouillon; while others produced more in the latter than in Dunham's solution. The sugar-free bouillon proved a more favorable medium for growth than did the Dunham's solution, some organisms showing only slight growth in the latter in twenty-four hours.

On testing the sugar-free bouillon for tryptophan, a very much stronger reaction was obtained than with ordinary bouillon. From this fact it may be inferred that the usefulness of sugar-free bouillon as a medium for indol detection, lies, not in the absence of sugar, but in the fact that in the fermentation incident to the preparation of the medium, the tryptophan group is split off from the proteid molecule and thus rendered more readily accessible to attack by micro-organisms.

There is unquestionably a decided advantage in the addition of tryptophan to culture media for the quick detection of indol production; but the length of time required in isolating it, precludes the practicability of making general use of the substance in the preparation of media.

ANTHRAX-LIKE BACILLI.

DAVID J. LEVY.

A short time ago I received some hair and crusts from the skin of cattle of the western part of this county for examination for the possible presence of a tricophyton-like organism. The material was ground up with sterile sand in a sterile mortar and plain agar plates were poured and developed at 30° C. On examining these plates 48 hours later there were found in addition to the mycelial growth various bacterial colonies, among them several consisting of symmetrically woven, convoluted strands, presenting the typical macroscopic and microscopic picture of the medusa-head colony of anthrax. Furthermore, on hanging drop examination, this colony was found to consist of bacilli forming long, interwoven threads. The individuals were observed to possess nearly squared ends, were apparently motionless and presented the characteristic form, size and arrangement of the anthrax bacillus.

Microscopically, the colonies and germs were indistinguishable from the anthrax bacillus. Although there was no suspicion of anthrax in the cattle from which the hairs and the crusts were obtained, and although anthrax does not exist and so far as I know has not existed in Michigan, the occurrence at any time of the bacillus here in a weakened or a virulent condition is by no means impossible. It seemed desirable to determine whether the organism in question was an anthrax bacillus or an ordinary saprophyte. It may be stated in advance that the results thus far attained show that the germ is not the anthrax bacillus but a bacillus resembling the latter in many of its properties. This circumstance led to a review of the literature of anthrax-like bacilli, and it is the purpose of this paper briefly to discuss these, and to point out certain differences among them, and the relations they bear to the organism isolated here. To that end it may be well to describe the latter organism first.

In form and size it closely resembles the anthrax bacillus, save in points to be brought out below. It forms median spores and stains by Gram's method. The colonies on agar plates present, as before indicated, the typical medusa-head appearance. On transferring the original colonies to inclined agar tubes, the resulting growth, while presenting the gross appearance of anthrax, on microscopical examination showed no felted arrangement, but consisted of irregular granular colonies. On replating these cultures however, typical medusa-head colonies were again obtained and this apparent irregularity has not since been met.

As before stated, the examination of the original colony showed it to consist of apparently non-motile bacilli, of the form and size of anthrax bacilli, forming the characteristic long threads. On microscopical examination of the sub-cultures however, instead of long threads there were only short ones, very many of the bacilli were single, these latter possessed quite rounded ends and were slightly yet undoubtedly motile. In some instances the motility of the single rods and even of short chains was marked. It required replating with the consequent production of medusa-heads to convince me that this germ was the one originally met with. Another instance of long threads of apparently non-motile rods on the original plates, which on subculture broke up into shorter threads and individual cells with undoubted motility is mentioned in the literature. In that case as in this, the non-motile long thread characteristic did not return. It may be stated here that the length of the threads and the degree of motility vary on different media. The rounded end character of the cells is not met with throughout, but many fields will show bacilli with squared ends, particularly those in threads, and others with rounded ones. Also, frequently whole fields of non-motile bacilli will be observed, with only here and there occasional motile rods and short chains.

The gelatine plates are rapidly liquefied. The colonies are irregular and none having a typical medusa-head appearance were met with on this medium. On gelatine the germ tends to become somewhat longer and narrower, and thread formation is more marked and the motility less so than on agar.

On inclined agar the appearance is at first that of the true anthrax bacillus but the growth spreads more rapidly and extensively than does the latter. In old cultures the agar becomes darkened.

In gelatine stab there results a rapid liquefaction, which at first funnel-shaped soon becomes cylindrical and eventually involves the entire contents. A surface growth forms which is less viscous than that of B. anthracis. This breaks up quite readily, increasing the sediment. In no instance have I observed the branching, root-like growth from the line of inoculation into the surrounding gelatine. Of course the true anthrax bacillus does not always show this characteristic.

Bouillon becomes clouded in five or six hours at 37°C. and later clears with the formation of a sediment and a surface pellicle. The surface growth breaks up and sinks on gentle shaking, leaving an adherent surface ring. A new pellicle may form.

On potato the growth is slightly moist, possibly dryish, and somewhat glistening. It is not folded. Spores are very abundant. The rods show a tendency toward involution forms.

Milk is coagulated in 24 to 48 hours without the production of acidity. The coagulum is later peptonized.

Inoculations of mice and guinea pigs, although made with large quantities of the germ, proved uniformly non-fatal. Large doses produced a local lesion, an ulcerated sore, which healed up in the course of about two weeks.

In 1889 Hueppe and Wood [1] called attention to the existence of *B. anthracoides* which they isolated from soil and water. This germ differed from B. anthracis only in that its ends were more rounded, and its growth was more rapid. It was devoid of pathogenic effects toward mice and guinea pigs. This germ was not motile. By means of large doses local effects could be produced in guinea pigs. They reported that true anthrax bacilli could be attenuated by passage through mice which previously had been inoculated with B. anthracoides and also that mice could be fully immunized against anthrax by means of this bacillus. They reported likewise the successful immunization of guinea pigs. In one or two cases in which death resulted in the presumably immune animals, the anthrax bacillus isolated was found to be attenuated.

This germ differs materially from the one described by Bainbridge [2] in 1902 under the same name—B. anthracoides. The latter possessed motility—flagella were demonstrated. There was no spiking in gelatine. It was pathogenic for mice and produced a local affection in guinea pigs. Culturally it resembled closely the germ isolated here.

In the same year (1889) Klein [3] observed two anthrax-like bacilli, *B. sessilis* and *B. leptosporus*—the former from material derived from a cow dying of suspected anthrax, the latter as a contaminating germ. The former was non-pathogenic for guinea pigs. The characteristics of these two organisms on solid media were not described.

Wahrlich [4] in 1890–91 isolated from water from a waste-pipe a non-motile anthrax-like germ having ends slightly more rounded and spores more spherical than those of B. anthracis. The threads also were more distinctly jointed. In other respects it was practically identical with B. anthracis. The pathogenesis was not reported.

In 1894 Burri [5] isolated from South American "Fleischfuttermehl" a motile bacillus presenting in general the same characteristic as the one with which we have been working. This likewise was non-pathogenic for mice.

In 1897 Hartleb and Stutzer [6] investigated "Fleischfuttermehl" to determine whether the B. *pseudanthracis* of Burri is a constant saprophyte in this substance, or whether it is an occasionally occurring, attenuated anthrax bacillus. "Fleischfuttermehl" is the residue remaining after the extraction of meat, which residue is then dried and ground up and is used in certain German localities, among other places, for feeding stock. The heating process involved could result in the attenuation of true anthrax bacilli. They collected twelve samples from various parts of west Germany and found anthrax-like bacilli in seven. The seven cultures were of three varieties differing chiefly in characteristic of growth in bouillon and in degree of motility. Variety I, which most closely resembled the true anthrax bacillus, was carefully worked out and proved to be nearly identical with that described by Burri. By growth under anaerobic conditions they caused this germ to become pathogenic toward mice. Likewise it caused a local reaction in guinea pigs, and seemed to cause the lessening of virulence of true anthrax bacilli by passage through guinea pigs so treated. They found a spiking in gelatine, also a slight acid production in milk. They say that the chief difference between B. pseudanthracis and B. anthracis lies in the motility of the former and the character of the growth in beef tea. The greater the virulence of B. pseudanthracis the less persistent was the cloudiness in bouillon. They consider this germ as probably a modified variety of B. anthracis.

Willach[7] (1896) investigated a bacillus isolated from the blood and the spleen of a cow dying shortly after delivery. Material from the same source was sent to the hygienic laboratory of a university, the name of which was not given and the germ was there pronounced to be B. anthracis, though atypical on account of the character of the gelatine growth. Mice died thirty to forty hours after inoculation. Willach, however, found the germ to be non-pathogenic toward guinea pigs. On a repeated test the university observer found that his germ had lost all virulence and was *motile* and admitted that the material sent him did not contain the anthrax bacillus.

McFarland[8] in 1898 found a single medusa-head colony on a plate poured from pus from an unusual sort of abscess. He suspected a true anthrax colony as a contamination, as his students had been working just previously with the anthrax bacillus. The germ proved to be devoid of pathogenic effects toward guinea pigs, white mice and rabbits. This germ was non-motile, its gelatine growth resembled that of B. anthracis but otherwise it resembled more closely the bacillus isolated here. He called this germ *B. anthracis similis*.

Gottstein[9] (1902) investigated an anthrax case occurring in a tannery and demonstrated the presence of B. anthracis. From wool brought from this tannery he isolated a certain motile bacillus which in practically all its cultural properties resembled B. anthracis. This was pathogenic for mice. On impregnating wool containing this germ with anthrax spores and making a suspension thereof in bouillon and inoculating a mouse, the animal died of true anthrax. If, however, a smilar suspension was incubated for twenty-four hours at 37° C. and a mouse was then inoculated with this incubated suspension, the animal died of infection with the anthrax-like bacillus. On plates the germ could also out grow the genuine B. anthracis.

Schulz[10] (1903) found anthrax-like bacilli in the milk of a sick goat.

Bongert[11] (1903) met with anthrax-like bacilli in material from various sources. They were all motile, and unlike B. anthracis clouded beef tea with subsequent clearing and with formation of a scum which did not readily break up on shaking. They were non-pathogenic. When occasionally a mouse did die, the rods met with in the spleen were longer, thicker, and had ends more rounded than the anthrax bacillus.

Baumann[12] (1905) examined water for the presence of the anthrax bacillus. He found medusa-head colonies, which consisted of long threads of apparently non-motile rods. The sub-cultures showed only shorter threads and single rods, with somewhat rounded ends. These were motile. The germ resembled very closely the one encountered here. It was non-pathogenic toward mice and guinea pigs. In one instance a mouse died but without an increase in virulence of the germ isolated from it. Baumann compared this germ with a hay bacillus, a "wurzel" bacillus, another anthrax-like bacillus and with a true anthrax bacillus and found that it most closely resembled the "wurzel" and the other anthrax-like bacillus.

Kaesewurm[13] found anthrax-like bacilli in the blood, milk and spleen of animals, also in hay, wool and blotting paper. These killed mice in large doses, but the virulence of the germs was not increased.

The B. apicum of Canestrini[14], pathogenic for bees but not for mice or guinea pigs, while referred to frequently as anthrax-like has certain properties, such as the production of pigment on potato, which throw it out of the class of the germs above considered.

So far as can be determined from the descriptions all of the foregoing differ in varying degree among themselves. The germ with which I have been working also evidently possesses distinctive features. I have not deemed it advisable to go here into the detailed points of difference between the germs described by the various observers. A tabulation would bring out these differences nicely. The chief points of difference between this group and the anthrax bacillus—outside of pathogenic effects—lie in the motility of the former and the clouding which they produce in bouillon. The significance of the group of bacilli is a matter of doubt. Some few of the investigators regard their germs as closely related to the anthrax bacillus. Others regard the germs observed by them as related to the hay bacilli or the root bacilli. Possibly there are two distinct groups—those related to the anthrax bacillus, e. g., B. anthracoides of Hueppe and Wood, and those more purely saprophytic, e. g., B. pseudanthracis of Burri.

If these organisms are weakened varieties of B. anthracis or if they can produce immunity to anthrax, they are of importance. If merely saprophytic, their resemblance to the anthrax bacillus renders them of interest. Some of them certainly are pathogenic toward mice and the pathogenicity toward this animal must be borne in mind in diagnosing anthrax. In view of the possible occurrence at any time of actual or suspected anthrax in Michigan, it is important that we bear in mind the existence and probably wide distribution of this group of anthrax-like bacilli.

University of Michigan.

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DISINFECTION BY MEANS OF FORMALDEHYDE AND POTASSIUM PERMANGANATE.

JAS. G. CUMMING.

The use of disinfectants and antiseptics as preservatives began at a remote period of antiquity. It is quite evident that some of the agents, which modern investigation has shown to be most effectual disinfectants, were not unknown in the earliest periods to which our knowledge extends. We find that our most reliable antiseptics or preservatives, the purified coal-tar compounds contributed by modern chemistry to the art of disinfection, were employed in a crude form by the Egyptian embalmers. Besides the coal-tar compounds, sulphur and its compounds appear to have been frequently used by the ancients. It certainly was in use in the time of Homer, for we find that Ulysses employed burning sulphur to fumigate a palace, the inmates of which had been slain. Here as in most of the historical references to sulphur at this time, it had its place among religious ceremonies. Later history tells of the practice of burning sulphur by the Italians for the prevention of parasitic diseases of vines and about the same time skin diseases of cattle were treated by the application of creasote.

The empirical knowledge of the ancients has had a new birth in the scientific discoveries of the present era. They knew that certain chemical substances might be used as preservatives and that others were used in parasitic diseases, but because they had no knowledge of the scientific causation of putrefaction, fermentation and contageous and infectious diseases, their application was limited and their results not always encouraging. The stimulus which has recently been imparted to the investigation of disinfectants is the discovery of microscopic life as being the cause of infectious and contagious diseases. Until comparatively recent times disinfection was based a purely chemical and physical knowledge, but since Pasteur and others have made their important discoveries the art of disinfection has been based on scientific principles.

As late as 1860 disinfection was an obscure art, but since this date new disinfectants have been discovered and the methods of using those already known, at that time, have been so thoroughly investigated and perfected, that severe epidemics have been practically unknown in civilized countries, during the last decade.

Of the various disinfectants employed at the present time for room disinfection formaldehyde is undoubtedly the most efficient. Three methods of procuring it in its gaseous state are in quite common use; the lamps which form formaldehyde by the partial oxidization of methyl alcohol generally through the agency of platinum black; the distillation of a solution of the gas in water; and the sheet method, by this method formaline is sprayed on suspended sheets from which it evaporates and diffuses throughout the surrounding space.

Recently a new method of disinfection has been suggested by Henry D. Evans and its practical application has been investigated by Dr. J.

P. Russell of the University of Maine. Their method, which might be designated as the "potassium permanganate process," consists of pouring a definite quantity of formalin upon a fixed amount of potassium permanganate. On adding formaldehyde to the $K\ Mn\ O_4$ a rapid process of oxidization ensues, and at ordinary room temperature the oxidization causes profuse boiling, which liberates the formaldehyde gas very rapidly.

This method has the advantages that the disinfector need not transport apparatus from place to place, that there is no generator or lamp which might originate fire, that almost the whole quantity of formaldehyde available for disinfection is liberated very rapidly, thus giving a maximum concentration of the gas before there has been time for leakage of the first part. But this latter advantage is only to be considered when we are disinfecting organisms of low resistance. We know that most of the organisms of contagious and infectious diseases have considerable resistance, so this apparant advantage is scarcely worth considering. Inasmuch as the boiling process is of exceedingly short duration scarcely any steam is given off. This lack of steam or moisture is to be considered as a marked disadvantage in using the "$KMnO_4$ process," and this is quite evident when a comparative study of the usefulness of this method and that of distillation is made.

The results of a long series of experiments led Dr. Evans to adopt the proportion of 10 cc. of formalin to 3.75 grms. $KMnO_4$ or approximately 6.5 ounces of $KMnO_4$ to one quart of formalin. In carrying out this process of disinfection the commercial 40% formalin solution is used, and it is most desirable for the permanganate to be either in the powdered form or in the long needle shaped crystals which are met with as the commercial article.

If the large C. P. octohedral crystals are used they should first be powdered so as to hasten the chemical reaction. As regards the generator an earthen or tin vessel with sides high enough to prevent the solution from boiling over will answer the purpose.

In a room requiring 1000 cc. of formaldehyde, used in the proportion of one quart to 1000 cubic ft. it is advisable to use a 3 gallon vessel. He states that it is an advantage to use a generator with flaring sides, so that the gas instead of ascending straight to the ceiling will ascend forming an inverted cone, and consequently be diffused more rapidly throughout the room.

Dr. Evans quantitative experiments show that about 81% of the formaldehyde was available for disinfecting purposes; the remaining 19% represents that part which has undergone oxidization.

In view of the fact that the secretary of the Maine State Board of Health makes strong claims for this procedure, Dr. Vaughan thought it was desirable to have a series of experiments made to prove or disprove its usefullness. This investigation consisted of seven different room-disinfection experiments. For two of the experiments the "permanganate process" was used, and for the remaining five the formaldehyde was distilled into the room by the Novy generator.

Over 3000 specimens were exposed to the action of the disinfectant in the two methods. The test organisms used were Diphtheria B. Anthrax B. Subtilis, Typhoid B., Colon B., Cholera, S. Pyogenes Alb., Pyocyaneous, Pneumonia B., Streptococcus.

The separate organisms were exposed on sterilized silk threads, squares of muslin and filter paper. These were thoroughly soaked in a suspension of the organisms to be tested, and then transferred by sterile forceps to a sterile Esmarch dish. The sets of specimens in the different experiments were allowed to dry, for a definite length of time under nearly as possible the same conditions as to temperature and atmospheric moisture. This part of the general technic was strictly adhered to; first, because of the marked difference in resistance of moist and dry specimens; secondly, because the health officer in his disinfection work usually encounters infectious and contagious material in a dry state. A room containing 1000 cu. ft. was used for these experiments, the average temperature of which was 15% C.

The first set of specimens were exposed to the available formaldehyde derived from 1000 cc of formalin, this being evolved by the 375 grms of $KMnO_4$. The result of this experiment shows that the organisms of diphtheria, pneumonia, anthrax and typhoid did not survive after one hour exposure. Subtilis and pyocyaneus did show growth after an exposure of eight hours. Colon and S. pyogenes alb. showed no growth after two hours. To get the comparative value between this method and the Novy generator method, a set of specimens as nearly alike those used in the foregoing experiment as possible were exposed to 1000 cc formaldehyde distilled into the room by the Novy generator. By this method only two organisms subtilis colon showed growth after one hour exposure.

The results of the two foregoing experiments clearly demonstrate that the "$KMoN_4$ process" is less effectual than the procedure followed out by the Novy generator. In the former the organisms of subtilis and pyocyaneus survive after an exposure of eight hours while by the distillation process one gets no growth after one hour exposure.

If the same set of organisms are exposed to the available formaldehyde in 750 cc of formalin and 260 grms $KMnO_4$ it is found that subtilis colon and pyocyaneus survive for at least 12 hours, while diphtheria and pneumonia show no growth after six hours; anthrax none after four; typhoid and streptococcus after three hours shows no growth. In this experiment cholera showed no growth whatever. Using 750 cc by the Novy process one gets practically the same results as were gotten with 1000 cc. So it can be plainly seen that the relative value of the two methods with 750 cc. of formalin differ quite markedly, even more so than when 1000 cc. were used.

When smaller amounts were employed it was found that there was even a more marked deviation between the efficiency of the two processes. And by a comparative study of the accompanying records one finds that very similar results are gotten in the two methods by using from 150 to 300 cc. of formalin by the Novy generator method and 1000 cc. by the $KMnO_4$ process.

From the foregoing results the following conclusions can be drawn: For thoroughness and efficiency the "$KMnO_4$ method" is not as useful as the distillation method. In other words, an equal amount of formalin being used in the two methods, one finds by the tables that the organisms of the same kind when exposed to formaldehyde liberated by the $KMnO_4$ method survive an exposure of much longer duration than ones which were exposed to formaldehyde which was generated by the Novy generator. This is a very important point and the differences are probably due to the fact that very little steam or moisture is given off in the one method while in the other a maximum amount is liberated; another reason for this difference is that about 20% of the formaldehyde is used up in the process of oxidization in the permanganate method.

The only advantages this new method has is convenience and the avoidance of fire, and it also does away with the necessity of transporting expensive and cumbersome apparatus. It is not a rapid and thorough method of disinfection, and should only be employed when its advantages outweigh its disadvantages. If a generator for distilling the formaldehyde cannot be conveniently procured, and the exposure to the disinfectant can be made for a sufficient length of time to warrant thoroughness the method might be employed.

It is quite true that any layman might employ the "$KMnO_4$ process," inasmuch as the method of procedure is so simple. All one requires is a suitable vessel and formalin and $KMnO_4$ in the right proportions, but in cities where all disinfecting apparatus should be at hand, it is advisable to use the Novy generator.

Pasteur Institute, U. of M.

POTASSIUM PERMANGANATE METHOD.

Exposure in hours.		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13	14
	*S. T...	*+	−	−	−	−	−	−	−	−	−	−	−	−	−
Diphtheria B.	C. S....	−	−	−	−	−	−	−	−	−	−	−	−	−	−
	P. S....	−	−	−	−	−	−	−	−	−	−	−	−	−	−
	S. T ...	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Anthrax B.	C. S....	−	−	−	−	−	−	−	−	−	−	−	−	−	−
	P. S....	−	−	−	−	−	−	−	−	−	−	−	−	−	−
	S. T ...	+	+	+	+	−	+	+	+	−	−	−	−	−	−
Subtilis	C. S....	+	+	+	−	−	+	−	+	−	−	−	−	−	−
	P. S....	−	+	−	+	+	−	−	−	−	−	−	−	−	−
	S. T....	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Typhoid B.	C. S....	−	−	−	−	−	−	−	−	−	−	−	−	−	−
	P S....	−	−	−	−	−	−	−	−	−	−	−	−	−	−
	S. T....	+	+	−	−	−	−	−	−	−	−	−	−	−	−
Colon B.	C. S....	−	+	−	−	−	−	−	−	−	−	−	−	−	−
	P. S....	+	+	−	−	−	−	−	−	−	−	−	−	−	−
	S. T....	+	+	−	−	−	−	−	−	−	−	−	−	−	−
Cholera	C. S....	−	+	−	−	−	−	−	−	−	−	−	−	−	−
	P. S ...	−	−	−	−	−	−	−	−	−	−	−	−	−	−
	S. T....	+	+	−	−	−	−	−	−	−	−	−	−	−	−
S. Pyogenes Alb.	C. S. ..	+	+	−	−	−	−	−	−	−	−	−	−	−	−
	P. S....	+	−	−	−	−	−	−	−	−	−	−	−	−	−
	S. T ..	+	+	+	+	+	+	+	+	+	−	−	−	−	−
Pyocyaneus	C. S....	+	+	−	+	+	+	+	−	−	−	−	−	−	−
	P. S....	+	+	−	+	−	−	−	−	−	−	−	−	−	−
	S. T....	+	+	+	−	−	−	−	−	−	−	−	−	−	−
Streptococcus	C. S....	+	−	−	−	−	−	−	−	−	−	−	−	−	−
	P. S ...	+	−	−	−	−	−	−	−	−	−	−	−	−	−
	S. T. ..	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Pneumonia B.	C. S....	+	−	−	−	−	−	−	−	−	−	−	−	−	−
	P S....	−	−	−	−	−	−	−	−	−	−	−	−	−	−

*S. T. Silk thread. *+ Growth. 1000 cc. Formalin.
C. S. Cloth squares. − No growth. 375 grms. Potassium Permanganate
P. S. Paper squares.

POTASSIUM PERMANGANATE METHOD.

Exposure in hours.		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12	13.	14.
Diphtheria B.	S. T.	+	+	+	+	−	+	−	−	−	−	−	−	−	−
	C. S.	−	+	−	−	−	−	−	−	−	−	−	−	−	−
	P. S.	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Anthrax B.	S. T.	+	+	+	+	−	−	−	−	−	−	−	−	−	−
	C. S.	+	−	−	−	−	−	−	−	−	−	−	−	−	−
	P. S.	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Subtilis	S. T.	+	+	+	+	+	+	+	+	+	+	+	+	−	+
	C. S.	+	+	+	+	+	+	+	−	+	+	−	+	+	−
	P. S.	+	+	+	−	+	+	−	+	+	−	+	−	−	−
Typhoid B.	S. T.	+	+	+	−	−	−	−	−	−	−	−	−	−	−
	C. S.	−	+	−	−	−	−	−	−	−	−	−	−	−	−
	P. S.	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Colon B.	S. T.	+	+	+	+	+	+	+	+	+	+	+	−	+	+
	C. S.	+	+	+	+	+	+	+	+	+	+	−	+	−	−
	P. S.	−	+	−	−	−	−	+	+	−	−	−	−	−	−
Cholera	S. T.	−	+	−	−	−	−	−	−	−	−	−	−	−	−
	C. S.	−	−	−	−	−	−	−	−	−	−	−	−	−	−
	P. S.	−	−	−	−	−	−	−	−	−	−	−	−	−	−
S. Pyogenes Alb.	S. T.	+	+	+	+	+	+	+	+	+	+	−	+	+	−
	C. S.	+	+	+	−	+	+	−	−	−	−	−	−	−	−
	P. S.	+	+	+	+	+	−	−	−	−	−	−	−	−	−
Pyocyaneus	S. T.	+	+	+	+	+	+	−	−	+	+	+	+	−	−
	C. S.	+	+	−	−	−	−	−	+	−	−	−	−	−	−
	P. S.	−	+	−	−	−	−	−	−	−	−	−	−	−	−
Streptococcus	S. T.	+	+	+	+	−	−	−	−	−	−	−	−	−	−
	C. S.	−	−	−	+	−	−	−	−	−	−	−	−	−	−
	P. S.	+	−	−	−	−	−	−	−	−	−	−	−	−	−
Pneumonia B.	S. T.	+	+	+	+	−	+	−	−	−	−	−	−	−	−
	C. S.	−	−	−	−	−	−	−	−	−	−	−	−	−	−
	P. S.	−	−	−	−	−	−	−	−	−	−	−	−	−	−

750 cc Formalin. 160 grms. Potassium Permanganate.

NOVY GENERATOR METHOD.

Exposure in hours.		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12	13.	14.
Diphtheria B.	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Anthrax B.	S. T.	+	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtilis	S. T.	+	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	+	—	—	—	—	—	—	—	—	—	—	—	—	—
Typhoid B.	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Colon B.	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cholera	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	+	—	—	—	—	—	—	—	—	—	—	—	—	—
S. Pyogenes Alb.	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pyocyaneus	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Streptococcus	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pneumonia B.	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—

1000 cc Formalin. Distillation.

NOVY GENERATOR METHOD.

Exposure in hours.		1.	2.	3.	4.	5	6.	7.	8.	9.	10.	11.	12	13.	14.
Diphtheria B.	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Anthrax B.	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	+	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtilis	S. T.	+	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Typhoid B.	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Colon B.	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cholera	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
S. Pyogenes Alb	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pyocyaneus	S. T.	+	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	+	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Streptococcus	S. T.	+	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pneumonia B.	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—

750 cc Formalin. Distillation.

NOVY GENERATOR METHOD.

Exposure in hours.		1.	2.	3.	4	5.	6.	7	8	9.	10.	11.	12	13.	14.
Diphtheria B.	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Anthrax B.	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	+	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtilis.	S. T.	+	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	+	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Typhoid B.	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Colon B.	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cholera.	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
S. Progenes Alb.	S. T.	+	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pyocyaneus.	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Streptococcus.	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pneumonia B.	S. T.	+	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—

500 cc Formalin. Distillation.

NOVY GENERATOR METHOD.

Exposure in hours.		1.	2.	3.	4.	5.	6.	7.	8.	9.	10	11.	12.	13.	14.
Diphtheria B.	S. T.	+	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Anthrax B.	S. T.	+	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	+	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Subtilis	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Typhoid B.	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Colon B.	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Cholera	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
S. Progenes Alb	S. T.	+	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pyocyaneus	S. T.	+	+	+	—	—	—	—	—	—	—	—	—	—	—
	C. S.	+	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Streptococcus	S. T.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pneumonia B.	S. T.	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	C. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	P. S.	—	—	—	—	—	—	—	—	—	—	—	—	—	—

300 cc Formalin Distillation.

NOVY GENERATOR METHOD.

Exposure in hours.		1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
Diphtheria B.	S. T....	+	+	+	+	+	+	+	+	+	+	−	−	+	−
	C. S....	+	+	+	+	−	+	−	−	+	+	+	−	−	−
	P. S....	+	−	+	+	+	+	+	−	−	−	−	−	−	−
Anthrax B.	S. T....	+	+	+	+	+	+	+	+	−	−	−	−	−	−
	+ +	+	+	+	−	−	−	−	−	−	−	−	−	−	−
	P. S....	+	+	−	+	−	−	+	−	−	−	−	−	−	−
Subtilis	S. T....	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	C. S....	+	+	+	+	−	+	+	+	+	−	−	−	−	−
	P. S....	+	+	−	−	−	+	−	+	+	+	−	−	−	−
Typhoid B.	S. T....	+	+	+	+	+	+	−	−	+	+	−	+	−	−
	C. S....	+	+	+	+	−	+	+	+	+	−	−	−	−	−
	P. S....	−	+	+	+	+	+	+	+	+	+	−	−	−	−
Colon B.	S. T....	+	+	+	+	+	+	+	+	+	+	+	−	−	−
	C. S..	+	+	+	+	+	+	+	−	−	+	+	+	−	−
	P. S....	+	+	+	+	−	+	+	+	+	+	+	+	+	+
Cholera	S. T...	+	+	+	+	−	−	+	−	−	−	−	−	−	−
	C. S....	+	−	+	−	+	−	−	−	−	−	−	−	−	−
	P. S....	+	+	+	−	−	−	−	−	−	−	−	−	−	−
S. Pyogenes Alb.	S. T. ..	+	+	+	+	+	+	+	+	+	+	+	−	+	+
	C. S..	+	+	+	+	+	−	+	+	+	+	+	+	+	−
	P. S...	+	+	+	+	+	+	+	+	+	−	+	+	−	−
Pyocyaneus	S. T....	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	C. S...	+	+	+	+	+	+	+	+	+	−	+	+	+	+
	P. S....	+	−	+	+	−	−	−	+	−	−	−	−	−	−
Streptococcus	S. T....	+	+	+	+	+	−	+	+	+	+	+	+	−	+
	C. S....	+	+	+	+	+	+	+	+	+	+	+	+	−	−
	P. S....	+	+	+	+	−	−	−	+	−	−	−	−	−	−
Pneumonia B.	S. T....	+	+	+	+	+	+	+	+	+	+	+	−	−	−
	C. S....	+	+	+	+	+	+	+	+	−	−	+	−	−	−
	P. S....	+	+	+	−	+	−	−	−	+	−	−	−	−	−

150 cc Formalin. Distillation.

THE BLACK RIVER SECTION NEAR BESSEMER.

W. C. GORDON.

During the months of July, August, September, and a part of October the Mich. Geol. Survey had a party of men making a section of the Keweenawan rocks as they are exposed between the city of Bessemer and Lake Superior. It is the attempt of this paper to give some idea of the work done by that party.

Bessemer is a city of about 4000 population, lying for the most part in S. 10 T. 47 N., R. 46 W. It is on the C. & N. W., and Wis. Cent. Ry's. and is entered by a spur line of the D. S. S. & A., the main line of which passes two miles to the north. It is an iron-mining town on the Gogebic Iron Range. Six miles to the west of it is the Wisconsin state line.

Immediately around the village the land is cleared and under cultivation, but the D. S. S. & A. Ry. marks the northern limit of cleared land, beyond which is the virgin forest.

Just north of, and passing so close as to almost touch the city limits, is an east and west ridge rising from 200 to 250 feet above the surrounding country. In places it develops into steep bald hills, and even bluffs. The ridge is broken through frequently by north and south gaps which vary in width from a few hundred yards up to a mile. These gaps immediately suggested to Dr. Lane the possibility of north and south faults, and later investigation proved the suggestion a true one. North of this ridge the country is flat and drift covered for about six miles; or, if we may express it so, there is a gap six miles wide extending east and west. Beyond this gap is again hill country, but not a continuous ridge. To the west is an isolated peak whose eastern side presents a cliff of felsite about 100 feet high, the hill itself rising nearly 250 feet. This hill is known as Chippewa Bluff. Eastward from this bluff, and about two miles away, is a hill of basic rock having about the same elevation. The rather broad top of this hill makes it have somewhat the appearance of a highland. Between these last two hills is a north and south gap. Directly north of Chippewa Bluff, and distant about three miles, is a conglomerate ridge whose longer axis extends east and west. This ridge is about two miles long. Beyond it, and not far distant, is Lake Superior.

Black River enters the area worked just north of the east and west ridge spoken of above. After flowing westward, practically along the foot of this ridge, for about three miles it turns northward and soon swings somewhat to the east. It flows to the east of Chippewa Bluff, taking to the low land that lies between it and the highlands that lie to the east. As it continues its northern course it is forced still further east around the conglomerate ridge, after which it takes a direct route to Lake Superior.

The river is from one hundred to one hundred and fifty feet wide, but is very shallow. During the low water of August, even a small row-boat could not continue with uninterrupted passage. But during flood season it rises several feet. All along its course there are rapids. Those in the upper part, being caused by the collecting of glacial boulders in the stream bed, are small. Farther north, in S. 21 T. 48 N., R. 46 W., the river cuts down to the country rock and from that point the rapids increase in frequency and in size. The last three miles is a mere succession of rapids and falls and presents very picturesque scenery. In all, the river has about 600 ft. fall from the time it enters the area worked by the party to its mouth. That portion south is also said to be rapid, but the party was not on the upper part of the river at all. The river water is dark but I do not know whether this is the source of the name "Black River" or not.

Along the west bank of the river, sometimes close, and sometimes as much as a half mile distant, is a road from Bessemer to the lake. The road was originally cut through by the government, after which it was handed over to the township of Ironwood in which it lies. As there is no land under cultivation along the road, and nothing at all save a small fishing station at its lake end, there is practically no travel over it, except by pleasure-seekers. As a result the road is kept in poor condition.

The country so briefly described above is the one in which the survey party spent the season of 1905. They worked a strip four miles wide extending from Bessemer to the lake. The strip takes in the west four miles of R. 46 W. and extends across T's 49 and 48 N. and two miles into T. 47 N. Its southern extremity lies south of the east and west ridge spoken of as passing so near the Bessemer city limits, and extends north. It crosses the six miles of drift covered country, and covers Chippewa Bluff and the highlands to the east. It also takes in the conglomerate hill farther north. Flowing practically down the center of it is Black River.

The road along the west bank served as a convenient avenue for the party to reach different parts of the area they were working. A still greater boon was the advantage of the work that Black River had been doing for years in cutting its bed down to, and laying bare the country rock in almost continuous cross-section. Had it not been for the river bed the season's work could have yielded no great amount of information. But the state geologist saw the value of the river cut when he directed the party to take that field. The only exposures outside the river bed are on the hills and ridges spoken of above.

The first work done was to accurately survey and level the road, after which a pacing and barometrical survey was made of the district, using the road as a base line. The iron quarter-pin between S. 4, T. 47 N., R. 46 W. and S. 33, T. 48 N. R. 46 W. was used as an initial station for the transit work. This station is two miles from Bessemer.

The distance along the road from the initial station to the lake is 13.34 miles while the direct distance between the same two points is 11.06 miles. A traveller on the road two miles from the initial station is 1.63 miles to the west of it. The lake end of the road is 0.83 miles to the east of it. While the road does not follow the river closely it takes the same general direction.

On the whole the road is fairly level and retains its elevation until within two and a half miles of the lake. The initial station of the transit line was used also as a bench-mark and is 685 ft. above the lake. Another point about two and a half miles from the lake is 600 ft. above it, so that there is a decline of only 85 ft. in the first 11 miles. In the remaining distance there is a fall of 600 ft. the last 100 being the height of the lake hill. On the whole, the road has not many hills, and no very bad ones, save that just spoken of, which is steep. The next largest is just south of the D. S. S. & A. R. Ry., and is one which Bessemer people have to go over in going to and from North Bessemer which is their passenger station for the D. S. S. & A. R. Ry. This hill is also just 100 ft. high but is not so steep as the lake hill.

Bessemer is on the Gogebic iron range, and is underlain by rocks of that series, but the ridge just to its north exposes Keweenawan rocks. The nearest Penokee exposures to the Keweenawan rocks are graywackes, which strike nearly east and west and have a dip of 55° to 60° N.

The first exposures above the graywacks are of red sandstone, whose vitreous appearance makes it somewhat resemble a quartzite. This sandstone is the basal member of the Keweenawan series.

The work of geologists, such as Van Hise in his Penokee-Gogebic monograph puts an unconformity between the iron-bearing and the copper-bearing rocks above them. The exposures near Bessemer do not warrant the saying that there is an unconformity, nor do they warrant the saying that there is not. The rocks are not exposed along the contact, there being a width of at least one-half mile unexposed. Concerning conformity, or unconformity, one can say nothing from the area worked by us.

The basal sandstone of the Keweenawan dips 70° to 73° N. There is a surface exposure of 200 ft. How much of the drift covered area is underlain by sandstone, and how much by graywacke cannot be said.

Above this sandstone is a thick series of eruptives. The sedimentaries of the Penokee and the basal sandstone of the Keweenawan represents a period of quiet, but the great thickness of eruptives in the base of the Keweenawan marks a change. There is exposed almost continuously a surface width of 8600 ft., which with a dip of 70° means a thickness of 8000 ft. of eruptives. Following is a surface width of 13000 ft. without exposure. Since the dip gradually decreases as we go north it is not at all probable that this area is underlain by rocks that have an average dip greater than 65°, which would give a thickness of 11800 of rock. This area is probably underlain by eruptives, since such rocks are exposed on either side, yet it is not at all certain that there are not some sedimentaries. Beyond the unexposed area are eruptives with a surfaced width of 19000 ft., which if we allow to dip of 56° N., gives us a thickness of 15600 ft. Here then is a total thickness of 35400 ft. in which the rocks are practically wholly basic eruptives.

Above these basic eruptives is a felsite whose exposed width is 660 ft., and it cannot exceed 2000 ft. The known thickness is 460 ft., since its dip is 45°, and it cannot exceed 1400 ft. The resisting power of this felsite has enabled Chippewa Bluff to stand against the degrading agencies of nature.

Above the felsite there is a series of interbedded sedimentaries and eruptives. These have a surface exposure of about 9000 ft. With an average dip of 37° there is a thickness of 5400 ft. The top of these interbedded eruptives and sedimentaries takes in the last eruptives exposed and probably marks the top of Irving's Lower Keweenawan.

Above this point only sedimentaries occur, and their exposures on the Black River show them to be conglomerates sandstones and shales.

I shall consider these rocks briefly under the heads that I have outlined above. There is no real reason why such a division should be made, except for the sake of convenience in this present paper, and yet the division can no doubt be excused since there is represented in each a difference in the way in which nature has displayed hereself.

1.	Basal sandstone	200 ft.
2.	Eruptives with little or no sedimentary rock...	35400 ft.
3.	Felsite with a known thickness of 460 but with a possible	1400 ft.
4.	Interbedded sedimentaries and eruptives........	5400 ft.
5.	Sedimentaries	1500 ft.
	Total	43900 ft.

1. The basal sandstone: I shall not add anything to what I have already said about this sandstone.

2. Eruptives with little or no sedimentaries: At the base there are amygdaloidal with amygdules mostly of quartz, many of which are agate. Above them are labradorite porphyrites with small phenocrysts of feldspar. Not far from the base is a thin bed of very coarsed grained gabbro. Its presence is interesting since it is, I think, the first exposure of the Bad River gabbro noted in the Keweenawan of Michigan. In all probability it is a sill. Above the gabbro there is a series of flows partly melaphyres, and partly labradorite-porphyrites. There are, in all, several flows of these poryphyrites one of which has phenocrysts of feldspar 30mm. in length. About 7,500 feet from the base of the Keweenawan there is a thin felsite-porphyrite and above it are exposures of ophite. Then follows the space without exposure which is here being considered as containing eruptives only. It is possible, though not probable, that there is considerable sedimentary rock in it. Beyond this drift covered part is a series of lustre mottled melaphyres. Some have mottling as much as an inch across but the most of the mottling is much smaller. These ophites continue almost up to the Chippewa felsite.

This body of eruptives is not wholly without sedimentaries for there are some sandstones just beneath the felsite and at least one bed farther down with a thickness of 100 feet. But it is quite certain that the sedimentaries are small factors. It is interesting to notice here that although the great mass of Keweenawan rocks up to this point are basic, yet what few sedimentaries are present are acid.

There does not seem to be any flows of very great thickness in all this great body of eruptives. At the very base where the rock is well exposed on the Bessemer bluffs the different flows are readily distinguished and they show different thicknesses from 10 up to 250 feet. It is quite certain that the larger lustre mottling in 21-48-46 is indicative of thicker flows, as is also the coarser grain of the rocks on the highlands to the east of Chippewa Bluff. But it seems quite evident that there are no very thick flows.

Where the rock is well exposed it is quite common to see a thin seam of sandstone, sometimes as much as two inches thick, between two flows. Also where pockets are formed in the top of the flow, as they sometimes are, they are filled with well stratified sand. These things would seem to indicate that these Keweenawan flows occurred under water.

3. Felsite: Above this thick mass of basic rocks which is almost wholly of eruptive origin is a felsite flow. I shall call it in this paper the Chippewa felsite. It has a dip of 45°N. and a strike of N.80°E. It is certainly 460 feet thick, and, as there is a space above it without outcrop, it may have a thickness of 1,400 feet. But, since there are so many thin strata beginning to appear at this horizon, it would be simply a guess to say what rock fills the gap. The felsite may continue across it, the conglomerate above may extend down through it, or it may contain basic eruptives. The felsite is not unlike that composing some of the pebbles that occur in the conglomerates above it.

There are outcrops of this rock only in Black River and on Chippewa Bluff. In the latter place it forms the cap of, but not the whole hill. For at least two-thirds of the way up the south side there are exposures of ophite, and before reaching the felsite there are some thin beds of sandstone and a small amount of volcanic material.

The felsite has a fine grained chocolate brown ground mass, and carries phenocrysts of orthoclase and quartz.

4. Interbedded sedimentaries and eruptives: The thickness is placed at 5,400 feet, but it may be greater, since a part or even the whole of, the space without outcrop may be underlain by these rocks. If so this division would extend downward about 1,000 feet more than is here indicated.

This division contains sedimentaries and basic eruptives. The former have so increased in proportion to the latter that one cannot help but notice the difference from the great thickness of eruptive rocks below the Chippewa felsite. Below the felsite the per cent of sedimentaries is practically nothing, but from it up to the top of the last eruptives they form about 25 per cent of the rock. The per cent of sedimentaries increase as we go upward in the division itself.

Some of the eruptive beds contain five or six flows, and some less. They are, for the most part, ophites. The lava flows are all thin, mostly under 150 feet, and the average thickness would not exceed 100 feet. All have amygdaloidal surfaces. The weathering seems to be much greater in these flows than in those below the Chippewa felsite. The amygdules are largely calcite, chlorite and laumontite.

There are at least six sedimentary beds in this division, and all are composed of acid material Sometimes these beds are purely sandstone, and sometimes conglomerate. Others shew both phases. There is a great variety of pebbles but the felsite pebbles form nearly the whole mass. The highest sedimentary bed of this division is a conglomerate 400 feet thick. The highest eruptive bed is 350 feet thick, and marks the close of the eruptive action of Keweenawan times. The top of this eruptive is probably the top of Irving's Lower Keweenawan.

5. Sedimentaries only: The highest division that is made in this paper contains sedimentaries only. The rock at the base of the division is a conglomerate. Some of the boulders are nearly a foot and a half in diameter, and from these there are all sizes down to the smallest sandstone grains. All the pebbles are water-worn and well rounded. There are pebbles of amygdaloid, granite, diorite, syenite, quartzite, jasper, labradorite-porphyrite, and felsite-porphyrite, but all these are few in number and it is putting it quite strong enough to merely say that they are present, for nearly the whole mass is made up of different varieties of felsite pebbles and boulers. The finer material between the pebbles is also acid. As we go upward we find that the conglomerate gradually changes to a sandstone, and the last 300 feet shows no conglomerate at all except a thin band of 10 feet about 50 feet from the top. The sandstone has a red color, but in some places it is quite brown. All through it there are seams of white sandstone varying in thickness from a quarter of an inch up to one foot. It has a marked tendency to split along its bedding planes, cleaving almost like shale, and for this reason will never be of value as a building stone.

Above this thick conglomerate bed is the Nonesuch formation. Only the lower contact is exposed on the Black River and that at the very mouth. About five miles westward on the lake shore the upper contact is exposed, and the shale is seen to have a thickness of not more than 300 feet. This formation displays the typical greenish colored Nonesuch shales interbedded with Nonesuch sandstone. These are the youngest Keweenawan rocks exposed on the Black River.

The rocks described above are all exposed in the Black River section, and the thicknesses given here are calculated from the exposures in that section. Irving says of the Lower Keweeawan in his monograph on the copper-bearing rocks vol. V, U. S. G. S., p. 158, "On the Montreal river, taking the surface width and dip angles together, the apparent thickness is as much as 33,000 to 35,000 feet, but how much of this may be due to the continuation westward of the Keweenaw fault, or whether this fault extends so far as this, it is impossible to say. It certainly does not extend much farther and, from its evident rapid decrease in throw from the Ontonagon River westward, it seems that its influence on the Montreal cannot be great." At the base of our section the Montreal is about six miles west and at the top it is as much as eighteen miles. The thickness of the Lower Keweenawan on the Black River appears to be as much as 42,000 ft.

The section that was made on the Black River was small and does not warrant any very general conclusions, but there are a few points that may be noted.

There are no very thick flows in the Keweenawan as it is exposed in this section, nor are all of the flows alike lithologically. In the great eruptive division below the Chippewa felsite there are melaphyrs, ophites, labradorite-porphyrites, and felsites, and, indeed, almost every degree of acidity is displayed from the labradorite-porphyrites up to the felsite-porphyrites. All of the flows have amygdaloidal surfaces and massive centres, and most of them have pipe amygdules at the base.

Keweenawan time seems to have been inagurated quietly as is indicated by the basal sandstone. Soon, however, it displayed itself more violently, and lava flow after lava flow followed one another building up a great column of eruptives. Some of these flows seem to have followed each other in rapid succession, and again, a little time seems to have elapsed as is indicated by the thin seams of sandstone between some of the flows. The great eruptive period did not end as suddenly as it began for the sedimentaries become gradually more and more prominent as we ascend in the series. This prominence is displayed in the increasing frequency and greater thickness of the beds.

It is a very striking fact that all of the sedimentary rocks save the Nonesuch, no matter whether above the Chippewa felsite or below, are strikingly acid, and all resemble each other very much. The great mass of the building material of the aqueous rocks is felsite. The Nonesuch is basic and it is worthy of note that there is a sudden change from an acid sandstone to the basic Nonesuch.

At the base of the Keweenawan there is a very high dip, about 70° N. As we go toward the lake it gradually decreases so that at the mouth of the river there is a dip of not more than 25° N. The strike does not materially change, lying always between N. 70° and 80° E.

It does not, on the whole, seem that this change of dip is the result of tilting during Keweenawan times. If so the basic rocks would surely take a more important place in the building up of the great conglomerate beds. It is quite true that the basic pebbles would wear down rapidly, but, at any rate, the finer material between the pebbles would be basic; but it is not, it is acid. There are, however, a few of these basic pebbles present, but it seems to me easier to explain the presence of these pebbles without the tilting in Keweenawan time than it is the absence of basic material if the tilting took place during Keweenawan times.

The amount of felsite in the sedimentary rocks is enormons when compared with the amount in place. It seems quite certain that all of this material could not come from the felsite beds in sight. It seems more probable that there were originally great felsite knobs that have been worn away.

Again, there must be a reason why so much basic material began suddenly to be laid down at the beginning of the Nonesuch formation. It is at least suggestive of a time break, and that the base of the Keweenawan is being exposed and subjected to degredation.

Before leaving the rock descriptions I wish to call attention again to the fact that the divisions made above are merely for the sake of convenience in this present paper. The name "Chippewa" felsite is used in the same manner.

In the first part of the paper great north and south gaps were spoken of as breaking through the ridge near Bessemer. This ridge has in it several characteristic beds such as felsite-porphyrites and labradorite-porphyrites. The identifying of these bands is an easy task, and the identification makes it quite evident that there are at least four dip faults in the area worked.

Lying immediately north of Bessemer is a gap, at least a mile wide, through the ridge. The rocks are well exposed on either side, and a throw of about 1500 ft. is easily proved. West, about a half mile, from this gap is another fault with a throw of about 75 ft. The evidence of this fault is shewn by the rocks exposed about three-eights of a mile south of quarter-pin 4-9-47-46. About 300 ft. west of the rocks are thrown in the opposite direction about 125 ft. The stream bed of Powder-Mill creek lies in the line of weakness of another fault, the beds on the west side of the stream being shifted between 400 and 500 ft. north of those on the east side of the stream. Again in 6-47-46 there is evidence of a fault with considerable throw. In all these cases the west side is thrown north. These faults cause a line of weakness along which the rocks are easily weathered away, hence the gaps through the ridge.

There are evidences of faulting along the bed of Black River, slickensides and fractured rock being very common. In one place, 28-48-46, there is a very prominent fault-breccia. In no place in the river bed is there any evidence of the amount of throw. It is always evident that the fault plan is nearly north and south.

The Nonesuch shale is well exposed, west of the river mouth, along the lake shore, but it shews no ready evidence of faulting.

It is possible that the bed of Maple Creek is along the line of weakness caused by a fault.

The general surface of the country is about 600 feet above Lake Superior. The Bessemer ridge, Chippewa hill, the eastern highlands and the conglomerate ridge are all about equally high and are between 200 and 300 feet above the surrounding country. Except these elevated portions the country is generally level. The lake front is marked by terraces the first being about 100 feet. Behind it the country generally rises, so that with a distance of two miles the general elevation is reached. The lake has banks of red clay from 90 to 100 feet high, along whose base is a narrow bench.

Over the whole area there are numerous swamps of cedar and alder. A great deal of the land is swampy and would be very difficult to traverse during the wet season, especially the western part of the area worked.

In the last three miles of its course Black River has held pretty permanently to its present bed, but above that it has wandered considerably, and has cut out a valley of some width. For the most part there are thick cedar swamps along both edges of the river but in some places it is cutting into the foot of the bank.

The whole country is covered with glacial till, and in many places there are numerous large boulders in the soil. Of the fifty square miles of area covered by the party at least forty are fit for cultivation. Most of the land is second rate and, indeed, some is third rate, but there is a small amount which is first rate. However, before being put under cultivation, much of it would require to be drained. There are some farmers near Bessemer, and where they have cleared the land they have good looking farms. I do not know how much they produce annually, but they appear to be getting on well, quite as well as many farmers in Southern Michigan. The winter season is long, of course, and the summer short and with the danger of late frosts in the spring, and early frosts in the fall, there is a limit to the kinds of grain that can be produced. It is certain too, that it must be difficult and expensive to feed stock through a winter so long and cold. I do not know that I could advise any person to take up a farm in the district, for there is yet much land in the United States which is more easily put under cultivation, and is more valuable. At the same time, I must say that it is possible to live on this land, and live well too. If the time comes, and come it must, though probably not soon, when the people of the United States are being crowded for room such districts as this, although now only a wilderness, will support many people.

The country is covered with hemlock and maple chiefly, but there is a small amount of pine and spruce. In some places the timber is small and without value, as in 29 and 30 48-46, which have practically nothing but small poplar and spruce, mostly about three inches in diameter, and so thickly grown together that it is difficult to get through. There is a great deal of small cedar in the swamps.

In 18-48-46 there is a large peat bog covering at least a half square mile. The peat is generally about six feet thick. There are several other smaller peat bogs some on the west side of the river, and some on the east. There is no doubt that they will produce much fuel when the time comes that it is required.

Black River has many falls and rapids, and is capable of yielding a great deal of power. Even in the low water season of August there is considerable water in the river.

It is difficult to say whether there will ever be any copper mining in the western part of the Michigan Keweenawan. There does not appear to be any geological reason why copper should not be present as on Keweenaw Point. Copper is present in Western Michigan but it has not been found in quantity. Some of the rock from 3 and 4-48-46 shewed small particles of copper but the shewing was only small.

There have been some attempts at mining. Several years ago, in fact before 1850, some tunneling was done in the side of Chippewa hill. More recently an attempt was made by the Old Peak Mining company on the same hill and in 34-49-46 but without success.

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