PROCEEDINGS

OF THE

Iowa Academy of Science

FOR 1914

VOLUME XXI

EDITED BY THE SECRETARY

PUBLISHED BY THE STATE

DES MOINES
ROBERT HENDERSON, STATE PRINTER
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LETTER OF TRANSMITTAL.

Des Moines, Iowa, July 1, 1914.

To His Excellency, George W. Clarke, Governor of Iowa:

In accordance with the provisions of title 2, chapter 5, section 136, code supplement, 1907, I have the honor to transmit herewith the proceedings of the twenty-eighth annual session of the Iowa Academy of Science and request that you order the same to be printed.

Respectfully submitted,

James H. Lees,
Secretary Iowa Academy of Science.

OFFICERS OF THE ACADEMY.

1913.

President—C. N. Kinney.
First Vice President—H. S. Conard.
Second Vice President—Henry Albert.
Secretary—L. S. Ross.
Treasurer—George F. Kay.

EXECUTIVE COMMITTEE.

Ex-officio—C. N. Kinney, H. S. Conard, Henry Albert, L. S. Ross, George F. Kay.
Elective—E. N. Wentworth, E. J. Cable, A. G. Smith.

1914.

President—H. S. Conard.
First Vice President—H. M. Kelly.
Second Vice President—L. S. Ross.
Secretary—James H. Lees.
Treasurer—A. O. Thomas.

EXECUTIVE COMMITTEE.

Ex-officio—H. S. Conard, H. M. Kelly, L. S. Ross, James H. Lees, A. O. Thomas.
Elective—E. J. Cable, A. G. Smith, C. O. Bates.

PAST PRESIDENTS.

Osborn, Herbert	1887-88
Todd, J. E.	1888-89
Witter, F. M.	1889-90
Nutting, C. C.	1890-92
Pammel, L. H.	1893
Andrews, L. W.	1894
Norris, H. W.	1895
Hall, T. P.	1896
Franklin, W. S.	1897
Macbride, T. H.	1897-98
Hendrixson, W. S.	1899
Norton, W. H.	1900
Veblen, A. A.	1901
Summers, H. E.	1902
Fink, Bruce	1903
Shimek, B.	1904
Arey, M. F.	1905
Bates, C. O.	1906
Tilton, John L.	1907
Calvin, Samuel	1908
Almy, Frank F.	1909
Houser, Gilbert L.	1910
Begeman, L.	1911
Bennett, A. A.	1912
Kinney, C. N.	1913

MEMBERS OF THE IOWA ACADEMY OF SCIENCE.

LIFE.

Beyer, S. W....................Ames
Clarke, J. Fred............Fairfield
Conard, Henry S.............Grinnell
Erwin, A. T....................Ames
Fitzpatrick, T. J...........Lamoni
Greene, Wesley...........Des Moines
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Kay, G. F.................Iowa City
Kuntz, Albert, St. Louis Univ., St. ....Louis, Mo.
Norton, W. H.............Mt. Vernon
Pellett, Frank C............Atlantic
Ricker, Maurice..........Des Moines
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Seashore, C. E.............Iowa City
Shimek, B.................Iowa City
Summers, H. E..................Ames
Sylvester, R. H............Iowa City
Tilton, J. L..................Indianola
Williams, Mabel C.........Iowa City
Wylie, R. B...............Iowa City

FELLOWS.

Albert, Henry.............Iowa City
Almy, F. F..................Grinnell
Anderson, J. P..........Sitka, Alaska
Arey, M. F...............Cedar Falls
Bailey, Bert H.........Cedar Rapids
Baker, H. P., College of Forestry, ...Syracuse, N. Y.
Baker, J. A.................Indianola
Baker, R. P...............Iowa City
Bakke, A. L...................Ames
Bates, C. O..............Cedar Rapids
Begeman, Louis..........Cedar Falls
Bennett, A. A............Orange, Cal.
Bond, P. A................Iowa City
Brown, F. C...............Iowa City
Buchanan, R. E................Ames
Burnett, L. C..................Ames
Cable, E. J...............Cedar Falls
Condit, Ira S.............Cedar Falls
Cratty, R. I...............Armstrong
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Dox, A. W.....................Ames
Evvard, J. M...................Ames
Farr, Clifford H..........Iowa City
Fawcett, H. S..........Whittier, Cal.
Fay, Oliver J.............Des Moines
Finch, G. E..............Dillon, Mont.
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Gow, Jas. E.............Cedar Rapids
Guthe, Karl E.....Ann Arbor, Mich.
Guthrie, Jos. E. ....Ames
Hadden, David E................Alta
Hayden, Ada...................Ames
Hendrixson, W. S............Grinnell
Hersey, S. F.............Cedar Falls
Jenner, E. A..............Indianola
Kellogg, Harriette S..........Ames
Kelly, H. M.............Mt. Vernon
Keyes, Charles R........Des Moines
King, Charlotte M.............Ames
Kinney, C. N.............Des Moines
Knight, Nicholas........Mt. Vernon
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Kunerth, Wm...................Ames
Learn, C. D...........Stillwater, Okla.
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Macbride, T. H............Iowa City
McClintock, J. T...........Iowa City
Miller, A. A..............Davenport
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Mueller, H. A.............St. Charles
Norris, H. W................Grinnell
Nutting, C. C..............Iowa City
Orr, Ellison................Waukon
Pammel, L. H...................Ames
Pearce, J. N...............Iowa City
Pearson, R. A..................Ames
Peck, Morton E..........Salem, Ore.
Pew, W. H.....................Ames
Rockwood, E. W...........Iowa City
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Sieg, L. P.................Iowa City
Smith, A. G................Iowa City
Spinney, L. B..................Ames
Stange, C. H...................Ames
Stanton, E. W..................Ames
Stevenson, W. H................Ames
Stewart, G. W.............Iowa City
Stromsten, Frank A.......Iowa City
Thomas, A. O..............Iowa City
Trowbridge, A. C..........Iowa City
Turpin, C. M...................Ames
Van Hyning, T.......Gainesville, Fla.
Van Tuyl, F. M., Univ. Chicago, ... Chicago
Watson, E. B............Merced, Cal.
Webster, R. L..................Ames
Wells, A. A....................Ames
Wentworth, E. N., Agri. College ....Manhattan, Kas.
Wickham, H. F.............Iowa City
Williams, Ira A........Corvallis, Ore.
Wilson, Guy West..........Iowa City
Woodward, S. M...........Iowa City

ASSOCIATE.

Aitchison, Miss A. E.....Cedar Falls
Allen, F. W. ....Ames
Anderson, Miss Helvig...........
..................Rock Island, Ill.
Anderson, W. B................Ames
Armstrong, Leona............Spencer
Arnold, John F........Dallas Center
Ball, Theo. R.........Champaign, Ill.
Bardwell, Etta M......Cedar Rapids
Begg, A. S..........Cambridge, Mass.
Bennett, Walter W........Sioux City
Berninghausen, Fred ....Eldora
Berninghausen, Fred W..........
....................New Hartford
Berry, George H........Cedar Rapids
Bonney, A. F.............Buck Grove
Boot, David H..............Iowa City
Boyd, Mark F., Uni. of Nevada,
.......................Reno, Nev.
Brook, A. H....................Boone
Brown, Percy E................Ames
Buchanan, John H............Ames
Butterfield, E. J.......Dallas Center
Carlisle, L. B...............Dawson
Carter, Chas................Fairfield
Case, Chauncey ....Larrabee
Cavanagh, Lucy M.........Iowa City
Churchill, E. P..............Anamosa
Coe, H. S.............Brookings, S. D.
Colgrove, C. P............Cedar Falls
Collett, S. W................Fayette
Conklin, R. E.............Des Moines
Coffin, Chas. L., Penn College..
.... Oskaloosa
Cotten, Ruth H...........Iowa City
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Davis, W. H..............Cedar Falls
Dieterich, E. O............Iowa City
Dill, Homer R..............Iowa City
Dodd, L. E..................Iowa City
Dole, J. Wilbur..............Fairfield
Doty, H. S......................Ames
Eggleston, H. Ray........Storm Lake
Ellis, S. F...............Des Moines
Ellyson, C. W..................Alta
Ewers, A. F............St. Louis, Mo.
Finlayson, Jessie.........Des Moines
Foft, Samuel F.............Waukee
Fordyce, Emma J........Cedar Rapids
Fraser, Chas. M.......Nanaimo, B. C.
Frazier, Sabena S...........Oskaloosa
Frazier, Zoe R............Oskaloosa
French, R. A.............Des Moines
Fry, E. J., Queens College........
...................Kingston, Ont.
Gabrielson, Ira N.......Marshalltown
Giddings, Levi A.......Cincinnati, O.
Gittins, E. Mae.........Williamsburg
Goodell, F. E.............Des Moines
Griffith, Mary C.......Whittier, Cal.
Hagan, Wayne..............Clinton
Hammer, B. H.................Ames
Hanson, Elma May.......Des Moines
Hawkins, H. L..............Arlington
Hayer, Walter E...........Woodbine
Hayward, W. J............Sioux City
Heuse, E. O...........Champaign, Ill.
Higbee, F. G................Iowa City
Higley, Ruth................Grinnell
Hills, F. B............Newark, Del.
Jeffs, Royal E.........Wichita, Kan.
Jewell, Susan G..............Tabor
Johns, E. W.................Kingsley
Johnson, F. W...........Chicago, Ill.
Kemp, Elda M.........Hibbing, Minn.
Kenoyer, L. A.....Independence, Kan.
King, Inez Naomi.......Mt. Pleasant
Kuser, Wm. L.................Eldora
Larson, G. A..............Des Moines
Lawrence, F. A......Morse Bluff, Neb.
Lazell, Fred J.........Cedar Rapids
Leighton, Morris M., Univ. Chicago.................Chicago, Ill.
Lindley, John M............Winfield
Lloyd-Jones, Orren ....Ames
MacDonald, G. B................Ames
McCracken, H. W.......Columbus, O.
McKenzie R. Monroe........Fairfield
Merrill, D. E., State Coll., New Mex.
Messenger, G. H.............Linden
Moeller, Otto F.........Cedar Rapids
Morbeck, Geo. C........Sta. A., Ames
Mount, Geo. H............Cedar Falls
Muilenburg, G. A.......Golden, Colo.
Mull, Lewis B..........Chicago, Ill.
Neidig, R. E....................Ames
Ness, Henry....................Ames
Newell, Walter S.......Cedar Rapids
Nollen, Sara M...........Des Moines
Oleson, O. M...............Ft. Dodge
Paige, F. W.................Ft. Dodge
Patrick, W. W.............Iowa City
Paull, Mabel A............Sigourney
Pierson, Elvers.......St. Charles, Ill.
Plagge, H. J....................Ames
Quigley, T. H...........Fargo, N. D.
Read, O. B...............Cedar Falls
Redenbaugh, H. E....Stillwater, Okla.
Reilly, John F............Iowa City
Riggs, L. K...................Toledo
Roberts, T. ....St. Charles
Robinson, C. L..............Norwalk
Schatz, A. H. ....Merrill
Schmitt, C. J.................Avoca

Schultz, Orville ....Postville
Shimek, Ella..............Iowa City
Shipton, W. D..............Iowa City
Smith, Dr. Geo. L........Shenandoah
Somes, M. P......Mountain Grove, Mo.
Stanley, Forrester C.......Oskaloosa
Stephens, T. C.............Sioux City
Stevens, Wilbert A.............Tabor
Stewart, Katherine L...........
.............R. F. D. 1. Davenport
Stiles, Harold.................Ames
Stoner, Dayton............Iowa City
Taylor, Miss Beryl.......Macon, Ga.
Teeuween, Mrs. Gladys....Iowa City
Tenney, Glenn I..........Des Moines
Treganza, J. A. ....Britt
Truax, T. R...................Ames
Tuttle, E. V...............Lanesboro
Verink, E. D............Cedar Rapids
Vorhies, Fred...............Lansing
Walters, G. W............Cedar Falls
Watson, E. E................Fairfield
Webster, C. L. ....Charles City
Weigle, C. M..........Appleton, Wis.
Wheat, G. G.........Cambridge, Mass.
Whitney, Thomas H........Atlantic
Wifvat, Samuel, U. P. Sta., Des Moines
Williams, Arthur J........Iowa City
Wolden, B. O.............Wallingford
Wylie, Charles A................
...........U. P. Sta., Des Moines
Yothers, J. F....................Toledo

CORRESPONDING MEMBERS.

Andrews, L. W....................................Davenport
Arthur, J. C..............................Purdue University, Lafayette, Ind.
Bain, H. F......................................San Francisco, Cal.
Ball, C. R........................Department of Agriculture, Washington, D. C.
Ball, E. D..........................State Agricultural College, Logan, Utah
Barbour, E. H..............................State University, Lincoln, Nebr.
Bartsch, Paul...................Smithsonian Institution, Washington, D. C.
Beach, Alice M............................University of Illinois, Urbana, Ill.
Bessey, C. E..............................State University, Lincoln, Nebr.
Bruner, H. L..Irvington, Ind.
Carver, G. W..Tuskegee, Ala.
Conrad, A. H..............................18 Abbott Court, Chicago, Ill.
Cook, A. N..................University of South Dakota, Vermillion, S. Dak.
Drew, Gilman C......................................Orono, Maine
Eckels, C. W........................University of Missouri, Columbia, Mo.
Fink, Bruce ....Oxford, Ohio
Franklin, W. S....................Lehigh University, South Bethlehem, Pa.
Frye, T. C..............................State University, Seattle, Wash.
Gillette, C. P.......................Agricultural College, Fort Collins, Colo.
Goodwin, J. G....................................East St. Louis, Ill.
Gossard, H. A.......................................Wooster, Ohio
Halsted, B. D...................................New Brunswick, N. J.
Hansen, N. E.....................................Brookings, S. D.
Haworth, Erasmus.........................State University, Lawrence, Kans.
Hitchcock, A. S..................Department of Agriculture, Washington, D. C.
Hume, N. H......................................Glen St. Mary, Fla.
Leonard, A. G...................................Grand Forks, N. Dak.
Leverett, Frank ....Ann Arbor, Mich.
Miller, B. L...................................South Bethlehem, Pa.
Newell, Wilmon.................................College Station, Texas
Osborn, Herbert ....State University, Columbus, Ohio
Patrick, G. E.................Department of Agriculture, Washington, D. C.
Price, H. C..............................State University, Columbus, Ohio
Read, C. D..........................Weather Bureau, Sioux City, Iowa
Savage, T. E..Urbana, Ill.
Sirrine, Emma ....Dysart, Iowa
Sirrine, F. A......................124 South Ave., Riverhead, New York
Todd, J. E...Lawrence, Kan.
Trelease, William......................University of Illinois, Urbana, Ill.
Udden, J. A.......................................Rock Island, Ill.

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PROCEEDINGS OF THE

Twenty-Eighth Annual Session of the Iowa Academy of Science

REPORT OF THE SECRETARY.

Fellows and Members of the Iowa Academy of Science:

During the year the secretary has carried on the usual correspondence with the members, sending out three or four circular letters relative to the annual meeting, and on April 18 the printed program, of titles received to that date, was mailed. Since the printing of the program five other titles have been received, making a total of fifty-five, only three below the largest number ever presented before the Academy. Last year fifty-eight titles were presented.

Following out the instruction of the Academy at the 1913 meeting, addressed postal cards were sent to all fellows and associate members in a circular letter, asking for the educational positions occupied, or positions of honor, the information to be used in making up the lists of the members in the Proceedings. Something over ninety replies were received. This will make a beginning toward a more nearly complete directory.

The volume of the Proceedings for 1913 is the largest that has yet appeared; in fact, it is beyond the size allowed by the State. The ruling at the office of the Secretary of State is to the effect that all pages including blanks, but excepting the inserts, are to be counted toward the allotted 300. Such a ruling makes the number of pages in Vol. XX, fifty-six in excess of the number paid for by the State. The expense of this excess must be borne by the Academy. The number of pages included in the manuscript submitted cannot be determined until the type is set; and it is not practicable for the secretary to attempt to eliminate articles in order that the number may be kept within the 300. It is to be hoped that the committee appointed by the president to take up with the legislature the matter of increased number of pages may be successful in their work, and may obtain a removal of restriction or may secure an increase sufficient for years to come.

There are three groups of members in the Academy; one of these groups consists of "corresponding fellows, to be elected by vote from original workers in science in other states; also, any fellow removing to another state from this may be classed as a corresponding fellow." Those elected from original workers in other states are in reality elected to honorary fellowships, the honor, sometimes perchance, being to the Academy rather than to the one so elected. On April 29, 1911, an amendment to Sec. 4 was adopted reading as follows: "An annual fee of $1.00 shall be required from each corresponding fellow." The requirement of such a fee may be justifiable but the secretary is at a loss to know upon what grounds. In his opinion the amendment should be modified or should be stricken out.

A portion of an amendment adopted May 1, 1909, reads: "A person may become a life member on the payment of $7.00 after his election as a fellow, the transfer to be made by the treasurer." The secretary begs leave to suggest his belief that the life membership is too small, and that it should be increased to $15.00 at least.

Would it be advisable on the part of the Academy to attempt to enlarge the scope of its work sufficiently to have sectional meetings at the annual meeting? Would it be possible to have a biological section, a chemical section, a physical section, geological, psychological, mathematical? Why not have the archeologists, mathematicians, and the psychologists of the state in the ranks of the Academy? Possibly the botanist might not find papers on mathematics of absorbing interest, and most certainly the mathematician can imagine things more interesting to him than papers on zoology. But in the sectional meeting a member would find that which is of interest on topics which he might feel fitted to discuss. Isn't the Academy established firmly enough to contemplate such an enlargement, and wouldn't its influence in the state be increased thereby? The work of the Academy should be known by every educated person in the state, and should appeal to every one interested in any phase of science.

Respectfully submitted,

L. S. Ross,
Secretary.

TREASURER'S REPORT.

RECEIPTS.

Cash on hand April 26th, 1913	$162.70
Dues and initiation fees from fellows and members	215.00
Life members fees	28.00
Sale of Proceedings	3.52
Interest on Deposits	4.00
Total	$413.22

EXPENDITURES.

Expense of Lecturer, 27th meeting	$ 35.00
Postage, record book and stenographic work for treasurer	19.30
Programs, letter heads, post cards, etc., for Secretary	19.25
300 copies of Iowa Academy of Science Vol. XIX	221.27
Reprinting pages of Volume XIX	17.85
Cutting, stitching, pasting and trimming 100 copies, Vol. XIX	20.00
100 reprints of Vol. XIX	16.00
Wrapping and sending out Vol. XIX	10.00
Honorarium to Secretary	25.00
Postage, stamped envelopes, envelopes, etc., for Secretary	24.58
Cash on hand	4.97
Total	$413.22

Respectfully submitted,

GEORGE F. KAY, *Treasurer.*

REPORT OF COMMITTEE ON SECRETARY'S REPORT.

The committee on Secretary's report, mindful of the suggestions made by the secretary and the treasurer, beg leave to submit the following resolution: First; that the present annual fee for corresponding fellows be discontinued and that an amendment to this effect be submitted to the voting fellows before the next meeting in accordance with the provision of the constitution. Second; that an amendment raising the life membership fee from $7.00 to $15.00 be also submitted to the voting fellows of the Academy in accordance with the provision of the constitution. Third; that it is the sense of the Academy that hereafter the program of the Academy shall consist of two divisions; a general program Friday afternoon followed by sectional programs on Saturday morning or vice versa. That the president be authorized to appoint a committee, with full power to act, to determine the nature of these sections for next year. The report of the committee shall be provisional or tentative for the next meeting of the Academy. We would suggest that if the sectional plan be adopted, separate leaders be appointed by the president unless otherwise provided for, who shall have charge of the various sectional programs.

L. BEGEMAN,
G. W. STEWART,
S. F. HERSHEY,
Committee.

REPORT OF COMMITTEE ON MEMBERSHIP.

The Committee on Membership recommended the following:

Transfers from list of members to list of fellows.—P. A. Bond, Cedar Falls; Clifford H. Farr, Iowa City; W. Kunerth, Ames; Ellison Orr, Waukon; G. W. Walters, Cedar Falls; R. L. Webster, Ames; Francis M. Van Tuyl, Denmark.

To be elected to membership.—Miss Leona Armstrong, Spencer; A. C. Bailey, Steamboat Rock; Walter W. Bennett, Sioux City; Fred W. Berninghausen, Marble Rock; A. F. Bonney, Buck Grove; F. H. Broos, Boone; L. B. Carlisle, Eldora; Chas. L. Coffin, Iowa City; Ruth Cotton, Iowa City; L. E. Dodd, Iowa City; J. Wilbur Dole, Fairfield; H. Ray Eggleston, Storm Lake; Samuel F. Taft, Waukee; Jessie Finlayson, Des Moines; E. J. Fry, Iowa City; Wayne Hagen, Clinton; Elma May Hanson, Des Moines; W. J. Hayward, Sioux City; E. W. Johns, Kingsley; Inez Naomi King, Mt. Pleasant; Orren Lloyd-Jones, Ames; Otto F. Moeller, Cedar Rapids; G. C. Morbeck, Ames; E. L. Palmer, Cedar Falls; Herman E. Redenbaugh, Tabor; Orville Schultz, Ames; W. D. Shipton, Cedar Rapids; Arthur Smith, Little Rock; Wright Stacy, Iowa City; T. R. Truax, Ames; E. D. Verink, Cedar Rapids; E. E. Watson, Fairfield; Samuel Wifvat, U. P. Station, Des Moines; Arthur J. Williams, Iowa City; B. O. Wolden, Wallingford; Chas. A. Wylie, U. P. Station, Des Moines; J. F. Yothers, Toledo.

Report adopted.

L. S. Ross,
G. F. Kay,
Committee.

INCOMPLETE LIST OF THOSE IN ATTENDANCE.

A. F. Aitchison, M. F. Arey, C. O. Bates, L. Begeman, F. C. Brown, E. J. Cable, H. S. Conard, Ira S. Condit, W. H. Davis, Clifford H. Farr, J. E. Guthrie, J. C. Jensen, H. M. Kelley, G. F. Kay, L. E. Kenoyer, W. Kunerth, C. N. Kinney, G. A. Larson, D. W. Morehouse, L. H. Pammel, H. J. Plagge, O. B. Read, L. S. Ross, E. W. Rockwood, Dayton Stoner, L. P. Sieg, G. W. Stewart, H. E. Summers, Mabel C. Williams, G. W. Walters, Fred Berninghausen, D. H. Boot, Nicholas Knight, J. N. Pearce, J. H. Lees, P. A. Bond, S. F. Hershey.

OFFICERS OF THE ACADEMY FOR 1914-1915.

President....................................H. S. Conard, Grinnell
First Vice-President....................H. M. Kelly, Mount Vernon
Second Vice-President.......................L. S. Ross, Des Moines
Secretary...............................James H. Lees, Des Moines
Treasurer.................................A. O. Thomas, Iowa City

ELECTIVE MEMBERS OF THE EXECUTIVE COMMITTEE.

E. J. Cable, Cedar Falls; A. G. Smith, Iowa City; C. O. Bates, Cedar Rapids.

PROGRAM.

The meetings of the Academy were held in the General Assembly Room, Science Hall, Iowa State Teachers College, Cedar Falls, beginning at 1:30 p. m., Friday, April 24. A business meeting was called first, after which scientific papers were presented. The time Saturday forenoon was occupied with the remaining papers and with the final business meeting.

Dr. N. H. Winchell of the Minnesota Historical Society, gave the public address at 8:00 p. m. Friday. His subject was "The Antiquity of Man in America in Comparison With Europe."

A reception was given to the members of the Academy and friends after the address. Following the business session of Saturday forenoon a luncheon was served in the Gymnasium.

TITLES OF PAPERS RECEIVED.

1. Sulfofication in Soils .... P. E. Brown
   Bact. Lab., Ia. State Coll.
2. The Des Moines Diphtheria Epidemic of 1912-13 .... Chas. A. Wylie
   Bact. Lab., Drake Univ.
3. Bacterial Content of Desiccated Egg .... L. S. Ross
   Bact. Lab., Drake Univ.
4. An Incubator Opening to the Outside of the Building .... L. S. Ross
   Bact. Lab., Drake Univ.
5. U. S. Kelp Investigations in Alaska .... Robert B. Wylie
   Botan. Lab., S. U. I.
   Read by Title.
6. The Pollination of Vallisnaria .... Robert B. Wylie
   Botan. Lab., S. U. I.
   Read by Title.
7. Field and Forest Floras of Monona County .... David H. Boot
   Botan. Lab., S. U. I.
8. The Origin of the Cocklebur .... Clifford H. Farr
   Botan. Lab., S. U. I.
   Read but not offered for publication.
9. Notes on a Fossil Tree-Fern of Iowa .... Clifford H. Farr
   Botan. Lab., S. U. I.
10. The Myxomycetes of Puget Sound .... Thomas H. Macbride
    Botan. Lab., S. U. I.
    Read by Title.
11. Some Notes on the Ecology of Iowa Lichens .... Zoe R. Frazier
    Newton, Iowa.
12. Preliminary Report on the Flora of Linn County .... Ellis D. Verink
    Botan. Lab., Coe Coll.
13. The Male Gametophyte of Arisaema .... James E. Gow
    Botan. Lab., Coe Coll.
    Read by Title.

14. Sunflecks ....W. H. Davis
Botan. Lab., Ia. State Teachers' Coll.
15. Some Observations on Sycamore Blight and Accompanying Fungi
....J. P. Anderson
Botan. Lab., Ia. State Coll.
16. Weed Survey in Story County..............................L. H. Pammel
Botan. Lab., Ia. State Coll.
17. Alien Plants of Clear Creek Valley, Colorado..............L. H. Pammel
Botan. Lab., Ia. State Coll.
18. Notes on Variation in Micranthes Texana..................L. A. Kenoyer
Biol. Lab., Leander Clark Coll.
19. Barium in Tobacco and Other Plants....................Nicholas Knight
Chem. Lab., Cornell Coll.
Read by Title.
20. Colloidal Common Salt..................................Nicholas Knight
Chem. Lab., Cornell Coll.
Read by Title.
21. Electromotive Forces and Electrode Potentials in Mixed Solvents
....J. N. Pearce
Chem. Lab., S. U. I.
22. Equilibrium in the System—Mercuric Iodide-Anilin..................
.... J. N. Pearce and E. J. Fry
Chem. Lab., S. U. I.
23. Earth Movements and Drainage Lines in Iowa..............James H. Lees
State Geol. Surv.
24. Some Evidences of Recent Progress in Geology................G. F. Kay
State Geol. Surv.
25. Siouan Mountains; An Iowan Triassic Episode............Charles Keyes
Des Moines, Iowa.
26. Serial Unit in Stratigraphic Classification.................Charles Keyes
27. Stratigraphic Position of Our Oldest Rocks................Charles Keyes
28. On Precious Stones in the Glacial Drift............Garrett A. Muilenburg
Geol. Lab., S. U. I.
29. A New Section of the Railway Cut Near Graf, Iowa.........A. O. Thomas
Geol. Lab., S. U. I.
30. The Surface Clay of Adair County (Second Paper)........James E. Gow
Geol. Lab., Coe Coll.
Read by Title.
31. Evidences of Sand Dune Formation in Cedar Rapids and Vicinity
....Washburn D. Shipton
Geol. Lab., Coe Coll.
Read by Title.
32. Indian Pottery of the Oneota or Upper Iowa River Valley.....Ellison Orr
Waukon, Iowa.
33. Longitude by Wireless ....D. W. Morehouse
Phys. Lab., Drake Univ.
Read but not offered for publication.
34. Illuminating Power of Kerosenes Used in Iowa...........William Kunerth
Phys. Lab., Ia. State Coll.
35. Certain Diffraction Experiments in Sound..Harold Stiles and G. W. Stewart
Phys. Lab., S. U. I.

ABSTRACT.

This paper describes three experiments in sound diffraction, viz., the shadow of a rigid sphere, the passage of sound through narrow slits, and the sound through circular apertures.

Previous theoretical investigations are verified to within a reasonable degree in all three experiments. The paper is published in full in the Physical Review for April, 1914.

36. The Variation of Sound Intensity with Distance from the Source; An Interesting Case of Deviation from the Inverse Square Law ....G. W. Stewart
Phys. Lab., S. U. I.

37. Notes on the Construction of Selenium Bridges..........E. O. Dieterick
Phys. Lab., S. U. I.

38. The Adaptation of Selenium to Measurements of Energy Too Small to be Measured by Other Devices........L. P. Sieg and F. C. Brown
Phys. Lab., S. U. I.

39. The Effect of Pressure on the Light-Sensibility of Metallic Selenium Crystals..................................F. C. Brown and L. P. Sieg
Phys. Lab., S. U. I.
Read by title.

40. Sex Linked Factors in the Inheritance of Rudimentary Mammae in Swine..Edward N. Wentworth
Kansas Agri. College, Manhattan, Kansas.

41. The Effect of Calcium and Protein Fed Pregnant Swine Upon the Size, Vigor, Bone and Coat of the Resulting Offspring.......... ....John M. Evvard, Arthur W. Dox and S. C. Guernsey
Animal Husbandry, Ia. State Coll.

42. A Study of the Crow.......................................Frank C. Pellett
Office State Inspec. of Apiaries.
Read by title.

43. Butterflies of Chance Occurrence in Cass County........Frank C. Pellett
Office State Inspec. of Apiaries.

44. Nature and Birds.......................................Fred Berninghausen
Eldora, Iowa.

ABSTRACT.

Notes the failure of the oak *Quercus sessiliflora* to attain a vigorous development on account of its lack of adaptation to its environment and its inability to protect itself against its enemies. The characteristics and life habits of certain Iowa birds are described and their usefulness or harmfulness is discussed. The birds taken as illustrations are the kill-deer, the whippoorwill, the robin, the kingbird, the wren, the catbird, the screech owl, the quail, the blue jay, the horned owl and the flicker. The horned owl comes in for especial condemnation as a destroyer of our helpful singing birds.

45. Color Vision in Animals............................Mabel C. Williams
Psych. Lab., S. U. I.
Read but not offered for publication.

46. Effect of Low Temperature on the Oyster-Shell Scale, *Lepidosaphes ulmi* Linn...R. L. Webster
Zool. Lab. Ia. State Coll.

ABSTRACT.

The effect of the low temperatures of January, 1912, on the eggs of the oyster-shell scale in Iowa. An account based on samples of scale sent in a year later. In most cases the eggs had been killed by the severe winter.

47. A Catalogue of the Lepidoptera of Linn County........George H. Berry
Cedar Rapids, Iowa.

48. The Coleoptera of Henry County, Iowa..................Inez Naomi King
Zool. Lab., Iowa Wesleyan Univ.

49. An Observation on Longitudinal Division in Hydra..........L. S. Ross
Zool. Lab., Drake Univ.

50. A Convenient Table for Microscopic Drawing.................L. S. Ross
Zool. Lab., Drake Univ.
Read but not offered for publication.

51. Relation of Wind Velocity and Relative Humidity to Evaporation ....D. H. Boot
Bot. Lab., S. U. I.

52. The Origin of Eskers..................................A. C. Trowbridge
Geol. Lab., S. U. I.

53. Preliminary Report on Physiographic Studies in Northeastern Iowa ....A. C. Trowbridge
Geol. Lab., S. U. I.

54. An Area of Wisconsin Drift further South in Polk County, Iowa, than Hitherto Recognized................................John L. Tilton
Geol. Lab., Simpson College.

55. The Question of Electron Atmospheres.......................L. E. Dodd
Phys. Lab., S. U. I.
Read by title.

56. The Butterflies of Woodbury County.....................A. W. Lindsey
Zool. Lab., Morningside College.

57. Unusual Dolomites......................................Nicholas Knight
Chem. Lab., Cornell College.

58. The Sand of Sylvan Beach..............................Nicholas Knight
Chem. Lab., Cornell College.

59. Pleistocene Exposures in Cedar Rapids and Vicinity......W. D. Shipton
Geol. Lab., Coe College.

PAPERS PRESENTED

AT THE

Twenty-Eighth Meeting of the Academy

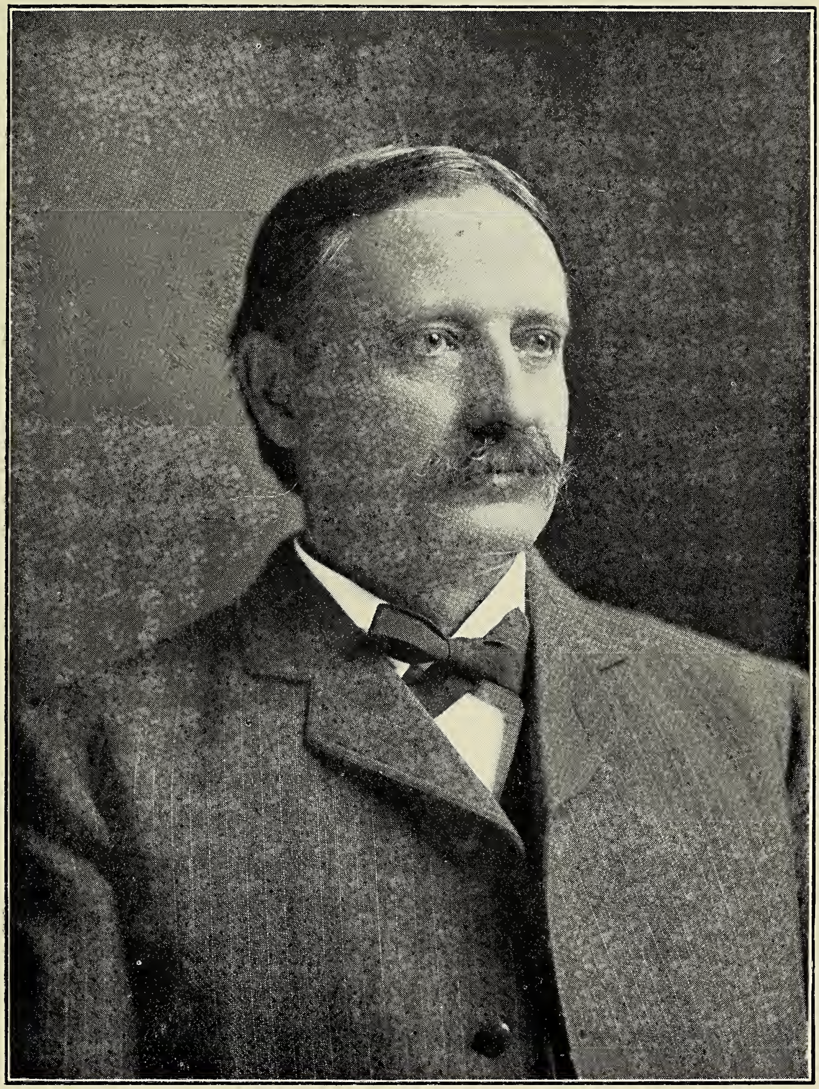

PLATE I. SETH EUGENE MEEK.

MEMORIAL NOTE ON SETH EUGENE MEEK.

BY CHARLES KEYES.

By the death of Dr. Seth Eugene Meek in Chicago on July 6, 1914, the Academy loses one of its charter members, and, in the first years of its existence, one of its most active and devoted workers.

Seth E. Meek was born at Hicksville, Ohio, April 1, 1859; and at the time of his demise, was therefore in the fifty-fifth year of his age. After attending the public schools of his native town, young Meek entered the State University of Indiana, from which he was graduated with honors in 1884. He then attended Cornell University, at Ithaca, New York, where he took up graduate work in zoology. Towards the end of the first year at Cornell being offered the chair of Natural Science in Eureka College (Illinois), he entered upon full professorial duties in that institution, and performed them with great credit for a year, when he was called to Iowa.

Professor Meek, in the autumn of 1887, came to Coe College, at Cedar Rapids, having been elected to the post of Head of the Department of Natural History. During the five years which he spent in this institution he built up the natural science work into one of the leading departments in the college and one of the best in the whole state. Besides working in the field of zoology, in which branch of science he was always most interested, he took a great liking to geology, and in the last mentioned science he continued to carry on important investigations long years after he left the state. His activities were by no means confined wholly to Coe College, but his helpful influence was felt on the educational circles of the entire state. He took a prominent part in the doings of the various educational gatherings which were held during his residence in Iowa. It was during his sojourn in this state that in recognition of his elaborate original investigations in zoological fields the State University of Indiana conferred upon him the degree of doctor of philosophy.

In 1892 Doctor Meek went to Arkansas as professor of zoology and geology in the State University at Fayettesville. Here he remained four years, extending his knowledge on the fishes of the Ozark region. These investigations were conducted in the intervals of a busy school life. He resigned his chair in this institution in order that he might give more of his time and energies to original investigation; and he became connected with the United States Fish Commission. After a year in Washington, Doctor Meek was appointed assistant curator of the Field Museum of Natural History in Chicago, a post which he held with singular distinction until the day of his death.

Other important posts held by Doctor Meek at divers times are that of Assistant Fish Comissioner of New York, lecturer in the State University of Illinois, and Ichthyologist of the Biological Survey of Panama.

Among the more extensive explorations which Professor Meek conducted are those in Mexico, Central America and the western parts of the United States.

Doctor Meek was a member of many of the learned societies, among them the American Association for the Advancement of Science, the Washington Academy of Sciences, the Washington Biological Society, and the Chicago Academy of Sciences. He was vice-president of our Academy for the years of 1890 and 1891.

Among the more pretentious publications of Doctor Meek, mention should be made of his great work on American Salt- and Fresh-water Fishes, North American Reptiles, and Fresh-Water Fishes of Tropical America. Many shorter memoirs were published by the Federal government; and numerous articles appeared in the periodical literature of the day. During the time that he resided in Iowa he traveled widely over the state. An important outcome of these investigations was a volume on the Food-Fishes of Iowa. Other papers to attract wide attention and to direct investigations on the zoological features of our state were published from time to time. Part of this Iowa work of research was undertaken in collaboration with Dr. David Starr Jordan.

While in Iowa Doctor Meek was always in prompt attendance at the sessions of our Academy. Before its members he read many papers; and they were always of the greatest interest, since they were presented in simple, untechnical form that those in other branches of science could readily comprehend. This feature also added a singular charm to his lectures. The following were among the papers read before the Academy:

Food-fishes of Iowa, 1889.

Fishes of the Cedar River Basin, 1890.

Occurrence of Lepus Campestris in Muscatine County, 1890.

Two Cases of Albinoism, 1890.

Fish-fauna of Arkansas and Iowa Compared, 1891.

For many years Doctor Meek was particularly interested in topics relating to the geographic distribution of animals; and from the information that he had derived from the study of the fishes of Mexico and Central America he was impressed with the idea that an investigation in the Canal Zone would throw much light upon this subject. For this reason he spent the greater part of two winters on the Isthmus of Panama, where he was assisted by Mr. S. F. Hildebrand, who represented the Smithsonian Institution, the ichthyological part of the biological work in the Canal Zone having been taken up jointly by that institution and the Field Museum of Natural History. A preliminary article on the results of this work was published in 1913; but a more complete account was being prepared at the time of his death.

Personally Doctor Meek was a man of singular charm of character, of pure motives and of stainless life. He was unassuming and modest to a high degree, always affable, kind, and ever willing to advise and help whomsoever called upon him for aid. As one of his daily associates said of him, "He was true gold."

At a recent meeting of the members of the scientific staff of the Field Museum in Chicago, it was resolved:

> "That the members of the Scientific Staff of the Museum for many years associated with the late Dr. Seth Eugene Meek, Assistant Curator of the Department of Zoology, appreciating his widely recognized scientific ability and worth, as well as his sterling personal character, do hereby express their sincere sympathy to the members of his family in their bereavement, and their deep regret for the loss to the scientific world of one of its leading workers in his field of research."

Doctor Meek was a rather voluminous writer. His more pretentious memoirs number upwards of sixty-five. Since the results of many of his studies on Iowa fishes especially were published elsewhere than in our state reports the complete list is appended.

1. Review of Species of Gerres found in American Waters. (Proc. Acad. Nat. Sci. Philadelphia, 1883, pp. 116-124, Philadelphia, 1884.)
2. Note on Genus Anguilla. (Bull. U. S. Fish Commission for 1883, p. 430, Washington, 1884.)
3. Review of American Species of Scomberomorus. (Proc. Acad. Nat. Sci. Philadelphia, 1883, pp. 219-232, Philadelphia, 1884.) With R. G. Newland.
4. Review of Genus Sphyræna. (Proc. Acad. Nat. Sci. Philadelphia, 1884, pp. 67-75, Philadelphia, 1885.) With R. G. Newland.
5. Review of American Species of Hemirhamphus. (Proc. Acad. Nat. Sci. Philadelphia, 1884, pp. 221-235, Philadelphia, 1885.) With D. K. Goss.
6. Notes on Collection of Anchovies from Havana and Key West; with Account of New Species Stolephorus Eurystole. (Proc. Acad. Nat. Sci. Philadelphia, 1884, pp. 34-46, Philadelphia, 1885.) With J. Swain.
7. Review of American Species of Genus Trachynotus. (Proc. Acad. Nat. Sci. Philadelphia, 1884, pp. 121-129, Philadelphia, 1885.) With D. K. Goss.

8. Review of American Species of Genus Synodus. (Proc. Acad. Nat. Sci. Philadelphia, 1884, pp. 130-136, Philadelphia, 1885.)
9. Note on Cuban Eel. (Bull. U. S. Fish Commission for 1884, p. 111, Washington, 1885.)
10. List of Fishes Collected in St. John's River at Jacksonville, Fla. (Bull. U. S. Fish Commission for 1884, pp. 233-237, Washington, 1885.) With D. S. Jordan.
11. Description of Four New Species of Cyprinidæ. (Proc. U. S. Nat. Museum for 1884, pp. 474-477, Washington, 1885.) With D. S. Jordan.
12. Description of Zygonectes Zonifer, New Species of Zygonectes from Nashville, Ga. (Proc. U. S. Nat. Museum for 1884, pp. 526-527, Washington, 1885.) With D. S. Jordan.
13. Description of New Species of Hybopsis (Hybopsis Montanus). (Proc. U. S. Nat. Museum for 1884, p. 527, Washington, 1885.)
14. Notes on Pipe-fishes of Key West, Fla., with Descriptions of Two New Species. (Proc. U. S. Nat. Museum for 1884, pp. 237-239, Washington, 1885.) With J. Swain.
15. List of Fishes Collected in Iowa and Missouri in August, 1884, with Descriptions of Three New Species. (Proc. U. S. Nat. Museum for 1885, pp. 11-17, Washington, 1886.) With D. S. Jordan.
16. Review of American Species of Flying-fishes. (Proc. U. S. Nat. Museum for 1885, pp. 46-67, Washington, 1886.) With D. S. Jordan.
17. Review of American Genera and Species of Batrachidæ. (Proc. Acad. Nat. Sci. Philadelphia, 1885, pp. 52-62, Philadelphia, 1886.) With E. A. Hall.
18. Review of American Species of Genus Scorpæna. (Proc. Acad. Nat. Sci. Philadelphia, 1885, pp. 394-403, Philadelphia, 1886.) With R. G. Newland.
19. Review of Genus Esox. (Proc. Acad. Nat. Sci. Philadelphia, 1885, pp. 367-375, Philadelphia, 1886.) With R. G. Newland.
20. Revision of American Species of Genus Gerres. (Proc. Acad. Nat. Sci. Philadelphia, 1886, pp. 256-272, Philadelphia, 1887.) With B. W. Evermann.
21. Note on Lamprey of Cayuga Lake. (Annals New York Acad. Sci., 1886, pp. 285-289, New York, 1887.)
22. Note on Elagatis Bipinnulatus. (Proc. Acad. Nat. Sci. Philadelphia, 1889, pp. 42-44, Philadelphia, 1890.) With C. H. Bollman.
23. Report on Explorations made in Missouri and Arkansas during 1889, with Account of Fishes Observed in each of River-basins Examined. (Bull U. S. Fish Commission for 1889, pp. 113-141, Washington, 1890.)
24. Note on Ammocœtes Branchialis, Linneus. (American Naturalist, Vol. XXIII, pp. 640-642, Philadelphia, 1890.)
25. Native Food-fishes of Iowa. (Proc. Iowa Acad. Sci., Vol. I, Pt. i, pp. 68-76, Des Moines, 1890.)
26. Report on Fishes of Iowa Based on Observations and Collections made during 1889, 1890 and 1891. (Bull. U. S. Fish Commission for 1890, pp. 217-248, Washington, 1891.)
27. Fishes of Cedar River Basin. (Proc. Iowa Acad. Sci., Vol. I, Pt. iii, pp. 105-112, Des Moines, 1893.)
28. Catalogue of Fishes of Arkansas. (Ann. Rept. Arkansas Geol. Surv. for 1891, Vol. II, pp. 215-276, Little Rock, 1894.)

29. Description of Etheostoma Pagei. (American Naturalist, Vol. XXVIII, p. 957, Philadelphia, 1894.)

30. New Cambarus (Cambarus Faxonii) from Arkansas. (American Naturalist, Vol. XXVIII, pp. 1042-1043, Philadelphia, 1894.)

31. Report of Investigations Respecting Fishes of Arkansas Conducted during 1891, 1892 and 1893, with Synopsis of Previous Explorations in Same State. (Bull. U. S. Fish Commission, for 1894, pp. 67-94, Washington, 1895.)

32. Notes on Fishes of Western Iowa and Eastern Nebraska. (Bull. U. S. Fish Commission for 1894, pp. 133-138, Washington, 1895.)

33. Description of New Species of Gobiesox (Gobiesox Muscarum). (Proc. California Acad. Sci., Second Series, Vol. V, pp. 571-572, San Francisco, 1896.) With C. J. Pierson.

34. List of Fishes and Mollusks Collected in Arkansas and Indian Territory in 1894. (Bull. U. S. Fish Commission for 1895, pp. 341-349, Washington, 1896.)

35. List of Fishes and Reptiles Obtained by Field Columbian Museum East African Expedition to Somali-land in 1896. (Field Columbian Mus. Pub., Zool. Series, Vol. I, pp. 163-184, Chicago, 1897.)

36. Salmon Investigations in Columbia River Basin and Elsewhere on Pacific Coast in 1896. (Bull. U. S. Fish Commission for 1897, pp. 15-84, Washington, 1898.) With B. W. Evermann.

37. Notes on Collection of Cold-blooded Vertebrates from Olympic Mountains. (Field Columbian Mus. Pub., Zool. Series, Vol. I, pp. 225-236, Chicago, 1899.)

38. Notes on Collection of Fishes and Amphibians from Muskoka and Gull Lakes. (Field Columbian Mus. Pub., Zool. Series, Vol. I, pp. 307-311, Chicago, 1899.)

39. Growth and Variation of Fishes. (Birds and Nature, Vol. VIII, pp. 84-89, 1900.)

40. Geological Succession of Fishes. (Birds and Nature, Vol. VIII, pp. 133-139, 1900.)

41. Genus Eupomotis. (Field Columbian Mus. Pub., Zool. Series, Vol. III, No. 2, 8 pages, Chicago, 1900.)

42. Geographical Distribution of Fishes. (Birds and Nature, Vol. VIII, pp. 161-164, 1900.)

43. Contribution to Ichthyology of Mexico. (Field Columbian Mus. Pub., Zool. Series, Vol. III, pp. 63-128, Chicago, 1902.)

44. Notes on Collection of Cold-blooded Vertebrates from Ontario. (Field Columbian Mus. Pub., Zool. Series, Vol. III, pp. 131-140, Chicago, 1892.) With H. W. Clark.

45. Contribution to Museum Technique. (American Naturalist, Vol. XXXVI, pp. 53-62, 1902.)

46. Review of D. S. Jordan and B. W. Evermann's "American Game and Food Fishes." (American Naturalist, Vol. XXXVI, pp. 557-558, 1903.)

47. Distribution of Fresh-water Fishes of Mexico. (American Naturalist, Vol. XXXVII, pp. 771-784, 1903.)

48. Fresh-water Fishes of Mexico north of Isthmus of Tehuantepec. (Field Columbian Mus. Pub., Zool. Series, Vol. V, 316 pp., Chicago, 1904.)

49. Annotated List of Collection of Reptiles from Southern California and Northern Lower California. (Pub. Field Mus. Nat. Hist., Zool. Series, Vol. VII, No. 1, 20 pp., Chicago, 1905.)
50. Two New Species of Fishes from Brazil. (Proc. Biological Soc. Washington, Vol. XVIII, pp. 241-242, Washington, 1905.)
51. Collection of Fishes from Isthmus of Tehuantepec. (Proc. Biological Soc. Washington, Vol. XVIII, pp. 243-246, Washington, 1905.)
52. Description of Three New Species of Fishes from Middle America. (Pub. Field Mus. Nat. Hist., Zool. Series, Vol. VII, No. 3, 6 pages, Chicago, 1906.)
53. Synopsis of Fishes of Great Lakes of Nicaragua. (Pub. Field Mus. Nat. Hist., Zool. Series, Vol. VIII, No. 4, 38 pages, Chicago, 1907.)
54. Notes on Fresh-water Fishes from Mexico and Central America. (Pub. Field Mus. Nat. Hist., Zool. Series, Vol. VII, No. 5, 28 pages, Chicago.)
55. Zoology of Lakes Amatitlan and Atitlan, Guatemala, with Special Reference to Ichthyology. (Pub. Field Mus. Nat. Hist., Zool. Series, Vol. VII, No. 6, 50 pages, Chicago, 1908.)
56. New Species of Fishes from Tropical America. (Pub. Field Mus. Nat. Hist., Zool. Series, Vol. VII, No. 7, 7 pages, Chicago, 1909.)
57. Synoptic List of Fishes known to Occur within Fifty Miles of Chicago. (Pub. Field Mus. Nat. Hist., Zool. Series, Vol. VII, No. 9, 118 pages, Chicago, 1910.) With S. F. Hildebrand.
58. Batrachians and Reptiles from British East Africa. (Pub. Field Mus. Nat. Hist., Zool. Series, Vol. VII, No. 11, 14 pages, Chicago, 1910.)
59. Notes on Batrachians and Reptiles from Islands north of Venezuela. (Pub. Field Mus. Nat. Hist., Zool. Series, Vol. VII, No. 12, 6 pages, Chicago, 1910.)
60. Descriptions of New Fishes from Panama. (Pub. Field Mus. Nat. Hist., Zool. Series, Vol. X, No. 6, 4 pages, Chicago, 1912.) With S. F. Hildebrand.
61. Mussels of Big Buffalo Fork of White River, Arkansas. (U. S. Dept. Commerce and Labor, Bureau Fisheries, for 1912, pp. 1-20, Washington, 1913.) With H. W. Clark.
62. New Species of Fishes from Costa Rica. (Pub. Field Mus. Nat. Hist., Zool. Series, Vol. X, No. 7, 7 pages, Chicago, 1912.)
63. New Species of Fishes from Panama. (Pub. Field Mus. Nat. Hist., Zool. Series, Vol. X, No. 8, Chicago, 1913.) With S. F. Hildebrand.
64. Annotated List of Fishes Known to Occur in Fresh-waters of Costa Rica. (Pub. Field Mus. Nat. Hist., Zool. Series, Vol. X, No. 10, Chicago, 1914.)
65. Report on Fishes of Panama, (In preparation.)

SULFOFICATION IN SOILS.

P. E. BROWN AND E. H. KELLOGG.

Sulfur has long been known to be one of the essential plant food constituents. It has always been believed, however, that there was sufficient present in all soils for optimum crop production. This assumption has been very largely based on Wolff's analyses of the ash of various crops which showed the presence of very small amounts of sulfur. Several investigators have found a considerable loss of sulfur upon ignition of plants for ash determinations, and recently Hart and Peterson, of Wisconsin, pointed out definitely the inaccuracy of determining the total sulfur of plant tissues by examinations of the ash. They analyzed numerous feeding stuffs for total sulfur, using the Osborn method, and compared their results with the earlier analyses of Wolff. This comparison showed quite conclusively that a large proportion of the sulfur in crops is lost upon ignition. It is evident, therefore, that considerably larger amounts of sulfur are removed from soils by common farm crops than has been supposed.

Analyses of various soils have shown the presence of only a limited amount of sulfur, the subsoil containing no more than the surface soil. The renewal of the sulfur supply in the surface soil from the lower soil layers is possible, therefore, for only a limited period.

The suggestion of Hart and Peterson that soils may be deficient in sulfur and crops may suffer for a lack of this element seems worthy of considerable attention.

Several other interesting suggestions are contained in the work of these men. For instance, it is pointed out that acid phosphate may produce increased yields, not entirely because of the phosphorus added to the soil, but because of the sulfur which is present in the form of calcium sulfate. Ammonium sulfate and potassium sulfate, when applied to soils, may bring about greater crop production, because of their sulfur content as well as their nitrogen or potassium content. Gypsum, which has ordinarily been considered an indirect fertilizer, because of its power to free other constituents, such as potassium, from an insoluble form, may exert a beneficial effect on some soils because of the sulfur contained in it. The fact that soils to which farm manure has been applied contain more sulfur than untreated soils is also clearly shown. The possibility immediately suggests itself that the benefits from the use

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of manure may be due in part to the sulfur present, even although it does occur in complex form.

It is evident from this work that the problem of the sulfur fertilization of soils is one which may be of considerable importance, and is at least worthy of careful study.

Sulfur, as is well known, occurs in crops and in manures in complex organic form in the proteins and must be transformed into sulfates before it can be of use to plants. The rate of production of sulfates in soils must, therefore, be of considerable importance in keeping plants supplied with the amounts necessary for optimum growth. This transformation of sulfur from the protein form into sulfates, like the production of nitrates from proteins, takes place in several stages. First, there is the production of hydrogen sulfide from the proteins. Large numbers of organisms, apparently, are able to decompose proteins with the liberation of this gas. All the decay bacteria are able to bring about this reaction, and, in fact, wherever protein destruction is occurring there is a production of hydrogen sulfide.

Further oxidation of this material immediately occurs through the activities of the sulfofying bacteria, or sulfur-oxidizing bacteria. There are two groups of these, the red, Rhodobacteriaceae, or Pupur-bakterien, and the Thiobacteriaceae, or colorless group. These organisms, as far as we now know, bring about the oxidation of sulfur in two stages. The first is the change from hydrogen sulfide to free sulfur, which is then deposited in granules in the cells of the bacteria. The second stage in the process is the oxidation of this free sulfur to sulfates, in which form the sulfur is available to plants. Winogradsky has isolated nine different organisms which have the power of oxidizing hydrogen sulfide with the production first of sulfur and then of sulfates, and he has shown also the rather extensive distribution of these organisms in nature. It is evident, therefore, that bacteria play an important part in the preparation of sulfates for plant nourishment and the cycle through which sulfur passes in nature would be incomplete without bacterial action.

The rate of production of sulfates in a soil, therefore, must be of considerable significance in the problem of the sulfur feeding of crops. If the sulfur present in organic form is very slowly oxidized to sulfates, crops will not be properly supplied with the element. In other words, if soils do not have a vigorous sulfofying power, there may be an abundance of total sulfur present and still there be an insufficient production of sulfates for optimum crop growth.

The questions, therefore, immediately arise: Can we determine the sulfofying power of soils? How? Is there any relation between the sulfofying power of soils and the proper sulfur feeding of plants? Can methods be devised to increase the sulfofying power of soils, or, in other words, the efficiency of the sulfofying bacteria?

This work was begun mainly to answer the first question: "Is it possible to determine the sulfofying power of soils? If so, how?" Further work is being carried on looking toward the solution of the other questions and considerable data are being accumulated which will be published in the near future. Most of this material is not in shape for presentation at this time and we will merely outline the work which has been carried on and the results, which have shown us that soils do have a sulfofying power and that this power is exceedingly variable in different soils and in soils under different treatment.

Most of the difficulties which have confronted us in this work have been of a chemical nature and we will mention some of them, with the methods which we have devised for their elimination. In the first place, one of the main troubles we have had has been in the extraction of the sulfates from the soil. The methods given in text-books and in all the references available suggested the extraction with dilute hydrochloric acid. A great many tests were run with this acid in varying strengths and comparisons were made with the results obtained by extraction with water. The latter method was found in every case to extract more sulfates than the hydrochloric acid. Magnesium sulfate and calcium sulfate were added to soils in known quantities, and, while practically the entire amounts were obtained according to the extraction with water, only very small proportions were secured when hydrochloric acid was used as a solvent. The calcium sulfate is more insoluble than the magnesium sulfate and its formation is probably more common in soils, hence the complete extraction of this material is regarded as of special significance in showing the value of the method. The stronger the acid employed the smaller was the proportion of the sulfates recovered from the soil. The interference of iron and organic matter undoubtedly explains the low results obtained with the acid. Tests were then made to ascertain how long it was necessary to shake the soil with water in order to extract the sulfates and it was found that six hours in the shaking machine was ample for complete extraction. At first the sulfates were determined by precipitating with barium chloride in the usual way and weighing the barium sulfate produced. This was found to be a very slow method of procedure and the sulfur photometer was obtained and has proved invaluable in giving quicker and quite as accurate results. Comparisons made of the gravimetric and photometric methods show absolute agreement.

Then came the question of deciding on some method of determining the power of the soil to produce sulfates, or its sulfofying power. Taking advantage of the results which have been secured in the study of the ammonifying and nitrifying power of soils, it was decided to use fresh soil as a medium. It was then necessary to employ some material containing sulfur to permit of an accumulation of sulfates to a measurable extent, or, in other words, to accentuate the sulfofying power of the soil just as dried blood or casein have been used in ammonification and ammonium sulfate in nitrification. Various sulfides were first employed, namely, calcium sulfide, barium sulfide, potassium sulfide, and sodium sulfide, and, with the exception of the barium sulfide, there was found to be very rapid transformation of these materials into sulfates, large amounts being produced in three or four days' incubation. There was probably a transformation of the barium sulfide also, but it was impossible to extract the sulfate formed from the soil. So rapid an oxidation occurred that our suspicion was aroused that the action was not entirely bacterial. Careful tests were made and it was found that on shaking any of the sulfides with soil for seven hours without incubation there was a large percentage of oxidation to sulfates. This showed that in the shaking process there was a purely chemical oxidation of the sulfides. This oxidation was much greater for the calcium and potassium sulfides than for the sodium sulfide. The change did not occur in sand and the oxidation varied considerably in extent in different soils.

It is evident, therefore, that it is necessary to ascertain how much chemical oxidation a sulfide will undergo in any particular soil by shaking it with water seven hours before that sulfide can be used as a measure of the sulfofying power of the soil. The percentage transformation of the sulfur into sulfate by chemical means is then subtracted from the total sulfate production after incubation and the difference gives the bacterial oxidizing power of the soil for sulfur.

In order to secure some material in the use of which this chemical oxidation would be avoided pure sulfur and iron sulfide have recently been employed. The former shows practically no oxidation upon shaking with soils and the latter none whatever.

Tests upon these materials are not sufficient yet, however, for any conclusions to be reached, as they have not been carried out with a sufficient number and variety of soils. The results which appear on the tables show the oxidation of sodium sulfide and of sulfur by chemical means and by bacterial action in several different types of soil. The examination of the last column, which shows in each case the percentage transformation of the sodium sulfide, or the sulfur into sulfates by bacterial means, will give some interesting comparisons.

TABLE I.—THE SULFOFICATION OF SODIUM SULFIDE.

Soil No.	Soil Source	Percent water in soils	Mgs. S. as sulfate	Av. mgs. S. as sulfate	Mgs. S. as sulfate in soils	Mgs. S. as sulfate oxidized by shaking	Mgs. S. as sulfate oxidized in soils	Per cent sulfur added oxidized in soils
1	Sandy loam, graveyard	16	9.21					
1	Same	16	10.95	10.08	trace	2.61	7.47	56.03
2	Sandy loam, low, poorly drained area	21	16.91					
2	Same	21	17.29	17.10	5.56	3.61	7.93	59.48
3	Heavy, black woodland soil	26	18.17					
3	Same	26	18.98	18.57	------	13.13*	5.44	40.81
4	Typical sand, river bank	11	4.41					
4	Same	11	4.02	4.21	trace	trace	4.21	31.58
5	Wisconsin drift soil, untreated	18	15.55					
5	Same	18	15.37	15.46	3.19	2.33	9.94	74.56
6	Wisconsin drift soil, manured at rate of 25 tons per acre	15	12.15					
6	Same	15	13.92	13.03	1.52	1.18	10.33	77.49

TABLE II.—THE SULFOFICATION OF FREE SULFUR.

1	Sandy loam, graveyard	16	6.15					
1	Same	16	6.01	6.08	trace	1.48	4.60	4.60
2	Sandy loam, low, poorly drained area	21	12.43					
2	Same	21	11.98	12.20	5.56	1.76	4.88	4.88
3	Heavy, black woodland soil	26	11.57					
3	Same	26	lost	11.57	------	9.87*	1.70	1.70
4	Typical sand, river bank	11	3.61					
4	Same	11	3.51	3.56	trace	trace	3.56	3.56
5	Wisconsin drift soil, untreated	18	10.05					
5	Same	18	10.34	10.19	3.19	1.37	6.63	6.63
6	Wisconsin drift soil, manured at rate of 25 tons per acre	15	12.48					
6	Same	15	13.11	12.79	1.52	0.48	10.79	10.79

*Includes sulfate from soil and that due to oxidation by shaking.

The method, as we are employing it, may be given as follows: Fresh soil is obtained, with the usual precautions that it shall be representative and that it shall not be contaminated in the sampling. 100 gm. quantities are weighed out in tumblers and thoroughly mixed. The sulfide is then added, 0.1 gm. of the sodium sulfide or the sulfur. The moisture conditions are then brought up to the optimum by additions of sterile water. The soils are then incubated for five to ten days at room temperature, at the end of which time the sulfates are leached out with water by shaking for seven hours in the shaking machine. The sulfates present are estimated by the use of the sulfur photometer.

The sulfates present in untreated soils are also determined and the purely chemical oxidation of the sulfide in the particular soil is ascertained. The difference between the sum of these two determinations and the total sulfur as sulfates at the end of the incubation period gives the sulfur oxidation or sulfofication by bacteria.

The results so far secured by the use of this method show that soils may vary considerably in their sulfur oxidizing power and that this variation in sulfofying power may be of considerable importance from the fertility standpoint. The possibilities of the future development of this subject are so clearly evident that it is unnecessary to mention them here. Suffice it to say that the question of sulfur fertilization is one which is commanding more and more attention, and if deficiencies in sulfur are to be avoided means must be employed which will return to the soil some of the element removed by crops, just as is the case with other elements. Farm manure and green manure are the logical farm materials which can be employed for this purpose and when the sulfur is applied in this form it must be transformed into sulfate and the rate at which this change occurs will determine the efficiency of the means of applying sulfur. The efficiency of the bacteria which oxidize sulfur to sulfates in the soil, or the sulfofying power of soils, will determine, therefore, the material which should be employed to prevent the depletion of the soil in the element sulfur.

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THE DES MOINES DIPHTHERIA EPIDEMIC OF 1912-13.

BY CHAS. A. WYLIE.

The diphtheria epidemic which this investigation covers began September, 1912, and closed April 19, 1913. Its beginning was coincident with the closing of the annual State Fair and the opening of the public schools. Its appearance was almost simultaneous all over the city, new cases appearing in remote sections and then cropping out again in the infected districts. Its center was very plainly in the so-called down town district, inhabited by the poorer classes of people. Yet it was no respecter of persons; rich and poor, learned and ignorant alike, suffered its dread ravages. Nor was it confined to youth alone; it seized upon whomever it could make prey.

This epidemic presented many different angles for investigations. We were constantly tempted to follow divers paths, many of them remote from the purpose of this investigation.

We shall confine ourselves principally to a plain statement of facts, as nearly as we could discover them. We shall not make any claim to accuracy in any of our data or conclusions, for reasons obvious to all who have endeavored to make similar reports. Absolutely accurate data and accurate conclusions therefrom were impossible. The data from which we constructed our charts are not correct, which fact we repeatedly discovered, much to our dismay. These data we secured at the city physician's office, where they had not been properly reported as the law provides.

We do not vouch for our report of the total number of cases, total number of deaths, or for the accuracy of our statement of conditions or conclusions drawn. We are convinced that the total count of diphtheria cases is too low, for we learned of cases which were not reported. At many places where two or more cases occurred in the same house only the first case was reported; and in other places, it is our opinion, there were cases which were not reported at all. This would lead to the conclusion that the death ratio is too large. Of this we are uncertain, for, especially at the beginning of the epidemic, some deaths occurred which were reported as caused by other diseases, and subsequent to the burial of the deceased clearly defined cases of diphtheria appeared among other members of the family. In one case which we found which occurred at the beginning of the epidemic, the child died only a few hours after the doctor was called. He treated the child for another disease, and doubtless reported the death as caused by that disease. Very soon after, another child in the family showed similar symptoms, although more marked. The same doctor was called again. He at once diagnosed the case as diphtheria, administered antitoxin, and the child quickly recovered.

From these facts we can draw no conclusion at all as to the degree of correctness of the death ratio. For, while on the one hand, not all the cases were reported; on the other hand, we are convinced some deaths occurred which were credited to other diseases. We shall assume, therefore, that the death ratio is approximately correct and shall present our figures on that assumption.

The investigation of the diphtheria cases among school children was most interesting. Chart No. I shows the total number of cases per month in each one of the schools of the city where children were removed because of diphtheria. In this it is seen that Irving school leads by an alarmingly large margin. This is in the center of the so-called down town section and is the poorer section of the city. Many of the houses and flats are dingy and dilapidated. Many of the back yards are littered with rubbish, the doors of some of the houses were poorly screened, and the interior of many of the homes visited bore striking evidence of a conservation of domestic labor. This section is the

CHART I.—DIPHTHERIA CASES PER MONTH IN THE DES MOINES SCHOOLS.

School	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mch.	Apr.	Total
Benton	----	2	----	----	----	1	----	1	4
	----	1*	----	----	----	----	----	----	1*
Bird	----	1	1	----	----	----	----	----	2
Bremer	1	----	1	1	1	2	----	----	6
Brooks	----	4	----	----	----	----	----	----	4
Bryant	2	----	----	1	----	2	----	----	5
Cary	----	----	----	1	----	----	----	----	1
C. C. C. College	----	----	----	----	----	1	----	----	1
Casady	----	----	1	----	----	1	----	----	2
	----	1*	----	----	----	----	----	----	1*
Cattell	----	2	2	----	----	----	----	----	4
Clarkson	----	----	1	----	----	1	----	----	2
Crocker	1	----	----	4	----	2	----	----	7
Curtis	----	2	3	1	----	----	----	----	6
	1*	----	----	----	----	----	----	----	1*
Des Moines College	4	----	----	2	----	----	----	----	6
High School, East Des Moines	----	2	----	----	----	----	----	----	2
High School, North Des Moines	----	----	1	----	----	----	----	----	1
High School, West Des Moines	----	1	----	1	----	----	1	----	3

CHART I.—DIPHTHERIA CASES PER MONTH IN THE DES MOINES SCHOOLS.—CONTINUED.

School	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mch.	Apr.	Total	
Drake University		1				1			2	
Elmwood					2	1		1	4	
						1*			1*	
Franklin	3	3	1		1	1			9	
				1*					1*	
Garfield	2		1	3					6	
Given				1					1	
Grant	1			1			2		4	
Grant Kindergarten			1						1	
Greenwood		1	1	3	2				7	
Highland Park College			1	3		2	1		7	
Howe						2			2	
Hubbell				1	2	2			5	
	5*	2*	1*						8*	13%
Irving	25	23	6	4	1	1	1		61	
Jefferson					1				1	
Kirkwood	1			1	1	2			5	
Lincoln	2	1		2	1		1		7	
Logan	2		1						3	
Longfellow		2	2						4	
McHenry		3							3	
McKinley		1	1						2	
Nash			1						1	
Oak Park			2						2	
Park Avenue			2	2	1	2			7	
Phillips			1			1			2	
Sabin		1						1	2	
Scott		2							2	
St. Ambrose	3	1		1					5	
St. Johns						1			1	
					1*				1*	
Visitation			1		2	3			6	
					2*				2*	
Wallace	1		2		2				5	
Washington				1					1	
Webster				2	1				3	
					1*				1*	
Whittier					1	1			2	
Willard	2		1						3	
	6*	4*	1*	1*	4*	1*			17*	
	50	53	34	36	19	30	6	2	230	
Diphtheria Ratio	12%	7.5%	2.9%	2.8%	21%	3.3%			7.3%	

Note: Numbers followed by stars indicate number of deaths.

The number of cases per school is subject to the following correction: The data from which we constructed this chart we obtained in the City Physician's office. On some of the cards filed there, two or three schools were named, indicating that two or three schools were represented by the home quarantined. In this chart we have given credit only to the first school mentioned in the report. This may or may not be correct.

rendezvous of at least fifty-seven varieties of cats and their canine enemies. To effect an absolute quarantine under such conditions was quite impossible. First, because the people were not in sympathy with the quarantine laws, and not only concealed the cases until they themselves became alarmed, probably infecting many others before reporting the disease; but, second, they were lax in observing the quarantine after it was placed upon the house and allowed cats and dogs to run hither and thither with little restriction.

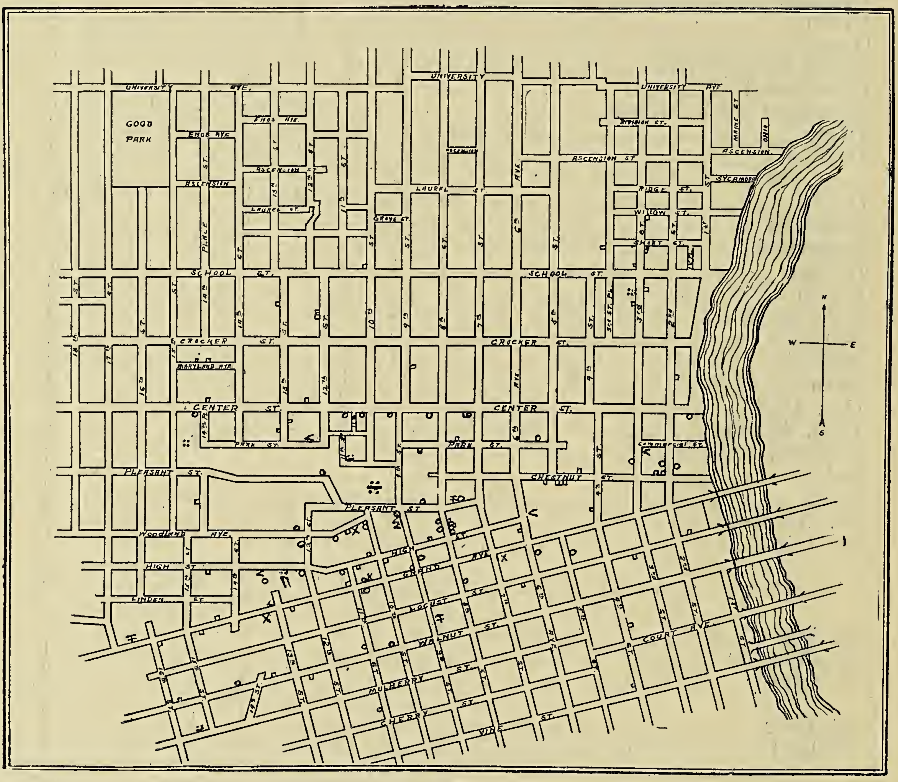

Chart II.

FIG. 1. Diphtheria cases in Irving school district.

The chief play ground of the children of this section is the street, alleys and back yards. Consequently, the gang spirit is pretty well developed. In this way a child who has become infected, though hardly aware of it yet, beyond a slight soreness in his throat, could infect a whole group of children. This is probably what happened, for not only did the epidemic spread by leaps and bounds among the Irving school children, but other children got it who lived in this section but who attended other schools, viz.: McHenry, Howe, Lincoln, St. Ambrose, Longfellow, Crocker, Garfield, Green, Cooper, Franklin, Highland Park College and West Des Moines High School. It will be observed that the number of cases in these schools is slightly above the average. By such means of dispersion the epidemic spread all over the city.

It may be noticed on the chart that the epidemic was well under control in Irving school by November. A nurse was employed for the Irving school and close supervision was made of the scholars. Another fact of much importance was that many of the parents withdrew their children from school at the beginning of the epidemic, but allowed them to play in the streets with other children. After confidence in the nurse became established, the children were returned to school, hence withdrawn from the streets, kept under stricter supervision and a very marked decrease in new cases resulted.

Chart II locates all the diphtheria cases in the Irving school district. Symbol ◯ locates cases of diphtheria of Irving school children; symbol □ locates cases of diphtheria of all others not in Irving school. Symbols × and ∓ indicate that there were two cases in one house. Symbols < and :: locate cases that resulted in death. The figure ÷ represents Irving school. It will be noticed that a circle, with Irving school as the center, and a five block radius, will include most of the cases in this district. This circle also will include the dingiest of the houses in this district.

In this district approximately one hundred and forty-two (142) cases were reported. Of this number sixty-one (61) were in Irving school. This leaves eighty-one (81) who were not in Irving school. Of this number seven (7), or 8.7 per cent, proved fatal. It will be noticed, then, that fifteen (15) of the one hundred and forty-two cases in Irving school district proved fatal, or one out of every ten resulted in death. This is an alarmingly large ratio.

The total number of cases in the city reported during the period of our investigation (September 1st, 1912, to April 19, 1913) was three hundred and twenty-four (324), with twenty-seven (27) deaths. The death ratio for the entire city was 8.3 per cent. There were, then, one hundred and eighty-two cases not in Irving school district and twelve (12) deaths, making the death ratio 6.5 per cent. The following table shows these facts more concretely:

	Cases	Deaths	Per Cent
The City	324	27	8.3
The City not including Irving School District	182	12	6.5
Irving School District	142	15	10.0
Irving School District, not including Irving School	81	7	8.7
Irving School	61	8	13.0

It will be noticed that Irving school contributed nearly one-sixth of the city's total, that nearly one-third of the total of deaths were in the Irving school. It will be noticed further that Irving school district contributed nearly one-half of the city's total cases, and over half its deaths.

Chart III illustrates these figures by three curves, a, b, c. Curve (a) represents Irving school; curve (b), Irving school district; and curve (c), the city. Here it will be noticed what impetus Irving school district gave the city's curve and then the persistence of the epidemic throughout the city after it was practically under control within the Irving school and Irving school district.

Chart IV illustrates the comparative relation of the epidemic in Irving school district and in the city. Curve (a) represents Irving school district and continues till a total count of one hundred and forty-two is reached, when the investigation closed on April 19, 1913. Curve (b) represents the development of the epidemic in the city and continues till a count of three hundred and twenty-four is made. Here it will be seen that the epidemic's principal increase during September and October was in the Irving school district. Below is shown by figures the relation of the epidemic in Irving school district and in the city:

NEW CASES.

	City	Irving School District	Irving School
September	44	32	25
October	76	46	23
November	56	19	6
December	45	18	4
January	44	15	1
February	39	6	1
March	15	6	1
April	5	0	0
	324	142	61

This shows very concretely the very direct relation of the city's epidemic development to the Irving school district.

Chart V shows graphically the number of cases in the city per month from May 1, 1912, to April 19, 1913. Here will be seen just an occasional case during the spring and summer, and only one death, that occurring in June. The following table shows this by figures:

	Cases	Deaths	Ratio, Per Cent
May	7	0	0
June	23	1	4.3
July	3	0	0
August	0	0	0
September	44	6	13.6
October	76	7	9.3
November	56	2	3.5
December	45	2	4.3
January (1913)	44	4	9.0
February	39	5	12.8
March	15	0	0
April 19	5	1	20.0
	357	28	7.8

It will be observed that there were no new cases reported in August, 1912, and in September forty-four (44) cases were reported, followed by seventy-six (76) more in October. What, then, was the cause of this sudden epidemic? It will be noticed on Chart III that the first case appeared on September 8th, and was in the Irving school district. This was right at the close of the annual State Fair. Houses all over the city were opened and beds were let to out of town visitors, numbering several thousands, from all over the state. Houses in the down town district were especially in demand by those seeking accommodations, because they were more in the center of the city. This would lead to the suggestion that the disease was either brought in by the visitors, or that the bacteria were stirred up in some of the formerly quarantined houses through the effort to provide accommodations for as many guests as possible. Whichever might have been the case, the disease could quite readily have been carried hither and thither by the transient crowd. But why, then, should it start in the Irving district and gain such headway before it made its appearance in other parts of the city, since homes all over the city were opened to guests? The houses in other parts of the city, as a rule, are better kept and by habit better sanitary rules are observed, and the environment was less favorable to these bacteria should they have appeared there. It might, then, be asked, why did the disease persist in other sections of the city after it was practically under control in the Irving school district? It will be remembered that extra vigilance was maintained in the Irving school district and the disease soon brought under control. Further, it is possible for one individual who has the virulent diphtheria bacteria in his throat in large numbers to be by nature so immune to their action that for days he might be quite unaware that he has the disease. In this way he could spread the disease broadcast unwittingly. We found several cases where this did actually occur. Two apparently healthy children may play together. One is stricken with the disease. The other child seeks a new play mate. Soon the third child is stricken, and then, soon after, the second child has a very mild attack, in fact, scarcely being sick at all. In such a case the second child caught the disease from the first and passed it on to the third before he himself was taken ill. Such incidents were multiplied many times over. One incident which came to our notice was the case of a man placed under quarantine. He was scarcely ill at all, but after the twenty-first day negative cultures were obtained. The next day positives were obtained. The third day negatives were again obtained, followed by positives on the fourth day. These alternated for five weeks more, keeping the man under quarantine for over two months. How many more, then, may there have been, who unknowingly had the disease, were only slightly affected by it, were not quarantined, and who spread it broadcast among their associates, at home, in social gatherings and on the street? Can we wonder, then, that the problem in this city was so difficult?

The death ratio was alarmingly large during this epidemic. Why? Perhaps the organisms were unusually virulent. It will be observed that the largest death ratio was in the Irving school district. Here, it was found, there was greater tendency to hesitate in calling the doctor, and, when he was called, to oppose his wishes and commands. Some would not permit the antitoxin to be administered unless as a last resort, and quite frequently the delay cost the life of the patient. In many places the patient was not properly cared for, due to ignorance and opposition to the commands of the physician.

There was considerable complaint of partial paralysis after recovering from the disease, poor vision, speech impediments, deafness, stiffness of the joints and uncertainty in the use of the limbs. Many blamed this to the heavy doses of the antitoxin, which, in nearly every case, had been delayed, and then a very large dose given to save the life of the patient. On being questioned on this point, however, nearly all would admit that had the antitoxin not been administered the patient would probably have died, so they accepted without demur this temporary paralysis. We heard of one patient who went to an osteopath, who aided much in hastening control of the limbs. We are inclined to believe, on reading results of investigations, that the after effects noticed were due more to the toxic effects of the bacilla diphtheria than to the antitoxin administered.

Following the period which closed our investigation only a very few new cases appeared. Constant vigilance was maintained and in a very few weeks the epidemic was completely conquered.

The author takes pleasure here to acknowledge the valuable assistance given him by Elizabeth Mae Gittins, who helped to procure and arrange data, and by Dr. H. L. Sayler, City Physician, who turned over to us all his records.

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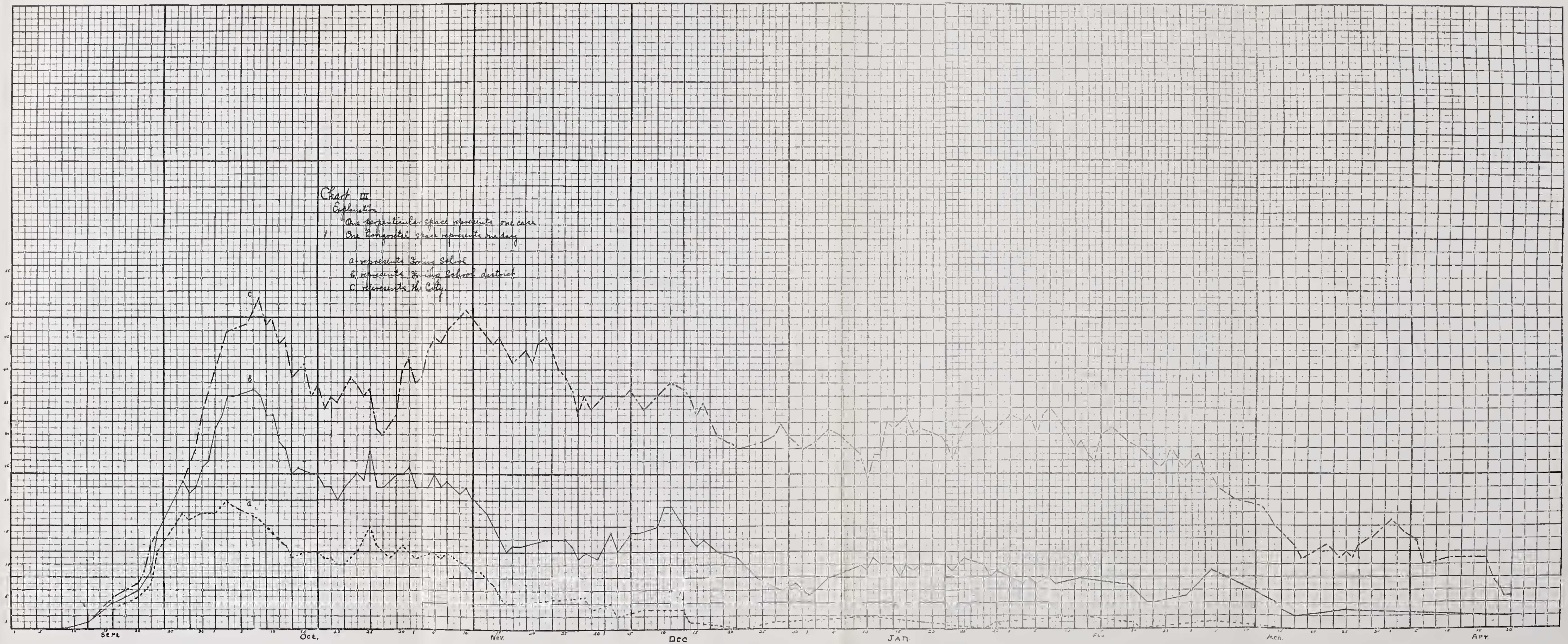
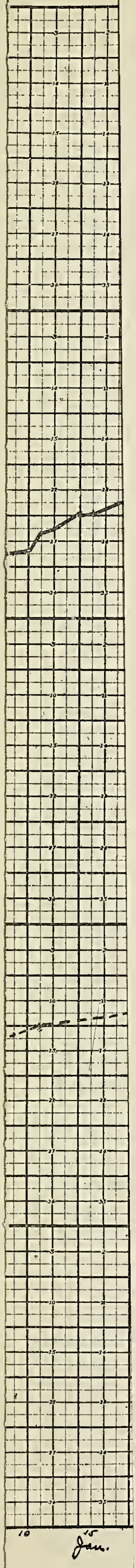


PLATE II. Diphtheria cases in Irving school, Irving school district and the city.



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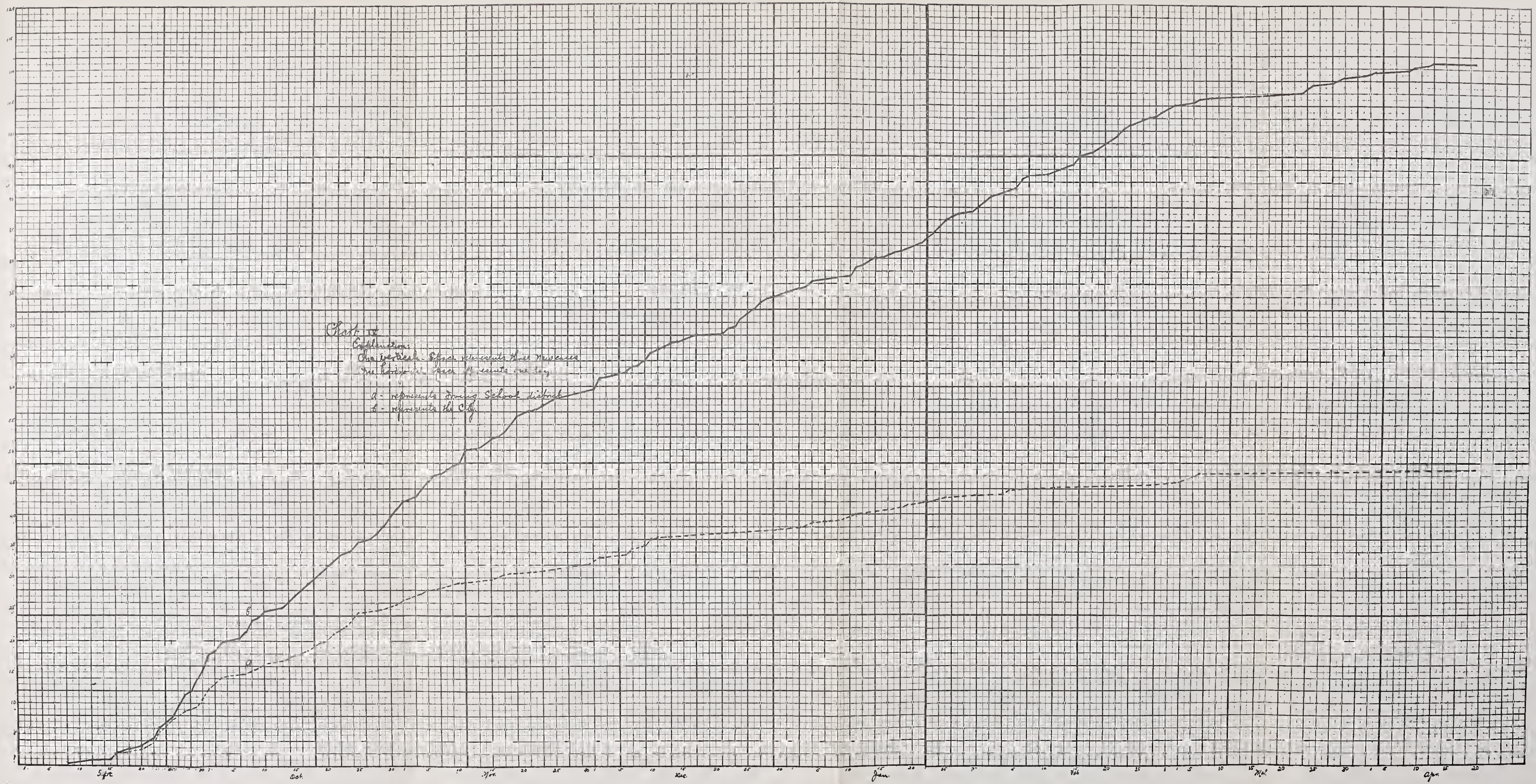

PLATE III. Comparison of diphtheria epidemic in Irving school district and in the city.

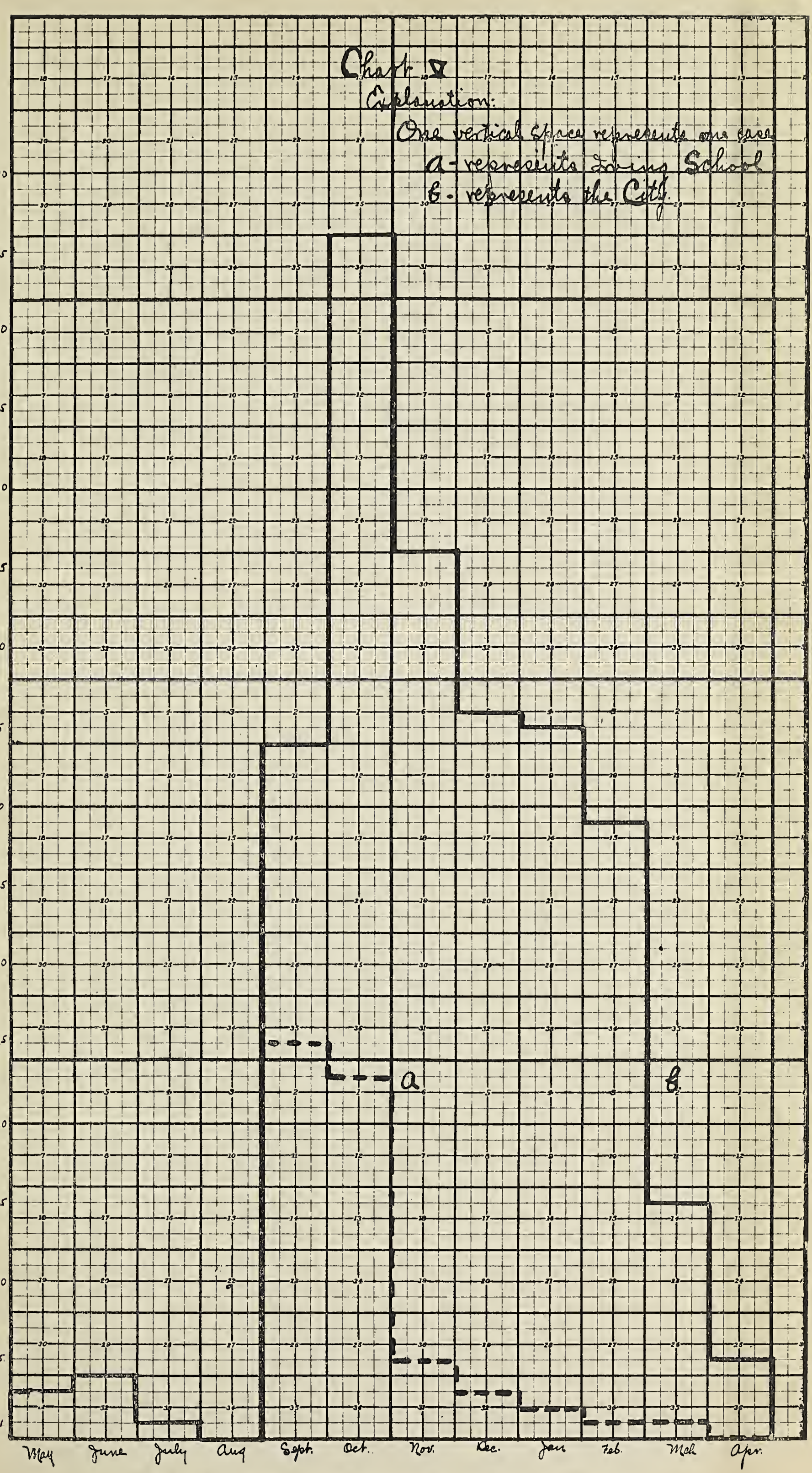

PLATE IV. Number of cases of diphtheria in the city.

BACTERIAL CONTENT OF DESICCATED EGG.

L. S. ROSS.

The value of eggs as an article of food for human consumption has been recognized for a long period of time. The relative value, as compared to other available food products, may be subject to further investigation, even though much work has already been done. But whatever may be the variance in conclusions, yet the fact of the great food value of eggs has been established by experiment and by practical experience. With the realization of the value of a food, is an attendant increased consumption and the necessity for increased production, and also the advisability of extending the period over which the given food is available. During the months of plenty, provision should be made for the "lean" months.

Many foods are of such a nature that they lend themselves readily to preservation by various means. On the other hand, the preservation of some is a problem that has been solved, in some degree of satisfaction at least, within recent years only. Because of economic reasons in the matter of transportation and storage, some plan of eliminating water from foods containing large percentages has been sought and in many instances has been readily found and practically applied. In other cases the problem was more difficult. But now we have desiccated milk, desiccated eggs and other dried foods that in their original condition contained large percentages of water.

No satisfactory method has yet been found whereby eggs in the shell can be preserved for any length of time. Even if such a method were known the economic problem of bulk and breakage would persist. The loss in transportation of eggs in the shell is very great. The frozen product may be kept indefinitely, but at considerable expense for refrigeration and storage. For a number of years experimenters have been trying various methods of desiccation, and are now preparing eggs by drying, for storing and for transportation, on a large scale. Various methods are used, as the tray method, disk method, belt method, and the instantaneous method by spraying the liquid into a chamber heated to about 160 degrees Fahrenheit. This method seems to be the best one devised. The per cent of water removed is so great that the solids from thousands of cases can be stored in containers in a relatively small space. Fresh eggs contain approximately seventy-four per cent water, while the powder prepared by the instantaneous method has only from three to five per cent. Here, then, is a food material rich in nutrients but without sufficient water for ordinary bacterial growth, and one that may be preserved a long period of time.

One of the problems connected with the preparation of the desiccated product is to avoid contamination of the eggs in their preparation for the drying chamber. They must be broken and poured from the shells and sent through the beater and tanks. The sanitary problem connected with this part of the process is the most serious and the most difficult to solve on the part of the honest manufacturer. Many studies show that the bacterial content of the fresh, unbroken egg is either small or wanting. The ordinary conditions, however, under which eggs are produced and are gathered are such that the shell very generally carries large numbers of bacteria of various kinds; and it is a practical impossibility to break and pour the eggs without a degree of contamination closely correlated with the condition of the shell. Samples removed from the shell in the laboratory under aseptic conditions, by flaming the shell and using sterilized instruments, may be sterile, or may contain a very small number of bacteria, while samples of eggs of the same kind taken from the pans in the factory may show thousands per cubic centimeter. At present no practical method of preventing such contamination is known. At best, the product, whether frozen or desiccated, will contain many more bacteria than are normally present in the fresh, unbroken egg; this number being dependent largely upon the condition of the shell, whether clean or dirty, and upon care and conditions in the factory.

The eggs known as "spots" contain many bacteria, but under careless conditions in the factory the product prepared from good, "candled" eggs may show as many bacteria as the product prepared from the "spots." For this reason a bacterial count does not of necessity prove the condition of the original; neither does the gas production, for in the greater number of examinations of fresh eggs broken in the pans, gas is produced in the fermentation tubes. This is in accord with what might be expected when the wide distribution of the *Bacillus coli* group is taken into consideration.

Another question of importance arising is, with reference to the effect of storage upon the bacterial content of the prepared egg, whether frozen or desiccated. Results obtained at Washington after a series of examinations are given in Bulletin No. 158 of the Bureau of Chemistry, 1912. The investigation included both frozen and desiccated products, and a decrease in content after storage was noted. This fact gives rise to some questions of importance. How rapid and to what degree is the decrease? Does a corresponding decrease occur in the product from "spots" and other inferior eggs? Can an inferior product be detected by count and fermentation tests after a lengthy period of storage? What conditions of storage will cause the most rapid diminution of bacteria? Is it possible that some desiccating plants may buy "spots" and then put the product on the market as high grade desiccated eggs?

Work extending over four seasons, beginning with 1910, leads me to the opinion, rather by inference, it is true, that dishonest manufacturers may find it possible to put a very inferior article on the market, one that may give satisfactory results when examined by the ordinary method of colony counting and the fermentation test after a period of storage. The dry powder contains food material for bacterial growth, but there is an insufficiency of water, and the vitality of the bacteria is gradually lost until, in time, the powder becomes practically sterile. The powder freshly prepared from "spots" and rotten eggs contains a great number of bacteria; but during the process of the instantaneous method, or upon the application of heat in baking, practically all bad odor is eliminated. Such a result was obtained in July, 1912, from an experiment performed relative to the preparation of powder from bad eggs for use in tanning. Several cases of eggs in all degrees of rottenness, some "spots," some "blood spots," some containing dead chicks, were broken and were run through the process of desiccation. The resulting powder was indistinguishable in its appearance by any one, unless it be by an expert, from the powder prepared from fresh eggs. Upon presentation of a small can of the powder and a can of the good product to one of my colleagues, for his inspection by the sense of smell, he found it impossible to determine which was good and which was bad. Knowing the two cans, I thought possibly I could detect a slight difference in the odor. Such a product stored for a considerable period of time will give a low bacterial count and will fail to produce gas in the fermentation tube.

During the four seasons of 1910, 1911, 1912, 1913, something like 550 examinations of liquid and powdered egg were made in the Drake bacteriological laboratory. At the beginning of the work there was no expectation of using the data for public presentation.

From April 8 to July 10, 1910, seventy-six samples of liquid white and sixty-six samples of liquid yolk were examined, a total of 142 tests. A summary of Table I shows a large percentage of both white and yolk producing from 100,000 to 500,000 colonies per cubic centimeter; in the case of the whites, 40.78 per cent, and of the yolks, 66.66 per cent. Of the white, 44.71 per cent produced less than 100,000 colonies, and of the yolks, 30.29 per cent. Of the 142 samples, twenty, or 14.08 per cent, yielded no gas in dextrose broth, .01 of a cubic centimeter being used. A much smaller percentage of the yolk samples than of the whites produced gas; in the former, 27.27 per cent with no gas, and in the latter only 2.63 per cent. Stated positively, 72.73 per cent of the samples of yolks produced gas and 97.37 per cent of the whites. During this season also a few tests were made on liquid whole egg and on desiccated yolk; these were not of sufficient number to give data of any special value.

Beginning April 5, 1911, and continuing until July 6, ninety-four samples of desiccated whole egg and thirty-three samples of liquid were tested. Of the desiccated samples, sixty-three, or 67.02 per cent, showed from 100,000 to 500,000 colonies per gram; 23.35 per cent less than 100,000, and 9.57 per cent between 500,000 and 1,000,000. Gas-producing samples in dextrose broth numbered sixty-five, or 69.15 per cent. Of the tests with the liquid samples, thirty were counted. Seven, or 23.33 per cent, gave a count between 100,000 and 500,000; three, or 10 per cent, showed less than 100,000 colonies, and twenty, or 66.66 per cent, a count of 500,000 and above. Of the entire thirty-three samples every one yielded gas in the dextrose tube, the per cent of gas ranging from 20 per cent to 89 per cent. (Table 2.)

In 1912 fifty-six samples of desiccated product were examined between May 6 and July 3. Of these, forty, or 71.42 per cent, developed between 100,000 and 500,000 colonies per gram; 12.49 per cent showed less than 100,000, and 1.78 per cent 500,000 or more. Of the fifty-six samples, forty-two, or 75 per cent, developed gas in lactose tubes, ranging from 11 per cent to 60 per cent. Four liquid samples all produced gas in lactose broth ranging from 64 per cent to 80 per cent. (Table 3.)

Beginning May 7, 1913, and continuing until July 2, ninety-eight samples of powdered egg were examined. Of these, seventy, or 71.42 per cent, developed from 100,000 to 500,000 colonies per gram; 20.40 per cent developed less than 100,000 and only 8.16 per cent 500,000 or more. In lactose broth, seventy-two, or 73.47 per cent, produced gas ranging from 5 per cent to 80 per cent. (Table 4.)

Of the entire 248 samples of desiccated egg examined during the three seasons, 173, or 69.75 per cent, showed from 100,000 to 500,000 colonies per gram; fifty-seven, or 22.98 per cent, less than 100,000 colonies, and eighteen, or 7.25 per cent, 500,000 or more. Gas was produced in 180 samples, or in 72.59 per cent. Dextrose broth was used in 1911 until May 24, when lactose was substituted and was used in 1912 and 1913. The percentage of tubes producing gas in 1911 was slightly lower than the percentage in 1912 and 1913, possibly because the incubation period was only twenty-four hours instead of forty-eight hours. Of the 142 samples of liquid tested in 1910, 122, or 85.91 per cent, produced gas in the dextrose tube. Seventy-six of the samples were whites, and of these, seventy-four, or 97.36 per cent, produced gas, while of the sixty-six samples of yolk, forty-eight, or 77.73 per cent, produced gas. This shows a difference in gas production decidedly in favor of the yolks over the whites. In breaking and pouring a greater degree of contamination of the whites is probable than of the yolks.

In order to get some data on the effect of storage upon bacterial content, some tests were made upon samples of powder that had been in the fluctuating temperature of the laboratory for varying periods of time. Also some samples were put into the incubator at a temperature near 35°C, but varying somewhat. At the time samples were put into the incubator others from the same lots were put into a cool room at a temperature of 17° to 19°C. The experiment with the samples in the cool room was soon checked by the fact that the mite, *Tyroglyphus siro,* developed in the cans, although they were presumably hermetically sealed with paraffin.

The specimens were examined at various dates after different periods of storage. The earliest time of examination of the samples in the laboratory was after a storage of seventy-four days, and the latest after storage of 575 days. The smallest per cent decrease in bacterial content was 36.67 in one specimen after a storage of eighty-one days. It seems that this result should be considered due to error, as it is so far below the average per cent decrease. Another test of the same sample after 240 days gave no results because of spreading colonies. In five instances the count after a longer period of storage showed a larger number of colonies than the count of the same samples after a shorter period. In three of the cases the difference is so slight that they may be left out of consideration. In all probability the other two may be explained as due to errors.

The average decrease in bacterial content in 113 tests upon fifty-six samples under laboratory conditions of temperature for periods of seventy-four to 575 days was 94.12 per cent, and of these only three, or 2.65 per cent, developed gas in the lactose broth in twenty-four hours, .01 gram being used in each tube. (Table 5.)

Beginning on August 22, 1913, and continuing at intervals until December 8, 1913, counts were made upon thirty-two samples of powdered whole egg that had been stored in the incubator for periods of 60, 100, 109, 112, 153, and 156 days. With the exception of five, the samples were put into the incubator after six to twenty-eight days' storage in the laboratory. The decrease in bacterial content ranged from 99.38 per cent to 100 per cent, with an average of 99.95 per cent. Three samples in the incubator sixty days showed a decrease of 99.78 per cent; one, at 109 days, a decrease of 99.90 per cent; nine, at 112 days, a decrease of 99.96 per cent; one, at 153 days, a decrease of 100 per cent; and eight, at 156 days, a decrease of 99.99 per cent. One sample, in the incubator 112 days, produced 37 per cent gas in lactose broth. No gas was produced in any of the others. (Table 6.)

At the same time that samples were put into the incubator, other samples taken from the cans in the incubator were put in the cool room in order to compare the effect of storage under noticeably different degrees of temperature. Two samples were tested after a period of sixty days and one after sixty-seven days; these showed a decrease respectively of 99.22 per cent, 99.07 per cent, and 94.25 per cent. The other samples had been invaded by the *Tyroglyphus siro.*

A little comparison of the results obtained shows that decrease in bacterial content took place more rapidly at a higher temperature than at a lower fluctuating room temperature, a storage ranging from seventy-four to 575 days at laboratory temperature giving an average decrease of 94.12 per cent, and a storage ranging from sixty to 156 days in the incubator, following no storage to a storage of twenty-eight days at room temperature, giving an average decrease of 99.95 per cent.

In so far as these experiments indicate, it seems that the desiccated egg loses a large percentage of the bacteria originally present if stored for even a relatively short period. Also the experiment indicates a more rapid diminution if storage is at a higher temperature than at a lower. And it seems possible that a poor product, even one prepared from "spots," and worse, might satisfy the ordinary bacterial test of colony counting and gas determination after a period of a few months' storage.

TABLE I—BACTERIAL TESTS LIQUID EGG FROM APRIL 8 TO JULY 1, 1910.

Date	Lot No.	Egg	No. Colonies per c. c. 48 hrs. at 37° C.	Per Cent Gas, 24 hrs. .01 c. c. Dextrose Broth	Date	Lot No.	Egg	No. Colonies per c. c. 48 hrs. at 37° C.	Per Cent Gas, 24 hrs. .01 c. c. Dextrose Broth
Apr. 8	1	White	13,500	—	Apr. 27	17	White	360,000	+
Apr. 8	1	Yolk	3,800	—	Apr. 27	17	Yolk	500,000	—
Apr. 9	2	White	400	—	Apr. 28	18	White	79,000	+
Apr. 9	2	Yolk	900	—	Apr. 28	18	Yolk	90,000	+
Apr. 11	3	White	52,300	+	Apr. 29	19	White	318,000	+
Apr. 11	3	Yolk	3,400	+	Apr. 29	19	Yolk	55,400	—
Apr. 12	4	White	900	+	Apr. 30	20	White	79,000	+
Apr. 12	4	Yolk	700	—	Apr. 30	20	Yolk	49,000	+
Apr. 13	5	White	100,000	+	May 2	21	Whole Egg	108,000	+
Apr. 13	5	Yolk	42,000	—	May 3	21	White	300,000	+
Apr. 14	6	White	9,100	+	May 3	22	Yolk	29,000	+
Apr. 14	6	Yolk	6,500,000	+	May 4	22	White	60,000	+
Apr. 14	6	Pow'd Yolk	(per gram) 50,000	+	May 4	23	Yolk	190,000	+
Apr. 15	7	White	650,000	+	May 5	23	White	110,000	+
Apr. 15	7	*Machine White	2,000	+	May 5	24	Yolk	72,000	8
Apr. 15	7	Pow'd Yolk	(per gram) 74,300	+	May 6	24	White	35,000	40
Apr. 16	8	White	6,500	+	May 6	25	Yolk	15,000	31
Apr. 16	8	Yolk	7,400	—	May 7	25	White	225,000	43
Apr. 18	9	White	(40 hrs.) 100,000	+	May 7	26	Yolk	180,000	4
Apr. 18	9	Machine White	(40 hrs.) 100,000	+	May 9	27	Yolk	150,000	7
Apr. 18	9	Yolk	500,000	+	May 10	26	White	25,000	38
Apr. 19	10	White	55,000	+	May 10	27	White	71,000	50
Apr. 19	10	Machine White	6,000	+	May 10	28	Yolk	93,000	0
Apr. 19	10	Yolk	40,000	+	May 11	28	White	95,000	55
Apr. 20	11	White	17,800	+	May 11	29	Yolk	99,000	5
Apr. 20	11	Yolk	36,500	+	May 12	29	White	82,000	57
Apr. 21	12	White	1,400	+	May 12	30	Whole Egg	260,000	0
Apr. 21	12	Yolk	3,300	+	May 12	31	Whole Egg	260,000	6
Apr. 21	12	Pow'd Yolk	(per gram) 21,700	—	May 13	30	White	450,000	50
Apr. 21	12	Feed Pump Yolk	2,000,000	+	May 13	32	Yolk	230,000	1
Apr. 22	13	White	1,100	+	May 14	31	White	7,000	50
Apr. 22	13	Machine White	3,000	+	May 14	33	Yolk	215,000	8
Apr. 23	14	White	11,600	+	May 16	32	White	8,000	68
Apr. 23	14	Feed Pump Yolk	250,000	+	May 16	34	Yolk	145,000	3
Apr. 23	14	Pow'd Yolk	(per gram) 19,400	+	May 17	33	White	360,000	80
Apr. 25	15	White	50,000	+	May 17	35	Yolk	230,000	0
Apr. 25	15	Yolk	120,000	+	May 18	34	White	200,000	50
Apr. 26	16	White	1,000	+	May 18	36	Yolk	108,000	12
Apr. 26	16	Yolk	28,700	+	May 19	35	White	220,000	54

*Eggs broken with a machine.

TABLE I—CONTINUED—BACTERIAL TESTS LIQUID EGG FROM APRIL 8 TO JULY 1, 1910.

Date	Lot No.	Egg	No. Colonies per c. c. 48 hrs. at 37° C.	Per Cent Gas, 24 hrs. .01 c. c. Dextrose Broth	Date	Lot No.	Egg	No. Colonies per c. c. 48 hrs. at 37° C.	Per Cent Gas, 24 hrs. .01 c. c. Dextrose Broth
May 19	37	Yolk	240,000	24	June 13	53	White	38,000	26
May 20	36	White	370,000	50	June 13	57	Yolk	160,000	12
May 20	38	Yolk	215,000	22	June 14	54	White	240,000	26
May 21	37	White	30,000	55	June 14	58	Yolk	195,000	8
May 21	39	Yolk	234,000	15	June 15	55	White	15,000	23
May 23	38	White	168,000	17	June 15	59	Yolk	230,000	8
May 23	40	Yolk	262,000	31	June 16	56	White	85,000	50
May 24	39	White	950,000	60	June 16	60	Yolk	150,000	0
May 24	41	Yolk	210,000	25	June 17	7	White	30,000	53
May 25	40	White	450,000	60	June 17	39	White	80,000	64
May 25	42	Yolk	228,000	5	June 17	40	White	30,000	71
May 26	41	White	700,000	60	June 17	57	White	180,000	57
May 26	43	Yolk	270,000	1	June 17	61	Yolk	275,000	18
May 27	44	Whole Egg	160,000	40	June 18	58	White	70,000	64
May 28	45	Whole Egg	340,000	2	June 18	62	Yolk	220,000	29
May 31	42	White	102,000	41	June 20	59	White	350,000	52
May 31	46	Yolk	204,000	1	June 20	63	Yolk	210,000	31
June 1	43	White	375,000	52	June 21	60	White	290,000	64
June 1	47	Yolk	270,000	1	June 21	64	Yolk	220,000	21
June 2	44	White	160,000	47	June 22	61	White	600,000	60
June 2	48	Yolk	400,000	2	June 22	65	Yolk	310,000	50
June 3	45	White	370,000	47	June 23	62	White	260,000	60
June 3	49	Yolk	190,000	25	June 23	66	Yolk	395,000	0
June 4	46	White	440,000	50	June 24	63	White	275,000	35
June 4	50	Yolk	100,000	5	June 24	67	Yolk	335,000	0
June 6	47	White	785,000	44	June 25	64	White	490,000	60
June 6	51	Yolk	175,000	0	June 25	68	Yolk	260,000	0
June 7	48	White	325,000	53	June 27	65	White	900,000	73
June 7	52	Yolk	215,000	18	June 27	69	Yolk	300,000	8
June 8	49	White	815,000	63	June 28	66	White	1,200,000	60
June 8	53	Yolk	350,000	36	June 28	70	Yolk	300,000	10
June 9	50	White	100,000	50	June 29	67	White	1,650,000	88
June 9	54	Yolk	140,000	0	June 29	71	Yolk	340,000	5
June 10	51	White	750,000	53	June 30	68	White	600,000	60
June 10	55	Yolk	85,000	16	June 30	72	Yolk	240,000	0
June 11	52	White	300,000	75	July 1	69	White	244,000	65
June 11	56	Yolk	130,000	0	July 1	73	Yolk	200,000	0

TABLE II—BACTERIAL TESTS DESICCATED EGG FROM APRIL 5 TO JULY 6, 1911.

Date	Lot No.	Egg	No. Colonies per gram 48 hrs. at 37° C.	Per Cent Gas 24 hrs. .01 gram Dextrose Broth	Date	Lot No.	Egg	No. Colonies per gram 48 hrs. at 37° C.	Per Cent Gas 24 hrs. .01 gram Dextrose Broth
April 5	2	Pow'd	15,500	0	May 1	28 Cooler	Liquid	(1c.c.) 850,000	28
April 5	3	Pow'd	110,000	6	May 3	29	Pow'd	270,000	42
April 5	4	Pow'd	24,000	10	May 3	30	Pow'd	445,000	26
April 5	5	Pow'd	13,000	9	May 3	30 Beater	Liquid	(1c.c.) 2,190,000	30
April 5	6	Pow'd	64,000	0	May 3	30 Cooler	Liquid	(1c.c.) 1,600,000	24
April 6	7	Pow'd	100,000	5	May 5	31	Pow'd	150,000	25
April 7	8	Pow'd	50,500	25	May 6	32	Pow'd	250,000	0
April 8	9	Pow'd	28,500	0	May 6	33	Pow'd	450,000	56
April 11	10	Pow'd	36,500	14	May 8	34	Pow'd	168,000	51
April 11	11	Pow'd	139,000	18	May 8 a.m.	34 Beater	Liquid	(1c.c.) 130,000	50
April 12	12	Pow'd	165,000	7	May 8 a.m.	34 Cooler	Liquid	(1c.c.) 950,000	56
April 13	13	Pow'd	87,000	3	May 8 p.m.	34 Beater	Liquid	(1c.c.) 550,000	53
April 14	14	Pow'd	188,000	30	May 8 p.m.	34 Cooler	Liquid	(1c.c.) 275,000	53
April 15	15	Pow'd	53,500	30	May 8 p.m.	34 2d Tank	Liquid	(1c.c.) 1,000,000	50
April 17	15	Pow'd	353,000	30	May 9 a.m.	35 Beater	Liquid	(1c.c.) ?	57
April 17	16	Pow'd	112,000	16	May 9 a.m.	35 Cooler	Liquid	(1c.c.) ?	53
April 19	17	Pow'd	300,000	36	May 9	35	Pow'd	52,000	73
April 19	18	Pow'd	215,000	26	May 10	36	Pow'd	165,000	60
April 21	19	Pow'd	180,000	36	May 10 p.m.	36 Beater	Liquid	(1c.c.) 340,000	76
April 21	20	Pow'd	320,000	33	May 10 p.m.	36 Cooler	Liquid	(1c.c.) 230,000	87
April 24	15	Pow'd	280,000	10	May 11 a.m.	37 Beater	Liquid	(1c.c.) 680,000	77
April 24	21	Pow'd	1,000,000	26	May 11 a.m.	37 Cooler	Liquid	(1c.c.) 2,000,000	20
April 25	22	Pow'd	140,000	5	May 11 p.m.	37 Beater	Liquid	(1c.c.) 3,950,000	89
April 25	Checks	Pow'd	150,000	10	May 11 p.m.	37 Cooler	Liquid	(1c.c.) 2,000,000	68
April 25	1st Tank	Liquid	(1c.c.) 615,000	60	May 11 a.m.	37	Pow'd	125,000	61
April 25	2d Tank	Liquid	(1c.c.) 840,000	43	May 11 p.m.	37	Pow'd	125,000	0
April 25	Pan	Liquid	(1c.c.) 8,500	46	May 12 a.m.	38	Pow'd	750,000	50
April 25	1st Tank 5 p.m.	Liquid	(1c.c.) 530,000	50	May 12 p.m.	38	Pow'd	425,000	60
April 25	1st Tank 9 p.m.	Liquid	(1c.c.) 1,200,000	40	May 12 a.m.	38 Beater	Liquid	(1c.c.) 3,000,000	26
April 25	23	Pow'd	200,000	40	May 12 a.m.	38 Cooler	Liquid	(1c.c.) 600,000	55
April 26	21	Pow'd	570,000	30	May 12 p.m.	38 Beater	Liquid	(1c.c.) 120,000	80
April 26	23	Pow'd	390,000	36	May 12 p.m.	38 Cooler	Liquid	(1c.c.) 2,200,000	58
April 26	24	Pow'd	360,000	33	May 12 p.m.	38 Pan	Liquid	(1c.c.) 13,500	86
April 27	25	Pow'd	650,000	36	May 15	39	Pow'd	290,000	53
April 27	Beater	Liquid	(1c.c.) 2,550,000	55	May 15	40	Pow'd	310,000	50
April 27	Cooler	Liquid	(1c.c.) 8,250,000	47	May 17	41	Pow'd	330,000	66
April 29	26	Pow'd	74,000	26	May 17	42	Pow'd	300,000	70
April 29	27	Pow'd	250,000	33	May 20	43	Pow'd	270,000	63
May 1	28	Pow'd	340,000	33	May 20	44	Pow'd	455,000	70
May 1	28 Beater	Liquid	(1c.c.) 1,000,000	66	May 20	45	Pow'd	300,000	60

TABLE II—CONTINUED—BACTERIAL TESTS DESICCATED EGG FROM APRIL 5 TO JULY 6, 1911.

Date	Lot No.	Egg	No. Colonies per gram 48 hrs. at 37° C.	Per Cent Gas 24 hrs .01 gram Dextrose Broth	Date	Lot No.	Egg	No. Colonies per gram 48 hrs. at 37° C.	Per Cent Gas 24 hrs. .01 gram Lactose Broth
May 24	48 Pan	Liquid	(1c.c.) 3,000	80 lactose bal. of season	June 19	65	Pow'd	215,000	0
					June 19	66	Pow'd	800,000	0
					June 19	67	Pow'd	215,000	0
May 24	48 Beater	Liquid	(1c.c.) ?	82	June 19	68	Pow'd	255,000	20
May 24	48 Cooler	Liquid	(1c.c.) 205,000	80	June 23	69	Pow'd	425,000	0
May 24	48 2d Tank	Liquid	(1c.c.) 275,000	66	June 23	70	Pow'd	145,000	0
May 24	46	Pow'd	300,000	13	June 23	71	Pow'd	185,000	0
May 24	47	Pow'd	300,000	0	June 23	72	Pow'd	70,000	30
May 26	48	Pow'd	130,000	33	June 23	73	Pow'd	265,000	26
May 26	49	Pow'd	500,000	80	June 23	74	Pow'd	900,000	0
May 26	50	Pow'd	445,000	13	June 28	75	Pow'd	300,000	0
May 31	51	Pow'd	425,000	16	June 28	76	Pow'd	230,000	0
May 31	52	Pow'd	390,000	30	June 28	77	Pow'd	130,000	0
May 31	53	Pow'd	800,000	26	June 28	78	Pow'd	250,000	10
June 3	54	Pow'd	400,000	43	June 28	79	Pow'd	75,000	23
June 3	55	Pow'd	445,000	0	June 28	80	Pow'd	510,000	5
June 3	56	Pow'd	800,000	36	July 6	81	Pow'd	20,000	0
June 12	57	Pow'd	60,000	26	July 6	82	Pow'd	285,000	0
June 12	58	Pow'd	150,000	0	July 6	83	Pow'd	60,000	0
June 12	59	Pow'd	37,000	0	July 6	84	Pow'd	75,000	0
June 12	60	Pow'd	65,000	0	July 6	85	Pow'd	50,000	10
June 12	61	Pow'd	93,000	0	July 6	86	Pow'd	85,000	0
June 12	62	Pow'd	350,000	0	July 6	87	Pow'd	255,000	0
June 12	63	Pow'd	260,000	0	July 6	88	Pow'd	390,000	46
June 19	64	Pow'd	275,000	30					

TABLE III—BACTERIAL TESTS DESICCATED EGG FROM MAY 6 TO JULY 3, 1912.

Date	Lot No.	Egg	No. Colonies per gram 48 hrs. at 37° C.	Per cent gas 48 hrs. .01 gm. lactose broth	Date	Lot No.	Egg	No. Colonies per gram 48 hrs. at 37° C.	Per cent gas 48 hrs. .01 gm. lactose broth
May 6	90	Pow'd	2,200	0	June 12	34	Pow'd	190,000	50
May 6	91	Pow'd	46,700	22	June 12	35	Pow'd	341,000	49
May 9	92	Pow'd	12,000	52	June 15	36	Pow'd	86,000	44
May 9	93	Pow'd	85,000	15	June 15	37	Pow'd	180,000	0
May 11	94	Pow'd	200,000	46	June 15	38	Pow'd	204,000	47
May 11	94 (sugar)	Pow'd	173,000	40	June 15	39	Pow'd	144,000	47
May 11	95	Pow'd	54,000	0	June 15	Beater	Liquid	(1c.c.) 3,000,000	80
May 15	8	Pow'd	35,000	52	June 15	Pipe	Liquid	(1c.c.) 3,600,000	77
May 15	9	Pow'd	162,000	59	June 15	1st Tank	Liquid	(1c.c.) 2,500,000	64
May 15	10	Pow'd	115,000	58	June 15	2d Tank	Liquid	(1c.c.) 2,000,000	77
May 18	11 (sugar)	Pow'd	59,000	20	June 21	40	Pow'd	120,000	0
May 18	12	Pow'd	63,000	54	June 21	41	Pow'd	500,000	50
May 22	13	Pow'd	43,000	53	June 21	42	Pow'd	373,000	50
May 22	14	Pow'd	170,000	58	June 21	43	Pow'd	45,000	60
May 22	15	Pow'd	157,000	27	June 21	44	Pow'd	338,000	45
May 22	16	Pow'd	198,000	45	June 27	45	Pow'd	400,000	0
May 25	17 (sugar)	Pow'd	87,000	11	June 27	46	Pow'd	160,000	22
May 25	18	Pow'd	140,000	37	June 27	47	Pow'd	141,000	22
May 25	19	Pow'd	113,000	35	June 27	48	Pow'd	468,000	0
May 29	20	Pow'd	140,000	31	June 27	49	Pow'd	154,000	0
May 29	21	Pow'd	255,000	43	July 3	50	Pow'd	129,000	0
May 29	22	Pow'd	332,000	48	July 3	51	Pow'd	252,000	0
June 3	23	Pow'd	495,000	36	July 3	52	Pow'd	530,000	0
June 3	24	Pow'd	132,000	44	July 3	53	Pow'd	200,000	0
June 3	25 Current Receipts	Pow'd	94,000	52	July 3	54	Pow'd	336,000	0
June 3	00 Spots	Pow'd	200,000	27	July 3	55	Pow'd	150,000	0
June 5	26 (sugar)	Pow'd	425,000	55	July 3	56	Pow'd	390,000	0
June 5	27	Pow'd	200,000	34	July 3	Spots	Pow'd	1,560,000	15
June 5	28	Pow'd	300,000	47	July 3	Spots Beater	Liquid	(1c.c.) 40 to 50,000,000	36
June 8	29	Pow'd	123,000	51	July 3	Spots Pipe	Liquid	(1c.c.) 40 to 50,000,000	37
June 8	30	Pow'd	344,000	20	July 3	Spots 1st Tank	Liquid	(1c.c.) 40 to 50,000,000	37
June 8	31	Pow'd	39,000	37	July 3	Spots 2d Tank	Liquid	(1c.c.) 40 to 50,000,000	36
June 8	32	Pow'd	82,000	20	July 3	Spots (Broken in) Beater	Liquid	(1c.c.) 40 to 50,000,000	36
June 12	33	Pow'd	300,000	50					

TABLE IV—BACTERIAL TESTS DESICCATED EGG FROM MAY 7 TO JULY 2, 1913.

Date	Lot No.	Egg	No. Colonies per gram 48 hrs. at 37° C.	Per Cent Gas 48 hrs. .01 gram Lactose Broth (Record of two tubes)	
May 7	125 first	Pow'd	6,000	45	50
May 7	125 last	Pow'd	6,700	0	20
May 7	126 first	Pow'd	5,100	50	60
May 7	126 last	Pow'd	2,000	0	30
May 10	127 first	Pow'd	6,000	0	0
May 10	127 last	Pow'd	12,100	0	0
May 10	128 first	Pow'd	13,300	50	50
May 10	128 last	Pow'd	230,500	50	60
May 10	129 first	Pow'd	95,600	50	50
May 10	129 last	Pow'd	270,000	0	0
May 14	130 first	Pow'd	62,000	41	45
May 14	130 last	Pow'd	185,000	0	20
May 14	132 first	Pow'd	168,000	40	50
May 14	132 last	Pow'd	200,000	0	0
May 16	133 first	Pow'd	284,000	30	30
May 16	133 last	Pow'd	284,000	32	36
May 16	134 first	Pow'd	166,000	40	66
May 16	134 last	Pow'd	290,000	0	25
May 16	135 first	Pow'd	193,000	0	20
May 16	135 last	Pow'd	269,000	0	50
May 21	139 first	Pow'd	27,000	58	58
May 21	139 last	Pow'd	210,000	40	43
May 21	140 first	Pow'd	210,000	46	56
May 21	140 last	Pow'd	337,000	54	56
May 23	141 first	Pow'd	140,000	50	54
May 23	141 last	Pow'd	525,000	50	54
May 23	142 first	Pow'd	252,000	46	46
May 23	142 last	Pow'd	655,000	50	50
May 24	136 first	Pow'd	120,000	62	64
May 24	136 last	Pow'd	130,000	0	0
May 24	137 first	Pow'd	183,000	69	72
May 24	137 last	Pow'd	95,000	0	0
May 24	143 first	Pow'd	182,000	76	76
May 24	143 last	Pow'd	312,000	54	76
May 27	144 first	Pow'd	180,000	75	80
May 27	144 last	Pow'd	360,000	0	60
May 27	146 first	Pow'd	261,000	70	75
May 27	146 last	Pow'd	445,000	46	50
May 29	147 first	Pow'd	153,000	48	62
May 29	147 last	Pow'd	255,000	0	48
May 29	148 first	Pow'd	102,000	0	45
May 29	148 last	Pow'd	201,000	0	35
June 2	149 first	Pow'd	130,000	0	0
June 2	149 last	Pow'd	246,000	30	64
June 4	153 first	Pow'd	252,000	50	55
June 4	153 last	Pow'd	552,000	57	66
June 4	154 first	Pow'd	(24 hrs.) 105,000	50	63
June 4	154 last	Pow'd	495,000	43	52
June 6	155 first	Pow'd	410,000	0	54
June 6	155 last	Pow'd	440,000	41	50
June 6	156 first	Pow'd	87,000	60	62
June 6	156 last	Pow'd	250,000	0	35
June 9	157 first	Pow'd	(24 hrs.) 165,000	0	0
June 9	157 last	Pow'd	345,000	0	80
June 9	158 first	Pow'd	445,000	0	0
June 9	158 last	Pow'd	780,000	0	20
June 11	160 first	Pow'd	565,000	0	44
June 11	160 last	Pow'd	655,000	0	0
June 11	161 first	Pow'd	380,000	0	5
June 11	161 last	Pow'd	405,000	0	9
June 13	162 first	Pow'd	390,000	0	0
June 13	162 last	Pow'd	312,000	0	0
June 13	163 first	Pow'd	360,000	15	21
June 13	163 last	Pow'd	450,000	0	17
June 16	164 first	Pow'd	162,000	0	10
June 16	164 last	Pow'd	192,000	0	0
June 16	165 first	Pow'd	126,000	0	8
June 16	165 last	Pow'd	192,000	9	15
June 18	167 first	Pow'd	260,000	0	0
June 18	167 last	Pow'd	275,000	0	23
June 18	168 first	Pow'd	75,000	0	32
June 18	168 last	Pow'd	70,000	0	0
June 21	169 first	Pow'd	180,000	0	30
June 21	169 last	Pow'd	242,000	0	0
June 21	170 first	Pow'd	56,000	33	40
June 21	170 last	Pow'd	50,000	0	0
June 21	171 first	Pow'd	45,000	0	0
June 21	171 last	Pow'd	250,000	0	0

June 23	172 first	Pow'd	395,000	6	26		June 28	178 first	Pow'd	260,000	0	30
June 23	172 last	Pow'd	365,000	15	24		June 28	178 last	Pow'd	170,000	0	15
June 25	174 first	Pow'd	125,000	0	0		June 28	179 first	Pow'd	125,000	9	30
June 25	174 last	Pow'd	330,000	0	0		June 28	179 last	Pow'd	200,000	0	0
June 25	175 first	Pow'd	230,000	16	28		July 2	181 first	Pow'd	55,000	0	0
June 25	175 last	Pow'd	395,000	0	0		July 2	181 last	Pow'd	70,000	0	0
June 28	176 first	Pow'd	200,000	0	28		July 2	182 first	Pow'd	485,000	0	15
June 28	176 last	Pow'd	295,000	0	13		July 2	182 last	Pow'd	540,000	40	40
June 28	177 first	Pow'd	55,000	0	0		July 2	183 first	Pow'd	265,000	30	44
June 28	177 last	Pow'd	120,000	0	5		July 2	183 last	Pow'd	560,000	12	12

TABLE V—BACTERIAL TESTS DESICCATED EGG AT INTERVALS; 1912 PRODUCT.

Date of Test	Lot No.	Days Storage	No. Colonies per gram 48 hrs. at 37° C.	Per Cent Gas 48 hrs. .01 gm Lactose Broth	Per Cent Decrease in No. Colonies	Date of Test	Lot No.	Days Storage	No. Colonies per gram 48 hrs. at 37° C.	Per Cent Gas 48 hrs. .01 gm Lactose Broth	Per cent Decrease in No. Colonies
Aug. 7, '12	90	90	300	0	86.36	Feb. 18, '13	19	264	1,800	0	98.40
Jan. 15, '13	90	249	200	0	90.91	Aug. 13, '12	20	74	11,200	0	92.00
Dec. 8, '13	90	575	50	0	97.72	Jan. 21, '13	20	235	2,600	0	98.14
Aug. 7, '12	91	90	2,800	0	94.02	Aug. 13, '12	21	74	6,600	0	93.49
Jan. 15, '13	91	249	1,600	0	96.57	Feb. 18, '13	21	263	1,400	0	99.51
Aug. 7, '12	92	87	650	0	94.58	Aug. 13, '12	22	74	17,400	0	94.75
Jan. 15, '13	92	246	500	0	95.83	Feb. 18, '13	22	263	3,200	0	99.03
Aug. 7, '12	93	87	17,200	0	79.76	Sept. 14, '12	23	102	42,600	0	91.39
Jan. 15, '13	93	246	2,700	0	96.82	Mar. 7, '13	23	276	26,500	0	94.64
Aug. 7, '12	94	85	30,200	0	84.90	Sept. 14, '12	24	102	14,200	0	89.24
Jan. 15, '13	94	244	?	0	?	Mar. 7, '13	24	276	8,200	0	93.78
Dec. 8, '13	94	570	0	0	100.	Sept. 14, '12	25	102	2,000	0	97.86
Aug. 7, '12	94 (sugar)	85	21,800	0	87.97	Mar. 7, '13	25	276	700	0	99.24
Jan. 15, '13	94	244	5,200	0	97.	Sept. 14, '12	26	99	37,800	0	91.10
Aug. 7, '12	95	85	11,400	0	78.88	Mar. 7, '13	26	274	12,000	0	97.17
Jan. 15, '13	95	244	2,300	0	95.14	Sept. 14, '12	27	99	11,600	0	94.20
Aug. 7, '12	8	81	5,200	0	85.14	Mar. 7, '13	27	274	8,500	0	95.75
Jan. 15, '13	8	240	800	0	97.71	Sept. 14, '12	28	99	48,000	0	84.00
Aug. 7, '12	9	81	102,600	44	36.67	Mar. 7, '13	28	274	17,000	0	94.33
Jan. 15, '13	9	240	?	0	?	Sept. 14, '12	29	96	42,000	0	65.85
Aug. 7, '12	10	81	21,000	0	81.73	Mar. 7, '13	29	271	15,000	0	87.80
Feb. 18, '13	10	275	6,000	0	94.78	Sept. 14, '12	30	96	7,800	0	97.73
Aug. 13, '12	11	86	7,000	0	88.13	Mar. 7, '13	30	271	3,000	0	99.12
Feb. 18, '13	11	272	5,000	0	91.61	Sept. 14, '12	31	96	1,200	0	96.92
Aug. 13, '12	12	86	4,600	0	92.70	Mar. 7, '13	31	271	450	0	98.84
Jan. 21, '13	12	244	2,000	0	96.82	Dec. 8, '13	31	557	0	0	100.
Aug. 13, '12	13	81	11,200	0	73.95	Sept. 14, '12	32	96	7,000	0	91.46
Jan. 21, '13	13	240	4,500	0	87.20	Mar. 7, '13	32	271	2,200	0	97.31
Aug. 13, '12	14	81	26,800	0	81.23	Sept. 14, '12	00	102	9,000	0	95.50
Jan. 21, '13	14	240	1,400	0	99.17	Jan. 15, '13	00	280	?	0	?
Aug. 13, '12	15	81	5,600	0	96.43	June 30, '13	00	396	3,850	0	98.75
Feb. 18, '13	15	267	900	0	99.42	Sept. 23, '12	33	102	12,400	0	95.86
Aug. 13, '12	16	81	28,600	0	85.55	Apr. 14, '13	33	304	8,800	0	97.06
Feb. 18, '13	16	267	2,800	0	98.57	Sept. 13, '12	34	102	11,600	0	93.89
Aug. 13, '12	17	78	8,800	0	89.90	Apr. 14, '13	34	304	9,500	0	95.00
Jan. 21, '13	17	238	2,500	0	97.12	Sept. 23, '12	35	102	5,400	0	98.41
Aug. 13, '12	18	78	800	0	99.42	Apr. 14, '13	35	304	5,100	0	98.50
Feb. 18, '13	18	264	500	0	99.64	Sept. 23, '12	36	99	2,400	0	97.21
Aug. 13, '12	19	78	5,400	0	95.22	Apr. 14, '13	36	301	6,200	0	69.53

Sept. 23, '12	37	99	100	0	99.94	June 30, '13	46	368	3,000	0	98.12
Apr. 14, '13	37	301	100	0	99.94	Jan. 13, '13	47	197	14,200	0	89.92
Sept. 23, '12	38	99	5,000	0	97.54	June 30, '13	47	368	3,700	0	97.20
Apr. 14, '13	38	301	1,650	0	99.15	Jan. 13, '13	48	197	12,600	0	97.30
Sept. 23, '12	39	99	14,200	0	90.13	June 30, '13	48	368	11,000	0	97.67
Apr. 14, '13	39	301	13,100	0	90.90	Jan. 13, '13	49	197	700	0	99.54
Sept. 23, '12	40	93	800	0	99.33	June 30, '13	49	368	300	0	99.80
Apr. 14, '13	40	295	2,100	0	98.25	Jan. 13, '13	50	190	6,300	0	95.11
Sept. 23, '12	41	93	60,000	0	88.00	Jan. 13, '13	51	190	8,200	0	96.74
Apr. 14, '13	41	295	43,200	0	91.36	Jan. 13, '13	52	190	11,600	44	97.81
Sept. 23, '12	42	93	27,600	0	92.76	June 30, '13	52	361	5,300	0	99.00
Apr. 14, '13	42	295	23,300	0	93.91	Jan. 13, '13	53	190	6,800	0	96.60
Sept. 23, '12	43	93	400	0	99.11	June 30, '13	53	361	4,700	12	97.65
Apr. 14, '13	43	295	1,400	0	96.87	Jan. 13, '13	54	190	4,900	0	98.54
Sept. 23, '12	44	93	49,200	0	85.45	June 30, '13	54	361	3,800	0	98.86
Apr. 14, '13	44	295	5,300	0	98.43	Jan. 13, '13	55	190	5,100	0	96.60
June 30, '13	44	374	10,000	0	97.04	June 30, '13	55	361	2,000	10	98.66
Jan. 13, '13	45	197	2,400	0	99.40	Jan. 13, '13	56	190	11,200	0	97.12
June 30, '13	45	368	4,000	0	99.00	June 30, '13	56	361	9,400	0	97.59
Jan. 13, '13	46	197	6,500	0	95.93						

TABLE VI—BACTERIAL TESTS DESICCATED EGG AT INTERVALS; 1913 PRODUCT.

Date 1913	Lot No.	Days Storage			No. Col. per gram 48 hrs. at 37° C.	Per Cent Decrease No. Col.	Per Ct. Gas 48 hrs. .01 gram Lact'se Broth	Date 1913	Lot No.	Days Storage			No. Col. per gram 48 hrs. at 37° C.	Per Cent Decrease No. Col.	Per Ct. Gas 48 hrs. .01 gram Lact'se Broth
		Lab. Temp.	19° C.	35° C.						Lab. Temp.	19° C.	35° C.			
Aug. 22	137 last	28	60	0	600	99.07	0	Oct. 22	164 first	9	0	112	0	100.00	0
Aug. 22	137 last	28	0	60	0	100.00	0	Oct. 22	164 last	9	0	112	0	100.00	0
Aug. 22	144 last	25	60	0	2,800	99.22	0	Oct. 22	165 first	6	0	112	0	100.00	0
Aug. 22	144 last	25	0	60	50	99.98	0	Oct. 22	169 first	0	0	112	0	100.00	0
Aug. 22	146 first	25	67	0	15,000	94.25	0	Oct. 22	170 last	0	0	112	50	99.90	0
Aug. 22	146 first	25	0	60	1,700	99.38	0	Oct. 22	171 last	0	0	112	50	99.98	0
Oct. 10	147 last	23	0	100	0	100.00	0	Oct. 22	172 last	0	0	112	400	99.89	37
Oct. 10	148 last	23	0	100	0	100.00	0	Oct. 22	175 first	0	0	109	50	99.90	0
Oct. 10	153 last	18	0	100	0	100.00	0	Dec. 8	137 last	28	0	156	0	100.00	0
Oct. 10	155 first	16	0	100	100	99.97	0	Dec. 8	144 first	25	0	156	0	100.00	0
Oct. 10	156 first	16	0	100	100	99.88	0	Dec. 8	146 first	25	0	156	0	100.00	0
Oct. 10	156 last	13	0	100	200	99.92	0	Dec. 8	147 last	23	0	156	50	99.98	0
Oct. 10	157 first	13	0	100	100	99.93	0	Dec. 8	153 last	18	0	156	0	100.00	0
Oct. 10	157 last	13	0	100	50	99.98	0	Dec. 8	155 first	16	0	156	100	99.97	0
Oct. 10	158 last	13	0	100	100	99.98	0	Dec. 8	156 last	13	0	156	0	100.00	0
Oct. 10	161 first	11	0	100	200	99.94	0	Dec. 8	157 first	13	0	156	0	100.00	0
Oct. 22	162 first	9	0	112	100	99.97	0	Dec. 8	175 last	0	0	153	0	100.00	0
Oct. 22	163 last	9	0	112	200	99.95	0								

TABLE VII.

LIQUID WHITE 1910 PRODUCT. No. Colonies Per c. c.	Number of Samples	Per Cent of Total	LIQUID YOLK 1910 PRODUCT. No. Colonies Per c. c.	Number of Samples	Per Cent of Total
To 10,000	12	15.78	To 10,000	6	9.09
10,000 to 50,000	10	13.15	10,000 to 50,000	7	10.60
50,000 to 100,000	12	15.78	50,000 to 100,000	7	10.60
100,000 to 500,000	31	40.78	100,000 to 500,000	44	66.66
500,000 to 1,000,000	9	11.84	500,000 to 1,000,000	0	0
1,000,000 to 7,000,000	2	2.63	1,000,000 to 7,000,000	2	3.03
	76	99.96		66	99.98

DESICCATED EGG PRODUCT OF

No. Colonies per gram	1911		1912		1913	
	Number of Samples	Per Cent of Total	Number of Samples	Per Cent of Total	Number of Samples	Per Cent of Total
To 10,000	0	0	1	1.78	5	5.10
10,000 to 50,000	7	7.44	6	10.71	5	5.10
50,000 to 100,000	15	15.91	8	14.28	10	10.20
100,000 to 500,000	63	67.02	40	71.42	70	71.42
500,000 to 1,000,000	9	9.57	1	1.78	8	8.16
	94	99.94	56	99.97	98	99.98

SUMMARY OF DESICCATED PRODUCT.

No. Colonies per gram	Number of Samples	Per Cent of Total
To 10,000	6	2.41
10,000 to 50,000	18	7.25
50,000 to 100,000	33	13.30
100,000 to 500,000	173	69.75
500,000 to 1,000,000	18	7.25
	248	99.96

Bacteriological Laboratory,
Drake University, Des Moines.

AN INCUBATOR OPENING TO THE OUTSIDE OF THE BUILDING.

BY L. S. ROSS.

Having had the experience more than once of being routed out of bed after ten o'clock on winter nights to make journeys to the laboratory with diphtheria tubes to put into the incubator for early morning microscopical examination, and also of many an after-supper trip to see if any belated tubes had been dropped into the box prepared for them, it occurred to me that an incubator might be arranged so a tube in its containing case could be dropped into it from the outside of the building. I had a box so arranged, why not an incubator? Upon searching, an old incubator was found, one that is opened by lifting off the entire top as a lid. The top was replaced with a wooden top, made in two parts and covered with heavy felt. A hole was cut in one part of the

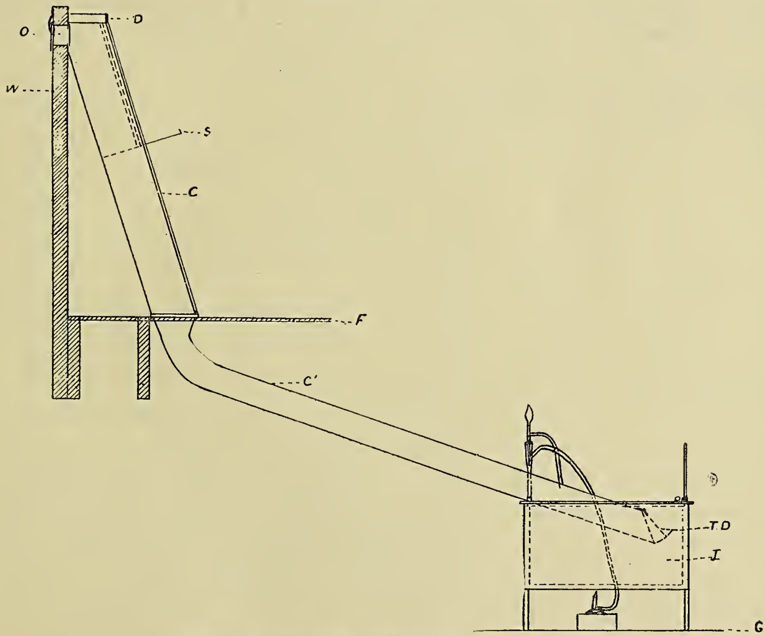

FIG. 2. Plan of incubator and chute.

W.—Wall of building.
O.—Opening into chute.
D.—Door of chute.
S.—Galvanized iron slide.
F.—Floor.
C. C.—Chute.
T. D.—Trap door.
I.—Incubator.
G.—Basement floor.

lid to admit a four inch galvanized iron pipe entering at an oblique angle. The pipe leads directly from the incubator, which is in the basement, up to the floor, where it connects with a wooden chute that in turn opens by a two inch square aperture to the outside of the building. The aperture is closed by two galvanized iron flaps, one on the inside of the wall and the other at the outside; the latter is kept closed by a spring in order to prevent the wind from opening it and sending gusts down into the incubator. At the lower oblique end of the pipe, the end in the incubator, is a hinged door that is opened by the force of the diphtheria tube case as it strikes after sliding down the chute. Then the door closes of its own weight after the tube has fallen into the incubator. A glass door, and a galvanized iron slide arranged to be opened or closed, are in the wooden chute above the floor. If desired, the slide may be closed so that tubes dropped into the chute during the day time may not go down into the incubator in the basement, but may be taken out and put into the incubator in the laboratory. The temperature of the incubator varies but little. It may be made more nearly constant by wrapping the iron pipe with asbestos paper, or with felt. The device has proved eminently successful and has saved many an after-supper trip to the laboratory. See figure 2.

Bacteriological Laboratory,
Drake University, Des Moines.

COMPARISON OF FIELD AND FOREST FLORAS IN MONONA COUNTY, IOWA.

BY D. H. BOOT.

The purpose of this paper is to present some of the results obtained in a study made of the field and forest floras of St. Clair township, Monona county, which indicate the close relations existing between the floras of the most extreme types of plant habitat found in Iowa.

The locality selected is in the east central part of Monona county, which is at the west end of the middle tier of counties of the state of Iowa. The eastern part of this county is very heavily rolling, the clay hills consisting of wind-blown loess, with a rather thin vegetable mold for a top soil. Five areas were chosen for study. One of these was a high prairie ridge running east and west, with the south side exposed to the strong southwest winds of summer, and carrying only a scanty xerophytic prairie vegetation. The second station was on a low prairie point between two high ridges, and with a southeast exposure. This prairie point was well protected from the southwest winds, and, like the first one, had never been disturbed by the plow. The third station was a piece of cleared ground that was reverting to forest again. This tract was on the north side of a high hill, and well protected from the hot summer winds. The fourth station was in a dense forest on the south bank of a deep gulch running east and west, so that it has a north exposure. The fifth station was on the north bank of the same gulch and differed from the fourth only in having a south exposure. The studies made included observations on the soil evaporation, on the relative humidity, the wind movement, and numerous other items that may affect plant growth; but this paper deals only with the lists of plants taken at each point and their correlation.

The study was made in the fall of 1909 and the spring of 1910. Collections of all plants in bloom were made August 3, August 14, August 21, September 18, April 9, April 30, June 1, June 9, and June 16, at each of the five different stations. The plants taken at the first station on August 3 were *Cirsium discolor* (Muhl.) Spreng. (Common Thistle), *Petalostemum candidum* Michx., (Prairie Clover), *Amorpha canescens* Pursh. (Lead Plant), *Brauneria angustifolia* (DC.) Britton (Purple Cone-flower), *Potentilla arguta* Pursh. (Cinquefoil), *Euphorbia corrollata* L. (Flowering Spurge), *Verbascum Thapsus* L. (Common

Mullein). No plants were blooming on this date at stations two or three; at station four *Desmodium grandiflorum* (Walt.) DC. (Tick Trefoil), *Phyrma leptostachya* L. (Lopseed), *Hystrix patula* Moench. (Bottle-bush Grass), *Campanula americana* L. (Tall Bell-flower), *Geum virginianum* L (Avens); and at station five *Desmodium grandiflorum* (Walt.) DC. (Tick Trefoil), *Campanula americana* L. (Tall Bell-flower), *Geum virginianum* L. (Avens), *Laportea canadensis* (L.) Gaud. (Wood Nettle), *Elymus striatus* Willd. (Wild Rye), *Chenopodium album* L. (Lambs' Quarters), were taken. August 14, the plants taken were *Amorpha canescens* Pursh. (Lead Plant), *Brauneria angustifolia* (DC.) Britton (Purple Cone-flower), *Euphorbia corrolata* L. (Flowering Spurge), *Polygonum convolvulus* L. (Black Bindweed), *Euphorbia preslii* Guss. (Spurge), *Dyssodia papposa* (Vent.) Hitchc. (Fetid Marigold), *Trifolium repens* L. (White Clover), *Salsola kali* var. *tenuifolia* G. F. W. Mey. (Russian Thistle), *Solidago nemoralis* Ait. (Goldenrod), *Polygonum pennsylvanicum* L. (Knotweed), *Asclepias verticillata* L. (Milkweed), *Petalostemum purpureum* (Vent.) Rydb. (Prairie Clover), *Linum sulcatum* Riddell (Flax), *Monarda mollis* L. (Horse Mint), *Verbena stricta* Vent. (Hoary Vervain), *Cirsium iowense* (Pammel) Fernald (Common Thistle), *Eragrostris megastachye* (Koeler) Link (A grass), *Houstonia angustifolia* Michx. (No common name), *Symphoricarpos occidentalis* Hook (Wolfberry), *Bouteloua curtipendula* (Michx.) Torr. (Mesquite Grass), *Andropogon furcatus* Muhl. (Beard Grass), for area No. 1. For area No. 2 there were taken *Cirsium discolor* (Muhl.) Spreng. (Common Thistle), *Petalostemum candidum* Michx. (Prairie Clover), *Euphorbia corrolata* L. (Flowering Spurge), *Euphorbia preslii* Guss. (Spurge), *Asclepias verticillata* L. (Milkweed), *Verbena stricta* Vent. (Hoary Vervain), *Petalostemum purpureum* (Vent.) Rydb. (Prairie Clover), *Linum sulcatum* Riddell (Flax), *Monarda mollis* L. (Horsemint), *Andropogon furcatus* Muhl. (Beard Grass), *Desmodium canescens* (L.) DC. (Tick Trefoil), *Helianthus tuberosus* L. (Jerusalem Artichoke), *Lactuca ludoviciana* (Nutt.) Riddell (Lettuce), *Symphoricarpos occidentalis* var. *laevigatus* Fernald (Snowberry), *Astragalus canadensis* L. (Milk Vetch), *Desmodium grandiflorum* (Walt.) DC. (Tick Trefoil). Area No. 3 was represented by *Monarda mollis* L. (Horse Mint), *Helianthus tuberosus* L. (Jerusalem Artichoke), *Polygonum lapathifolium* L. (Knotweed), *Impatiens pallida* Nutt. (Pale Touch-me-not), *Amphicarpa pitcheri* T. and G. (Hog Peanut), *Scrophularia leporella* Bicknell (Figwort), *Verbena urticaefolia* L. (White vervain). From area No. 4 were taken *Eupatorium urticaefolium Reichard* (White Snakeroot), *Phryma leptostachya* L. (Lopseed), *Campanula americana* L. (Tall Bell-flower), *Geum virginianum* L. (Avens), *Lappula virginiana* (L.) Greene (Beggars' Lice), *Circaea lutetiana* L. (Enchanter's Nightshade), *Eupatorium purpureum* L. (Joe-pye Weed), *Laportea canadensis* (L.) Gaud. (Wood Nettle). From area No. 5 *Phryma leptostachya* L. (Lopseed), *Campanula americana* L. (Tall Bellflower), *Geum virginianum* L. (Avens), *Agrimonia mollis* (T. and G.) Britton (Agrimony), *Desmodium dillenii* Darl. (Tick Trefoil). The plants collected on the 21st of August were: for area No. 1, *Cirsium discolor* (Muhl.) Spreng. (Common Thistle), *Amorpha canescens* Pursh. (Lead Plant), *Euphorbia corrolata* L. (Flowering Spurge), *Euphorbia preslii* Guss. (Spurge), *Dyssodia papposa* (Vent.) Hitchc. (Fetid Marigold), *Solidago nemoralis* Ait. (Goldenrod), *Asclepias verticillata* L. (Milkweed), *Petalostemum purpureum* (Vent.) Rydb. (Prairie Clover), *Monarda mollis* L. (Horsemint), *Verbena stricta* Vent. (Hoary Vervain), *Houstonia angustifolia* Michx. (No common name), *Bouteloua curtipendula* (Michx.) Torr. (Mesquite Grass), *Andropogon scoparius* Michx. (Beard Grass); for area No. 2, *Euphorbia corrolata* L. (Flowering Spurge), *Euphorbia preslii* Guss. (Spurge), *Ascelpias verticillata* L. (Milkweed), *Petalostemum purpureum* (Vent.) Rydb. (Prairie Clover), *Linum sulcatum* Riddell (Flax), *Monarda mollis* L. (Horsemint), *Verbena stricta* Vent. (Hoary Vervain), *Andropogon furcatus* Muhl. (Beard Grass), *Andropogon scoparius* Michx. (Beard Grass), *Sorghastum nutans* (L.) Nash. (Indian Grass), *Astragalus canadensis* L. (Milk Vetch), *Œnothera biennis* L. (Common Evening Primrose), *Verbena hastata* L. (Blue Vervain), *Helianthus hirsutus* Raf. (Sunflower), *Solidago serotina* Ait. (Goldenrod); for area No. 3, *Cirsium discolor* (Muhl.) Spreng. (Common Thistle), *Monarda mollis* L. (Horsemint), *Eragrostris megastachya* (Koeler) Link (A Grass), *Andropogon furcatus* Muhl. (Beard Grass), *Bidens vulgata* Greene (Beggar-ticks), *Œnothera biennis* L. (Common Evening Primrose), *Verbena hastata* L. (Blue Vervain), *Helianthus hirsutus* Raf. (Sunflower), *Heliopsis helianthoides* (L.) Sweet. (Ox-eye), *Polygonum lapathifolium* L. (Knotweed), *Amphicarpa pitcheri* T. and G. (Hog Peanut), *Verbena urticaefolia* L. (White Vervain), *Potentilla monspeliensis* L. (Cinquefoil), *Erigeron canadensis* L. (Horseweed), *Ambrosia artemisifolia* L. (Roman Wormwood), *Panicum capillare* L. (Old Witch Grass), *Polygonum dumetorium* L. (Knotweed), *Scrophularia marilandica* L. (Figwort); for area No. 4, *Campanula americana* L. (Tall Bellflower), *Ambrosia trifida* var. *integrifolia* (Muhl.) T. and G. (Great Ragweed), *Lactuca floridana* (L.) Gaertn. (Lettuce), *Impatiens pallida* Nutt. (Pale Touch-me-not); for area No. 5, *Euphorbia corrolata* L.

(Flowering Spurge), *Salsola kali* var. *tenuifolia* G. F. W. Mey. (Russian Thistle), *Andropogon furcatus* Muhl. (Beard Grass), *Kuhnia eupatorioides* var. *corymbulosa* T. and G. (False Boneset), *Eupatorium urticaefolium* Reichard (White Snakeroot), *Phryma leptostachya* L. (Lopseed), *Campanula americana* L. (Tall Bell-flower), *Laportea canadensis* (L.) Gaud. (Woodnettle), *Desmodium dillenii* Darl. (Tick Trefoil). On the 18th of September the following plants were collected: Area No. 1, *Cirsium discolor* (Muhl.) Spreng. (Common Thistle), *Euphorbia corrolata* L. (Flowering Spurge), *Dyssodia papposa* (Vent.) Hitchc. (Fetid Marigold), *Solidago nemoralis* Ait. (Goldenrod), *Linum sulcatum* Riddell (Flax), *Kuhnia eupatorioides* var. *corymbulosa* T. and G., *Aster sericeus* Vent. (Aster), *Solidago rigida* L. (Goldenrod), *Sorghastum nutans* (L.) Nash. (Indian Grass), *Aster multifloris* var. *exiguus* Fernald (Aster), *Bidens vulgata* Greene (Beggar Ticks); area No. 2, *Euphorbia corrolata* L. (Flowering Spurge), *Kuhnia eupatorioides* var. *corymbulosa* T. and G., *Heliopsis helianthoides* (L.) Sweet. (Ox-eye), *Aster cordifolius* L. (Aster); area No. 3, *Monarda mollis* L. (Horsemint), *Helianthus tuberosus* L. (Jerusalem Artichoke), *Helianthus hirsutus* Raf. (Sunflower), *Polygonum lapathifolium* L. (Knotweed), *Impatiens pallida* Nutt. (Pale Touch-me-not), *Eupatorium urticaefolium* Reichard (White Snakeroot); area No. 4, *Eupatorium urticaefolium* Reichard (White Snakeroot), *Campanula americana* L. (Tall Bellflower); area No. 5, *Aster cordifolius* L. (Aster). In the following spring the lists of plants collected are: for April 9, area No. 1, *Astragalus caryocarpus* Ker. (Ground Plum), *Erythronium albidum* Nutt. White Dog's-tooth Violet), *Viola sororia* Willd. (Violet), *Ostrya virginiana* (Mill.) K. Koch. (American Hop Hornbean), *Anemone patens* var. *wolfgangiana* (Bess.) Koch. (Pasque Flower), *Carex pennsylvanica* Lam. (Sedge), *Viola pedatifida* G. Dou. (Violet), *Antennaria neodioica* Greene (Everlasting), *Quercus macrocarpa* var. *oliviformis* (Michx. f.) Gray (Bur Oak); area No. 2, *Erythronium albidum* Nutt. (White Dog's-tooth Violet), *Taraxacum officinale* Weber (Dandelion); area No. 3, *Erythronium albidum* Nutt. (White Dog's-tooth Violet), *Taraxacum officinale* Weber (Dandelion), *Ribes gracile* Michx. (Missouri Gooseberry), *Prunus americana* Marsh. (Wild Plum), *Crataegus mollis* (T. and G.) Scheele. (Hawthorn), *Viola scabriuscula* Schwein. (Smooth Yellow Violet); area No. 4, *Carex pennsylvanica* Lam. (Sedge), *Taraxacum officinale* Weber (Dandelion), *Sisyrinchium campestre* Bicknell (Blue-eyed Grass), *Viola scabriuscula* Schwein. (Smooth Yellow Violet); *Phlox divaricata* L. (Blue Phlox), *Arisaema triphyllum* (L.) Schott (Indian Turnip), *Ranunculus abortivus* L. (Small-flowered Crowfoot), *Dicentra cucullaria* (L.) Bernh. (Dutchman's Breeches), *Ribes cynosbati* L. (Prickly Gooseberry), *Sanguinaria canadensis* L. (Bloodroot); area No. 5, *Erythronium albidum* Nutt. (White Dog's-tooth Violet), *Viola sororia* Willd. (Violet), *Ribes gracile* Michx. (Missouri Gooseberry), *Prunus americana* Marsh. (Wild Plum), *Phlox divaricata* L. (Blue Phlox), *Quercus macrocarpa* Michx. (Bur Oak). The plants collected on the 30th of April on area No. 1 were *Carex pennsylvanica* Lam. (Sedge), *Antennaria neodioica* Greene (Everlasting), *Lithospermum angustifolium* Michx. (Puccoon). For area No. 2 they were *Sisyrinchium campestre* Bicknell, (Blue-eyed Grass). For area No. 3 none were taken. For area No. 4, *Viola pubescens* Ait. (Downy Yellow Violet), *Galium aperina* L. (Cleavers), *Fragaria virginiana* Duchesne. (Strawberry) were collected. For area No. 5 the list included *Viola scabriuscula* Schwein. (Smooth Yellow Violet), *Phlox divaricata* L. (Blue Phlox), *Arisaema triphyllum* (L.) Schott (Indian Turnip), *Ranunculus abortivus* L. (Small-flowered Crowfoot), *Galium aperina* L. (Cleavers), *Osmorhiza longistylus* var. *villicaulis* Fernald. (Sweet Cicely). The plants collected on the 1st of June were: Area No. 1, *Poa pratensis* L. (Kentucky Blue Grass), *Ceanothus ovatus* var. *pubescens* T. and G. (Redroot); area No. 2, *Poa compressa* L. (Canada Blue Grass), *Tradescantia bracteata* Small (Spiderwort); area No. 3, *Trifolium repens* L. (White Clover), *Aquilegia canadensis* L. (Wild Columbine), *Phlox divaricata* L. (Blue Phlox), *Carya glabra* (Mill.) Sprach. (Pignut), *Arisaema triphyllum* (L.) Schott (Indian Turnip), *Sanicula canadensis* L. (Sanicle), *Ranunculus abortivus* L. (Small-flowered Crowfoot), *Delphinium tricorne* Michx. (Dwarf Larkspur), *Fragaria vesca* var. *americana* Porter (Strawberry); area No. 4, *Taraxacum officinale* Weber (Dandelion), *Phlox divaricata* L. (Blue Phlox), *Arisaema triphyllum* (L.) Schott (Indian Turnip), *Ranunculus abortivus* L. (Small-flowered Crowfoot), *Hydrophyllum virginianum* L. (Waterleaf), *Sanicula marilandica* L. (Black Snakeroot), *Galium aperina* L. (Cleavers); for area No. 5, *Taraxacum officinale* Weber (Dandelion), *Aquilegia canadensis* L. (Wild Columbine), *Phlox divaricata* L. (Blue Phlox), *Arisaema triphyllum* (L.) Schott (Indian Turnip), *Ranunculus abortivus* L. (Small-flowered Crowfoot), *Hydrophyllum virginianum* L. (Waterleaf), *Galium aperina* L. (Cleavers). For June 9 on area No. 1 the plants were *Ceanothus ovatus* var. *pubescens* T. and G. (Redroot), *Oxalis stricta* L. (Wood Sorrel); on area No. 2, *Oxalis stricta* L. (Wood Sorrel); for area No. 3, *Trifolium repens* L. (White Clover), *Poa pratensis* L. (Kentucky Blue Grass), *Taraxacum officinale* Weber (Dandelion), *Aquilegia canadensis* L. (Wild Columbine), *Arisaema triphyllum* (L.) Schott (Indian Turnip), *Delphinium tricorne* Michx. (Dwarf Larkspur), *Hydrophyllum virginianum* L. (Waterleaf), *Aquilegia canadensis* L. (Wild Columbine); for area No. 4, none; for area No. 5, *Aquilegia canadensis* L. (Wild Columbine), *Carya glabra* (Mill.) Sprach. (Pignut), *Hydrophyllum virginianum* L. (Waterleaf), *Sanicula marilandica* L. (Black Snakeroot), *Galium aperina* L. (Cleavers), *Carya glabra* var. *villosa* (Sarg.) Robinson (Broom Hickory). The plants taken on June 16 are: for area No. 1, *Brauneria angustifolia* (DC.) Heller, (Purple Cone-flower), *Aster multiflorus* var. *exogenus* Fernald (Aster), *Ceanothus ovatus* var. *pubescens* T. and G. (Redroot), *Rosa pratincola* Greene (Rose), *Capsella bursa-pastoris* (L.) Medic. (Shepherd's Purse), *Physalis pubescens* L. (Ground Cherry), *Onosmodium occidentale* Mackenzie (False Gromwell), *Anemone cylindrica* Gray (Anemone); for area No. 2, *Physalis pubescens* L. (Ground Cherry), *Anemone cylindrica* Gray (Anemone), *Triosteum perfoliatum* L. (Tinker's Weed), *Trifolium hybridum* L. (Alsike Clover), *Achillea millefolium* L. (Common Yarrow); for area No. 3, *Trifolium repens* L. (White Clover), *Aquilegia canadensis* L. (Wild Columbine), *Cryptotaenia canadensis* (L.) DC. (Honewort), *Evonymus atropurpureus* Jacq. (Burning Bush), *Vitis velutina* L. (Riverbank Grape), *Sanicula marilandica* L. (Black Snakeroot), *Juglans nigra* L. (Black Walnut); for area No. 4, *Trifolium repens* L. (White Clover), *Phlox divaricata* L. (Blue Phlox), *Hydrophyllum virginianum* L. (Waterleaf), *Cryptotaenia canadensis* (L.) DC. (Honewort), *Evonymus atropurpureus* Jacq. (Burning Bush), *Sanicula marilandica* L. (Black Snakeroot), *Vitis vulpina* L. (Riverbank Grape); for area No. 5, *Hydrophyllum virginianum* L. (Waterleaf), *Cryptotaenia canadensis* (L.) DC. (Honewort), *Celastrus scandens* L. (Climbing Bittersweet).

By grouping these plants under their several areas and dates there is obtained a gradual curve of transition indicated by the plant names, extending regularly from area No. 1 to area No. 5, and indicating gradual change in flora from the one locality to the next, so that we have no abrupt changes from the high dry prairie ridge to the low sheltered prairies, from the low sheltered prairie to the cleared land, from the cleared land to the dense forest with a north exposure, nor from this to the dense forest with the south exposure, but there is a gradual transition from the plant life of one area to that of the next, until finally in the dense forest we have few of the plants found out on the exposed prairies.

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NOTES ON A FOSSIL TREE-FERN OF IOWA.

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The members of the *Psaroneae* comprise a family of ferns which lived during later Paleozoic times and often developed to treelike dimensions. Some believe that they were closely related to the *Cyatheaceae,* to which modern tropical tree-ferns belong. Most botanists, however, consider the *Psaroneae* a family of the order *Marattiales.* Members of this order still live, but, though tropical, are, for the most part, low forms with stumplike stems and enormous leaves. The *Marratiales* have been sometimes thought of as ancestors of the *Pteridospermae,* and it is possible that the *Psaroneae* may yet be associated with this latter group. Specimens of the fossil *Psaronius* have in rare instances been found in organic contact with the impressions of the frond of *Pecopteris sterlzeli.* This last-named species closely resembles the leaves of *Pecopteris pluceneti,* which according to Grand 'Eury is one of the seed-bearing forms.

The *Psaroneae* proper are all treelike in habit, and have been found only in the Upper Carboniferous and the Lower Permian strata. Their geographical distribution includes Saxony, Central France, Bohemia, Brazil, and North America. Some writers believe that at times the tree reached a height of at least sixty feet.

A peculiarity of *Psaronius* lies in the fact that after the lower leaves had fallen off, adventitious roots grew out among the leaf scars and thence downward to the ground. Though these are individually very small, they are produced in such numbers that the leaf scars were completely obscured from view, and a sort of false cortex enveloped the stem in its lower region.

The genus is composed of three general types of stems distinguished by the arrangement of leaves and hence of leaf scars. Each of these types is represented by a number of species. One kind has the leaves in two longitudinal rows, *distichi;* in another there are four longitudinal rows, *tetrastichi;* and the remaining species have them disposed more or less in spirals, *polystichi.*

Several years ago some fragments of *Psaronius* were found in the Upper Carboniferous of Hardin county, Iowa. They consisted for the most part of petrifactions of adventitious roots, while one showed a small portion of the periphery of the stem. Dr. T. H. Macbride referred these to a new species, *Psaronius borealis,* and described them in the Proceedings of the Davenport Academy of Science for 1907. That description has been appended to this paper.

During the summer of 1913 Mr. Ralph Gray found another specimen of *Psaronius* in that same region. It had been eroded from the bank of a nearby stream, so that its geological position unfortunately cannot be exactly determined. Its composition is sandstone infiltrated with a large amount of iron. Since it bears no marks of glaciation there is no evidence that it grew and was fossilized in any other locality than that in which it was found. The country rock at that place is Upper Carboniferous, and this also lends strength to this interpretation, that it grew near the place of finding.

The fossil is cylindrical, about fourteen inches in length, and three inches in diameter. Judging from the thickness of the false cortex of roots the portion fossilized is that part of the stem some distance above the ground. The vascular system at the upper end indicates that the living stem must have extended upward at least twenty inches farther, so that this tree-fern was doubtless several feet in height.

The leaf scars are arranged in eight longitudinal rows, those of adjacent rows alternating. They thus appear to be spirally disposed, and hence this specimen should be classed with the *polystichi.* The distance between successive leaf scars of the same longitudinal row varies from twenty-five to thirty-two millimeters. Each leaf scar is oval in form, and its absciss surface has a vertical diameter of thirty-eight millimeters and a horizontal diameter of nineteen millimeters. On this surface there is a V shaped elevation somewhat below the center, doubtless marking the leaf trace. A very prominent groove extends downward from the lateral margin of each leaf scar, defining the boundary of the leaf base as it enters the stem proper. This groove varies from eight to thirteen millimeters in length. The leaf scars are not all well preserved, about half of them being hollow cavities which were packed with friable sand when the specimen was found. These poorly preserved leaf bases are for the most part on one side of the stem, which indicates that the latter lay on the surface of the ground for some time before it was petrified. In this way decomposition took place on the lower, more moist, side.

Between adjacent rows there appears a ridge, one centimeter in diameter, and perpendicular in direction. It is bounded on either side by the leaf scars and the grooves which are associated with them. The degree of convexity of the ridge is rather variable. It may be almost flat, or be uniformly rounded, or a sharp edge may be found on either side or along the center.

Among the leaf bases are the attachments of the rootlets which grew out after the leaves had fallen off. These are very minute, being not more than one millimeter in diameter. They are especially prominent along the grooves, but may occur in any part of the inter-abscissal area. The roots themselves were probably torn off in some way before petrifaction took place, for no evidence of abrasion is seen on the fossil remains. At the lower end of the stem an area of about twenty-eight square centimeters is covered with a mass of these rootlets about eight millimeters in thickness. These present a very fibrous appearance due to the parallel arrangement of the rootlets. It cannot be absolutely determined whether this represents the entire thickness of the false cortex at this place or not; but the general appearance favors such an interpretation. A few of the absciss surfaces of the leaf scars appear fibrous; it is probable that this indicates the overlying of rootlets, most of which had in some way been removed.

By polishing the upper end of the specimen it was possible to define the general system of vascular supply. From the marked radial symmetry of the leaf arrangement it seemed probable that the vascular system would also be symmetrically disposed. On this account the

Fig. 3.—Diagram of the slightly oblique polished surface of the upper end of the specimen, showing the arrangement of vascular bundles.

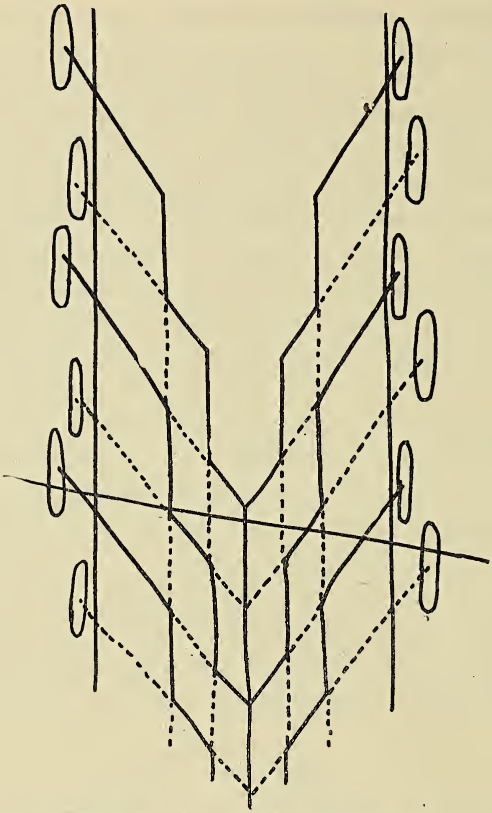

Fig. 4.—Schematic drawing of vascular system in longitudinal aspect.

polished surface was made slightly oblique, making possible the determination of the form and general course of the strands from a single section (Fig. 3). Figure 4 is a schematic drawing of the bundle arrangement in longitudinal aspect, constructed from a study of the polished section and the leaf scars. The leaf traces of only four rows of leaves are indicated in this scheme, those of the other four being omitted for the sake of simplicity. In order to distinquish between the leaf traces of successive nodes they have been represented alternately by broken and entire lines.

Beneath each ridge, which runs longitudinally between two rows of leaf scars, a horseshoe-shaped vascular strand extends from the base to the apex of the stem. This strand is convex outward and measures about eight millimeters from edge to edge. Small accessory bundles may sometimes be seen along these edges; they probably arise from the horseshoe-shaped strand and proceed to the rootlets. Other root bundles arise from the junction of the strand with the leaf trace itself.

For each leaf base there is a single leaf trace. As it enters the leaf base it is broad, and slightly convex outward. As it passes in its outward course between two of the horseshoe-shaped peripheral strands it connects with them along either edge. It will thus be seen that the peripheral strand in its upward course unites with a leaf trace first on one side and then on the other, but at no one level do peripheral strands and leaf traces constitute a complete ring.

The four leaf traces of the leaves of the next node above may be found alternate with those just described and on their inner side. They are similarly convex outward and in addition their edges are slightly recurved. They are at least two centimeters in width and are separated laterally by a distance of not more than one centimeter.

The leaf traces of the second node above the polished surface form a similar cycle within the one last mentioned. They are, however, less convex; and their edges are in no instance recurved. Within this cycle the system is somewhat more complicated. Each leaf trace of the third node above is broken into three vascular strands arranged side by side in the form of a curve. The middle strand is fused along its edges with the two adjacent traces of the next outer, or second, cycle. Since in this way each leaf trace of the second node unites on either side with the middle strand of the leaf trace of the third node there is formed a complete vascular ring. Each of the lateral strands of the leaf trace of the third node is joined to the middle strand of the leaf trace of the fourth node; while the lateral strand of the fourth sometimes remains independent or may connect with both the middle strand of the fourth and the lateral of the third node, forming a triradiate figure. This anastomosis of the leaf traces into three strands is only a local modification and does not disturb the individuality of the leaf trace as it is followed downward. It seems that these three strands unite again at a lower level to constitute the original leaf trace once more.

The leaf trace of the fifth node above is seen to anastomose in a similar manner, but the strands are in this case much narrower, being only about five millimeters in width. The four leaf traces of the fifth node, when followed downward, are seen to unite together to form the central strand of the stem. It thus appears that all leaf traces originate from this central strand and after more or less anastomosis proceed individually to their respective leaf bases. It will be remembered that in their course they fuse laterally with the leaf traces of the whorl immediately above and that immediately below. In this way two concentric vascular rings are seen to be formed enveloping the central strand. Each of these rings is, however, slightly perforate, due to the anastomosis of the individual leaf traces into three strands at different levels.

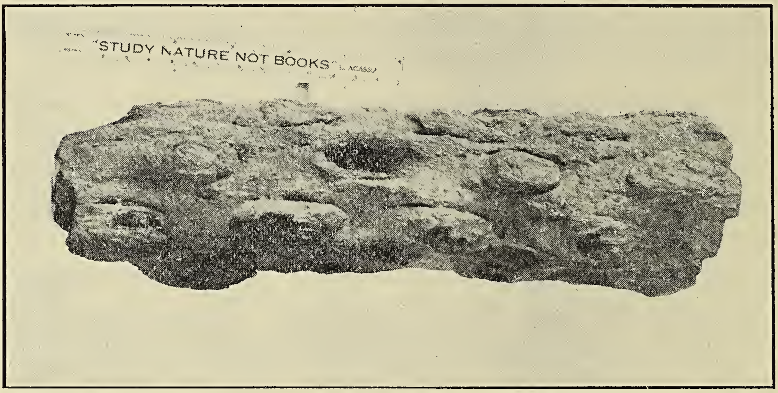

Fig. 5.—Photograph of the specimen of Psaronius.

It seems probable, therefore, that this stem arose from one with a single solid central vascular core, from which the leaf traces proceeded independently to the leaf bases. Such an arrangement would resemble the primitive protostele. The system, as here found, may thus have arisen by a lateral fusion of the leaf traces at different points. It is easy to see, that, should this tendency toward fusion continue a little farther, two imperforate hollow cylinders would be developed about the central strand. This might be thought of as a double siphonostele. It would furnish direct vascular connection between the roots and the leaves, irrespective of the vascular strand in the center; and, since it would be more peripheral, might, in a large stem, constitute a considerably shorter route, and hence transmit a larger amount of water than the central strand. According to the generally accepted theory of use and disuse the central strand would tend to abort under these circumstances. The same factor might operate to obliterate the inner of the two hollow cylinders, so that finally but one hollow cylinder or, in other words, an ordinary siphonostele would supplant the present more complex form. It is not here contended that this is the only way in which a siphonostele may have evolved from the protostele, but the specimen here described suggests the above as a possible course in this group of plants.

ADDENDA.

The following description of *Psaronius borealis,* Macbr. is taken from the Proceedings of the Davenport Academy of Science, vol. X, p. 158:

> The fossil here described is represented by several fragments of a pteridophytous stem about ten centimeters in length and six in width. The whole specimen is strongly impregnated with iron, probably haematite. The iron deposits are so extensive as to have replaced almost entirely the vascular parts of the associated structures. The central mass of the stem seems to have been composed of two elements, a parenchymatous, as we infer from the homologies of the case, now wholly lost and replaced by sand, and a vascular element preserved only in part, but showing the bandlike form characteristic of the stems of larger ferns, as for instance, some Cyatheas, where the section of each bundle is arcuate with the tips of the arc more or less reversed or flexed. This feature of the fossil is indicated in Plate V, Fig. 1. The entire stem, when perfect, must have been fifteen or eighteen centimeters in diameter.
>
> The outer part of the stem, Plate V, Fig. 2, much better preserved than the central axis, shows a vast multitude of vascular strands more or less parallel to each other and to the principal axis; not straight, however, but interwoven, grown through each other apparently in a most intricate mass. Between the strands a crude, rather thick-walled parenchyma is seen. Each strand has for its center a fibro-vascular bundle of the concentric type, showing scalariform ducts of unequal diameter; but the bundle is itself surrounded by a strongly developed sheath or moss of sclerenchymatous cells everywhere well preserved. Plate VI, Figs. 1 and 2.
>
> The generic reference of this fossil would seem sufficiently clear. Specific distinctions here, as elsewhere, are purely tentative, but for convenience of reference the specimen may be called by a specific name. The distribution of the principal vascular strands may possibly here suggest specific characters, although in existing forms such arrangement is generally significant of a much larger group.

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NOTES ON THE ECOLOGY OF IOWA LICHENS.

ZOE R. FRAZIER.

Many interesting features are presented by this group of organisms, some of which have been investigated more or less thoroughly, while others have received comparatively little attention. The work with Iowa Lichens has consisted almost entirely of reporting and describing species, with only very limited reference to structural modifications of thalli, and the relation between this and the ability of lichens to withstand adverse atmospheric conditions. In this, lichens are perhaps the most remarkable organisms in existence, and the full investigation of the secrets of this power offers an excellent field for the student of special problems.

The work, of which a partial result is here presented, was undertaken at the State University with the view of adding some observation along the line suggested. Further work of this kind would probably reveal many more interesting results.

All plants give off water in transpiration and it is well known that in many higher plants this process is more or less well controlled. This is especially true of xerophytic plants. Many of the lichens are extreme xerophytes, and the escape of moisture must be checked if they are to persist. Many forms regulate this by some modification of structure.

These structural adaptations are not so marked as in the vascular xerophytes yet certain modifications of the same general nature as those presented by the latter, may be observed. In collecting material the tree forms were found to be smaller in pastures, and the more exposed places, than the same species on the same kind of trees at the border of timber and other more protected places.

Those species growing on rocky cliffs varied greatly in size from the top of the cliff to the base, those at the crest being smaller than the same species growing at the base or in protected crevices of rock. In general, the species in the more exposed places are characterized by reduction of thallus.

Loss of water is prevented, by lichens, in various ways. Some species check it by a well developed cortex which is usually on the upper surface, more rarely on the lower surface. This cortex may be a well developed layer of thick-walled cells several layers in thickness, or it may be much reduced. The thickness of the cell wall varies in different thalli as does the cortical layer. In other species there is no true cortex but a covering of closely interwoven hyphæ, which serves the purpose of a cortex to a limited degree.

Some facts of interest were observed in regard to the variation in cortex of some of the species. *Dermatocarpon* has a well developed cortex above and below, the lower cortex, however, being developed to a lesser degree. Those specimens collected from the xerophytic Sioux quartzite of Lyon county, Iowa, show a thicker cortex than those from Muscatine and Johnson counties. They are smaller, more harsh to the touch and when soaked become tougher and not so soft as the Johnson and Muscatine county material.

Parmelias have an upper and more or less well developed lower cortex and are closely attached to the substratum, thus reducing transpiration.

Among *Placodiums* a cortex is developed in all except the crustose forms. *Placodium elegans,* collected from the exposed rocky cliffs at the Palisades in Linn county, had a thicker cortex than the same species collected from less exposed places. The *Lecanoras* have no cortex but in *Lecanora rubina* there is a heavy covering of closely interwoven hyphæ which probably is a protection against excessive evaporation. This species is well adapted to the xerophytic conditions of exposed ledges and is represented most abundantly by specimens from the Sioux quartzite of Lyon county, where exposure is extreme. In *Peltigera canina* there is a well developed upper cortex only. As a rule the cortex is best developed in the most xerophytic species.

Excessive transpiration is also checked by reduction of the apothecia in both numbers and size. Generally those forms growing on exposed rocks as the Sioux quartzite do not show large or exposed apothecia. *Rinodina* and *Dermatocarpon* have immersed apothecia. *Peltigera* collected from the exposed crests of hills had much reduced apothecia while the same species growing in the shade and protected places had large spreading disks. Among the cliff forms the apothecia of any species varied greatly in size from the top of the cliffs to the base except in cases where the whole cliff was protected; here there was no well marked variation. The specimens of *Placodium elegans* collected from the crevices of the cliffs of the Palisades in Linn county and from Turkey creek in Johnson county had larger disks than those growing on the exposed face of the rocks.

These facts may account in part at least for the persistence of these organisms in areas where other forms of plant life do not thrive.

The great resisting power of lichens has long been recognized in a general way. Some observations were made for the purpose of more accurately determining this power. In the following experiments the resistance of the algal cells of some lichens to heat and drying was tested. To obtain an absolute result, the lichens would have to be grown in connection with the experiment. This was not possible on account of the limited time to be devoted to the experiments, and impractical, for it would be impossible to eliminate all other factors affecting the growth of the lichens.

The algal cells were selected because they respond more readily to change. The most accurate results possible could be obtained only by careful observation of these cells subjected to heat and drying, and the comparison of them with fresh ones from the same thallus. Any change in the appearance of the protoplasts or cell walls would indicate a change in composition or organization of the cell. No attempt, however, was made to determine the change, if any, in the composition of the cell contents. The main point was to ascertain the decrease in water content, the change in organization of the cell, and its ability to recover from this. Each of the sets of experiments consisted in heating specimens of the selected species of lichens, which were chosen from various habitats.

In the first experiment the following species were used: *Dermatocarpon miniatum* (L.) Fr., *Peltigera canina* (L.) Hoffm., *Cladonia rangiferina* (L.) Webb., *Placodium elegans* (Link) Ach., *Cetraria ciliaris* Ach., *Parmelia caperata* (L.) Ach., and *Physcia stellaris* (L.) Nyl. The temperatures ranged from 27 7/9° C. to 101° C. during the six hours of the experiment. Comparatively fresh, healthy, vigorous representatives of the various species were chosen, and all except *Placodium clegans* were selected from shady places. An examination of the material at the outset showed it to contain only the usual numbers of dead algal cells in the thalli. The specimens, cut in small pieces, were placed in shallow glass dishes in the evaporating oven. Burning the specimens was prevented in all cases except *Dermatocarpon* and *Physcia* in which the hyphæ were slightly browned at the end of the experiment. An hourly record of temperature was made, and a piece of each species removed, except at 11:00 a. m. and 1:00 p. m., and placed in distilled water for twenty-four hours to soften it for examination to determine if the algal cells could be restored to their normal condition. For mounting, the specimens were crushed, as the algal cells only were to be studied.

Following is briefly given the temperature of the oven, the time at which the various specimens were removed, and any change noted when compared with a fresh piece of the same thallus. The specimens were placed in the oven at 8:00 o'clock a. m., the temperature being 27 7-9° C.

Cladonia rangiferina (L.) Webb., collected from the shady bluffs at Wyoming Hill, north of Muscatine.

9:00 A. M., Temperature 77 2-3° C.

The algal cells were changed from bright green to yellowish green. The protoplasts with their nuclei seemed normal.

10:00 A. M., Temperature 83 8-9° C.

The cells unchanged, except that the color had become yellow.

12:00 M., Temperature 82 2-9° C.

This specimen was greenish yellow like that removed at 9 a. m., and the protoplasts were somewhat shrunken, but the nuclei appeared normal.

2:30 P. M., Temperature 101° C.

The algal cells had become transparent, but were still yellowish green, and the protoplasts were shrunken into irregular masses. The gelatinous sheaths were much thinner, and nuclei were seen in nearly all cells.

Dermatocarpon miniatum (L.) Fr., collected from the shady north face of the rocky bluffs north of Iowa City.

9:00 A. M., Temperature 77 2-3° C.

All the algal cells appeared normal.

10:00 A. M., Temperature 83 8-9° C.

The color was changed to yellowish green, and a slight shrinkage of the protoplasts had taken place. The nuclei appeared normal.

12:00 M., Temperature 82 2-9° C.

The color of the algal cells was yellowish green, and the protoplasts were somewhat shrunken, and no cell showed a nucleus.

2:30 P. M., Temperature 101° C.

The color was changed to light brown, the cell contents were clear and shrunken into irregular masses, and the hyphæ were light brown, indicating that this specimen was slightly scorched, although under conditions not different from the others.

Parmelia caperata (L.) Ach., collected from a butternut tree in the woods at Mid River, northwest of Iowa City.

9:00 A. M., Temperature 77 2-3° C.

The color was changed from dark green to yellowish green, the nuclei were plainly visible, and the cells apparently normal.

11:00 A. M., Temperature 83 8-9° C.

The algal cells showed no difference from those removed from the oven at 9:00 o'clock.

12:00 M., Temperature 82 2-9° C.

The color was changed to light yellow, and the protoplasts were slightly shrunken. Most cells showed nuclei.

2:30 P. M., Temperature 101° C.

The color had become yellowish brown, and the protoplasts were shrunken. Nuclei were visible in some of the cells.

Peltigera canina (L.) Hoffm., collected from the exposed rocky slope north of Iowa City.

9:00 A. M., Temperature 77 2-3° C.

There was no change in the bright green color, nor were the cells shrunken. The cells were smaller than those of the fresh specimen, but this may have been a variation in the plant.

10:00 A. M., Temperature 83 8-9° C.

There was no perceptible change in the cells.

12:00 M., Temperature 82 2-9° C.

The color had changed to yellowish green, and some cells appeared slightly shrunken.

2:30 P. M., Temperature 101° C.

The algal cells had lost almost all their color; the contents were transparent and shrunken into irregular masses. The hyphæ were slightly brown.

Cetraria ciliaris Ach., collected from an old pine board fence one and one-half miles northwest of Earlville.

9:00 A. M., Temperature 77 2-3° C.

The color had changed from bright green to yellowish green. The cells were unshrunken and nuclei visible.

10:00 A. M., Temperature 83 8-9° C.

The color had changed to yellowish green, the protoplasts were considerably shrunken, but the granular appearance was still retained by some cells.

12:00 M., Temperature 82 2-9° C.

The color was yellowish green, the sheaths were thinner, and the protoplasts shrunken into irregular masses.

2:30 P. M., Temperature 101° C.

The color was still yellowish green, the protoplasts were greatly shrunken, and the walls thinner. Very few dead cells were present.

Placodium elegans (Link) Ach., collected from the tops of the bluffs near the boat house at the Palisades in Linn county.

9:00 A. M., Temperature 77 2-3° C.

The algal cells were normal with few dead cells.

10:00 A. M., Temperature 83 8-9° C.

The color had changed from bright green to greenish brown and the protoplasts were somewhat shrunken.

12:00 M., Temperature 82 2-9° C.

The color was greenish brown and the protoplasts were very much shrunken.

2:30 P. M., Temperature 101° C.

All the green color had disappeared, the protoplasts were much shrunken, the hyphæ were light brown, and many dead cells were present. This condition may not have been due to heating, as the specimen may have been taken from an old part of the thallus.

Physcia stellaris (L.) Nyl., collected from a butternut tree in the woods near Bayfield.

9:00 A. M., Temperature 77 2-3° C.

The algal cells were normal.

10:00 A. M., Temperature 83 8-9° C.

The color changed from green to yellowish green, and the protoplasts were somewhat shrunken.

12:00 M., Temperature 82 2-9° C.

The color was yellowish green, the protoplasts were greatly shrunken and the gelatinous sheaths were very thin.

2:30 P. M., Temperature 101° C.

The color had become greenish brown and the protoplasts were greatly shrunken. Not many empty cells were present.

The algal cells of the species used in this experiment, with the exception of those of *Peltigera,* changed from bright green to yellowish green at the end of the second hour, with the maximum temperature 83 8-9° C. *Cetraria,* however, was greatly bleached at the end of the first hour with the temperature at 77 2-3° C. With the exception of *Cetraria, Dermatocarpon* and *Physcia,* the algal cells began to show a shrinkage at the end of the third hour, with a temperature of 83 8-9° C. *Physcia, Dermatocarpon* and *Cetraria* showed a shrinkage at the end of the second hour, with a temperature of 83 8-9° C.

The purpose of the following experiment was to determine the relative resistance of those lichens from the Sioux quartzite of Iowa, collected by Professor Shimek in 1896, and kept in the Herbarium of the University of Iowa during the intervening sixteen years, as compared with the resistance of those collected from the same region June 30, 1913, six days before the experiment. The temperature was recorded each hour, and pieces of various thalli removed and placed in distilled water. The specimens chosen were *Parmelia conspersa, Lecanora rubina* and *Dermatocarpon miniatum.* The examination of the specimens before heating showed a slight difference in the shade of green of the algal cells, that of the old specimens being less brilliant than the color of the new ones, but there was no difference in the water content.

The oven was started at 9:00 o'clock A. M., with a temperature of 26 2-3° C. Following is briefly given the time at which each specimen was removed, the temperature, and a comparison of the old with the new thalli.

Lecanora rubina (Lam. & DC.).

9:00 A. M., Temperature 26 2-3° C.

The algal cells of the new specimen were slightly darker green than those of the old specimen. The protoplasts were normal.

10:00 A. M., Temperature 50° C.

The specimens showed no change.

11:00 A. M., Temperature 68 1-3° C.

The old specimen was bleached to very light yellow, and many empty algal cells were present, but none of the cell contents of either old or new showed any shrinkage. The old specimen was probably from a less vigorous part of the thallus, as the other parts of the same thallus were not so affected.

12:00 M., Temperature 79 4-9° C.

Both old and new specimens were bright yellowish green, and a few cells in each showed a slight shrinkage.

1:00 P. M., Temperature 90 5-9° C.

The old specimen had many empty algal cells. Those which were not empty were yellowish green, and all the cells of both old and new specimens were considerably shrunken.

2:00 P. M., Temperature 102 7-9° C.

The protoplasts of both old and new specimens were greatly shrunken, but the algal cells of the new specimens were brighter yellow.

Parmelia conspersa (Ehrh.) Ach.

9:00 A. M., Temperature 26 2-3° C.

The old specimen showed many dead algal cells and many cells were somewhat shrunken. This was a very poor part of the thallus.

10:00 A. M., Temperature 50° C.

The algal cells of both old and new specimens were bright yellowish green, and all cells were unshrunken.

11:00 A. M., Temperature 68 1-3° C.

The algal cells were still bright yellowish green, and a few cells of each specimen were slightly shrunken.

12:00 M., Temperature 79 4-9° C.

The algal cells of both specimens were slightly shrunken and yellowish green.

1:00 P. M., Temperature 90 5-9° C.

The algal cells showed no further change of color, but the protoplasts were more shrunken than at 12 o'clock.

2:00 P. M., Temperature 102 7-9° C.

All the algal cells were greenish yellow, and were considerably shrunken.

Dermatocarpon miniatum (L.) Fr.

9:00 A. M., Temperature 26 2-3° C.

The algal cells of both old and new specimens were dark green and unshrunken.

10:00 A. M., Temperature 50° C.

The cells were not changed from those of 9 o'clock.

11:00 A. M., Temperature 68 1-3° C.

The algal cells showed no shrinkage and the color was yellowish green.

12:00 M., Temperature 79 4-9° C.

There was no change in color of the algal cells. They were still yellowish green and unshrunken.

1:00 P. M., Temperature 90 5-9° C.

The algal cells from the old specimen were bright green, with very few cells shrunken. The new specimen was yellowish green and slightly shrunken. The cortex of the old specimen was thicker than that of the new specimen.

2:00 P. M., Temperature 102 7-9° C.

The algal cells were yellowish green, with some bright green cells in both new and old specimens. The cells were slightly shrunken in both.

The comparison in this experiment of fresh material with that which had been in the herbarium sixteen years brought out the following interesting results.

The old specimens of *Dermatocarpon* did not seem to be affected by their life in the herbarium, and did not show the effects of drying and heating sooner than the fresh ones. The old specimen of *Lecanora* lost its color and was greatly shrunken sooner than the fresh one.

A second experiment with other material from the same collections corresponded in all results to the one given here, and further emphasized the fact that these xerophytic forms can withstand drying to a remarkable degree.

A comparison of the resisting power of those shade inhabiting species with the xerophytic forms probably would bring out some further facts of interest. The effect of heat upon the color of the shaded and exposed species was equal, but the water content of the cells in the specimens from shade was reduced sooner than that in those from the Sioux quartzite.

CONCLUSIONS.

The following conclusions are suggested by the work recorded here:

Lichens vary in adaptation to habitat; this applies to both different species and to different individuals of the same species.

Variation in habitat is explained, at least in part, by structural adaptations.

Lichens show a remarkable power of resistance to drouth.

OSKALOOSA.

A PRELIMINARY REPORT ON THE FLORA OF LINN COUNTY.

BY E. D. VERINK.

During the past twenty years, under the incumbency of a number of professors in Coe College, the college herbarium was enriched by the collection of a large number of plants indigenous to Linn county. For many years these were poorly housed, room for herbarium facilities was lacking, and the collection was consequently neglected. The building of a new science hall has made it possible for the first time to revise this collection. The author has also spent three seasons collecting specimens in Linn county and, through the kindness of Mr. Geo. H. Berry, had access to the herbarium of the latter, which contains a number of species not found in the Coe herbarium. The accompanying list, then, should be fairly complete. While those who have worked at this collection in previous years may have been guilty of some errors, every effort has been made to check their work, and it is believed that the work as here presented, while not absolutely complete, is essentially accurate. It should, therefore, be of some value to students of our eastern Iowa Flora, and in that hope it is here presented. Acknowledgments are due to Mr. Berry, not only for access to his herbarium, but for assistance given in identifying specimens, to the late Dr. J. E. Gow for the suggestion leading to the undertaking and for revision of the manuscript, and special thanks are due to Miss Phoebe Smith for card indexing the entire Coe collection, as well as for valuable assistance in identification of species and preparation of manuscript.

AIOZACEAE.

Mollugo verticillata (L.), Carpet Weed (C); common.

ANACARDIACEAE.

Rhus canadensis (Marsh.), Sweet Scented Sumac (C); common.
Rhus glabra (L.), Smooth Sumac (C); common.
Rhus typhina (L.), Staghorn Sumac (C); common.

ARISTOLOCHIACEAE.

Asarum canadensis (L.), Wild Ginger (C); common.

(C) after the common name indicates specimens to be found in the Coe College Herbarium.
(B) after the common name indicates specimens to be found in Geo. H. Berry's Herbarium.

AMARYLLIDACEAE.

Hypoxis hirsuta (L.), Yellow Star Grass (C); common.
Narcissus poeticus (L.), Poet's Narcissus (C); common.

ACERACEAE.

Acer negundo (L.), Box Elder (C); common.
Acer saccharum (Marsh.), Sugar Maple (C); common.
Acer saccharum nigrum (Mx.f.), Black Maple (C); common.
Acer saccharinum (L.), White Maple (C); common.
Acer rubrum (L.), Red Maple; common.
Aesculus hippocastanum (L.), Horse Chestnut (C); common.

ARACEAE.

Acorus calamus (L.), Sweet Flag (C).
Arisaema dracontium (Schott), Green Dragon (C); rare.
Arisaema triphyllum (Schott), Jack-in-the-Pulpit (C); common.
Calla palustris (L.), Water Arrum (C); rare.
Orontium aquaticum (L.), Golden Club (C); rare.

ALISMACEAE.

Alisma plantago-aquatica (L.), Water Plantain (C).
Lophotocarpus calycinus maximum (J. G. Sm.) (C).
Sagittaria arifolia (Nutt.), Arrow Head (C); common.
Sagittaria engelmanniana (J. G. Sm.), Arrow Head (C).
Sagittaria heterophylla (Pursh.), Arrow Head (C).

ASCLEPIADACEAE.

Asclepias amplexicaulus (Sm.), Milkweed (C); common.
Asclepias incarnata (L.), Swamp Milkweed (C); common.
Asclepias pumila (Vail), Narrow-leaved Milkweed (C); common.
Asclepias purpurascens (L.), Purple Milkweed (C); common.
Asclepias sullivantii (Engelm.), Milkweed (C).
Asclepias syriaca (L.), Milkweed (C).
Asclepias tuberosa (L.), Pleurisy-root (C).
Asclepias verticillata (L.), Whorled Milkweed (C); common.

ACANTHACEAE.

Ruellia ciliosa (Pursh.), Hairy Ruellia (C).

BALSAMINACEAE.

Impatiens biflora (Walt.), Spotted Touch-me-not (C); common.

BETULACEAE.

Betula nigra (L.), Red or River Birch (C); common.
Carpinus caroliniana (Walt.), Blue Birch (C); common.
Corylus americana (Walt.), Hazelnut (C); common.
Ostrya virginiana (K. Koch.), American Hop Horn Bean (C); common.

BERBERIDACEAE.

Berberis vulgaris (L.), Barberry (C); not uncommon, exotic.
Caulophyllum thalictroides (Michx.), Pappoose Root (C).
Podophyllum peltatum (L.), May Apple (C); common.

BORAGINACEAE.

Lappula virginiana (Greene), Beggars Lice.
Lithospermum angustifolium (Michx.), Yellow Puccoon (C); common.
Lithospermum canescens (Lrhm.), Orange Puccoon (C); common.
Lithospermum gmelini (Hitchc.), Hairy Puccoon (C).
Lithospermum latifolium (Michx.), Puccoon (C).
Mertensia virginica (Link), Bluebells (C); common.
Myosotis arvensis (Hill), Mouse Ear (C); common.
Myosotis scorpioides (L.), Forget-me-not (C); common.
Myosotis virginica (BSP), Scorpion Grass (C); common.
Onosmodium hispidissimum (Mack), False Gromwell (C).

BIGNONIACEAE.

Catalpa speciosa (Warder), Catalpa Tree (C); common.
Catalpa bignonoides (Walt.), Catalpa Tree (C); not uncommon; exotic.

CONVOLVULACEAE.

Convolvulus arvensis (L.), Small Bindweed (C); common.
Convolvulus sepium (L.), Hedge Bindweed (C); common.
Cuscuta arvensis (Beyrich), Field Dodder (B.); common.
Cuscuta compacta (Juss.), Compact Dodder (C); common.
Cuscuta glomerata (Chois.), Dodder (C); common.
Cuscuta gronovii (Willd.), Dodder (C).
Cuscuta indecora (Chois.), Pretty Dodder (B).
Cuscuta coryli (Engelm.), Dodder (C).
Impomoea pandurata (G. F. W. Mey.), Man-of-the-earth (C).

CHENOPODIACEAE.

Chenopodium album (L.), Pigweed (C); common.
Chenopodium boscianum (Moa), Bosc's Goosefoot (B); fairly common.
Chenopodium hybridum (L.), Maple-leaved Goosefoot (C); rare.

Chenopodium murale (L.), Nettle-leaved Goosefoot (C) ; rare.
Chenopodium polyspermum, Many-seeded Goosefoot (C) ; rare.
Chenopodium urbicum (L.), Upright or City Goosefoot (C) ; not rare.
Cycloloma atriplicifolium (Spreng.), Winged Pigweed.
Kochia scoparia (L.) Schrad., Pigweed (C) ; uncommon, introduced.
Salsola kali tenuifolia (G. F. W. Mey.), Saltwort, Russian Thistle (C) ; uncommon.

CARYOPHYLLACEAE.

Agrostemma githago (L.), Corn Cockle (B) ; common, introduced.
Arenaria lateriflora (L.), Sandwort (C) ; common.
Cerastium brachypodum (Rob.), Mouse-ear Chickweed (C) ; common.
Cerastium nutans (Raf.), Chickweed (C) ; common.
Cerastium viscosum (L.), Mouse-ear Chickweed (C) ; not uncommon.
Dianthus chinesis, China Pink (C).
Lychnis coronaria (Desr.), Mullein Pink (C) ; introduced.
Saponaria officinalis (L.), Bouncing Betty (C) ; common, introduced.
Silene antirrhina (L.), Sleepy Catchfly (C) ; common.
Silene armeria (L.), Sweet William, Catchfly (C) ; introduced.
Silene dichotoma (Ehrh.), Forked Catchfly (C) ; introduced.
Silene nivea (Nutt.) Otth., Western White Campion (C).
Silene noctiflora (L.), Night-flowering Catchfly ; not uncommon.
Silene stellata (L.) Ait. f., Starry Campion (C).
Stellaria media (Cyrill), Common Chickweed (C) ; common.

CORNACEAE.

Cornus canadensis (L.), Bunch Berry (B) ; fairly common.
Cornus paniculata (L.) L'Her., Red Osier, Cornel ; fairly common.

CAMPANULACEAE.

Campanula americana (L.), Tall Bellflower (C).
Campanula rotundifolia, Common Harebell (C).
Specularia perfoliata (A. DC.), Venus' Looking Glass (C).

CUCURBITACEAE.

Echinocystis lobata (T. & G.), Wild Balsam Apple (C).
Sicyos angulatus, Bur Cucumber (C).

COMMELINACEAE.

Commelina communis (L.), Asiatic Day Flower (C) ; introduced.
Tradescantia bracteata (Small), Spiderwort (B).
Tradescantia occidentalis (Smyth), Pink Spiderwort (B).
Tradescantia virginiana (L.), Spiderwort (C).

CAPRIFOLIACEAE.

Lonicera dioica (L.), Smooth-leaved Honeysuckle (C); common.
Lonicera flava (Sims), Yellow Honeysuckle (C); common.
Lonicera glaucescens (Rybd.), Douglas Honeysuckle (B).
Lonicera sempervirens (L.), Trumpet Honeysuckle (B).
Lonicera sullivantii (Gray), Sullivant's Honeysuckle (C).
Lonicera xylosteum (L.), European Fly, or Honeysuckle (C).
Sambucus canadensis (L.), Common Elder (C); common.
Triosteum perfoliatum (L.), Wild Coffee (B).
Viburnum cassinoides (L.), White Rod, or Wild Raison (C); common.
Viburnum prunifolium (L.), Black Haw (C).
Viburnum pubescens (Pursh.), Downy Arrowhead (C).

COMPOSITAE.

Boltonia asteriodes (L.), L'her. (C).
Achillea millefolium (L.), Yarrow (C); common.
Ambrosia artemisiifolia (L.), Hogweed, Bitterweed (C); common.
Ambrosia trifida (L.), Great Ragweed (C); common.
Anaphalis margaritacea (B. & H.), Pearly Everlasting (C); common.
Antennaria canadensis (Greene), Ladies' Tobacco (C); common.
Antennaria neglecta (Greene), Indian Tobacco (C); common.
Antennaria neodioica (Greene), Cudweed (C); common.
Antennaria plantaginifolia (Greene), Pussy's Toes (C); common.
Anthemis cotula (L.), Mayweed (C); common.
Anthemis tinctoria (L.), Yellow Chamomile (G); common.
Aplopappus ciliatus (DC.), Cass (C).
Artemisia caudata (Michx.), Wormwood (C); common.
Artemisia kansana (Britton), Wormwood (C); common.
Artemisia longifolia (Nutt.), Long-eared Mugwort (C).
Artemisia ludoviciana (Nutt.), Western Mugwort (C).
Artemisia serrata (Nutt.), Wormwood (C).
Aster azureus (Lindl.), Skyblue Aster (C); common.
Aster commutatus (Gray), Aster (C); common.
Aster cordifolius (L.), Bushy Aster (C); common.
Aster drummondii (Lindl.), Aster (C); common.
Aster ericoides (L.), Frost-weed Aster; common.
Aster lowrieanus (Porter), Lowrie's Aster (C); common.
Aster novae-angliae (L.), New England Aster (C); common.
Aster paniculatus simplex (Burgess), Aster (C).
Aster ptarmicoides (T. & G.), Upland White Aster (C).
Aster tradescanti (L.), Michaelmas Daisy (C).

Aster vimineus foliolosus (Ait.), Gray Aster (C).

Bellis perennis (L.), Daisy (B).

Bidens discoidea (T. & G.), (C).

Brauneria angustifolia (DC.) Heller, Purple Cone-flower (C); common.

Brauneria pallida (Nutt.) Britton, Pale Purple Cone-flower (C).

Chrysanthemum leucanthemum var. *pinnatifidum* (Lecoq & La Motte), White Daisy (C).

Chrysanthemum segetum (L.), Corn Marigold (B); introduced.

Cirsium altissimus (L.) Spreng., Fall Thistle (C); common.

Cirsium undulatum (Nutt.) Spreng., Thistle (C); common.

Cirsium discolor (Muhl.) Spreng., Field Thistle (C); common.

Cirsium lanceolatum (L.) Hill, Bull Thistle (C); common.

Coreopsis palmata (Nutt.), Stiff Tickseed (B).

Coreopsis tinctoria (Nutt.), Garden Tickseed (B).

Dyssodia papposa (Vent.) Hitchc., Fetid Marigold (B).

Erigeron philadelphicus (L.), Fleabane (C); common.

Erigeron pulchellus (Michx.), Robin's Plantain (C); common.

Erigeron ramosus (Walt.) BSP., Daisy Fleabane (C).

Eupatorium altissimum (L.), Tall Thoroughwort (C).

Eupatorium capillifolium (Lam.) Small, Dog Fennel (C).

Eupatorium purpureum maculatum (L.) Darl., Spotted Joe Pye Weed (C).

Eupatorium perfoliatum (L.), Boneset (C); common.

Eupatorium purpureum (L.), Joe Pye Weed (C); common.

Eupatorium semiserratum (DC.), Small-flowered Thoroughwort (C).

Eupatorium urticaefolium (Reichard), White Snakeroot (B).

Gutierrezia sarothrae (Pursh.) Britton & Rushby, Gutierrezia (C).

Helenium autumnale (L.), Sneezeweed (C).

Helianthus decapetalus (L.), Wild Sunflower (C); common.

Helianthus giganteus (L.), Tall Sunflower (C).

Helianthus maximiliani (Schrad.), Maximilian's Sunflower (C).

Helianthus mollis (Lam.), Hairy Sunflower (B).

Helianthus occidentalis (Riddell), Few-leaved Sunflower (C).

Helianthus petiolaris (Nutt.), Prairie Sunflower (C).

Helianthus scaberrimus (Ell.), Stiff Sunflower (C).

Helianthus tuberosus (L.), Jerusalem Artichoke (C); common.

Hieracium aurantiacum (L.), Devil's Paint Brush (C); common, introduced.

Hieracium longipilum (Torr.), Long-bearded Hawkweed (C).

Hieracium venosum (L.), Rattlesnake Weed (C).

Iva xanthifolia (Nutt.), Burweed Marsh Elder (C); common.

Lactuca canadensis (L.), Wild Lettuce, Horseweed (C); common.

Lactuca floridana (L.) Gaertn., False or Florida Lettuce (C).

Lactuca spicata (Lam.) Hitchc., Tall Blue Lettuce (C).

Lactuca scariola (L.), Prickly Lettuce; common.

Lepachys pinnata (Vent.) T. & G., Gray Headed Cone-flower (C).

Liatris cylindracea (Michx.), Blazing Star (B).

Liatris punctata (Hook.), Dotted Button Snakeroot (C); not common.

Liatris pycnostachya (Michx.), Blazing Star (C); common.

Liatris scariosa (Willd.), Large Button Snakeroot (B).

Mikania scandens (L.) Willd., Climbing Wild Hemp (B).

Parthenium integrifolium (L.), American Fever-few (C).

Prenanthes alba (L.), White Lettuce (B).

Prenanthes serpentaria (Pursh.), Gall-of-the-earth (C); common.

Rudbeckia hirta (L.), Black-eyed Susan (C); common.

Rudbeckia laciniata (L.), Tall or Green-headed Cone-flower (C).

Rudbeckia triloba (L.), Thin-leaved Cone-flower (C).

Senecio aureus (L.), Golden Ragwort (C); common.

Senecio balsamitae (Muhl.), Balsam Groundsel (C).

Senecio canus (Hook.), Silvery Groundsel (C).

Senecio integerrimus (Nutt.), Entire-leaved Groundsel (C).

Senecio palustris (L.) Hook., Marsh Groundsel (C).

Senecio tomentosus (Michx.), Wooly Ragwort (C).

Sericocarpus linifolius (L.) BSP., Narrow-leaved White-topped Aster (C).

Solidago canadensis (L.), Canada Goldenrod (C); common.

Solidago canadensis gilvocanescens (Rybd.), Goldenrod (C).

Solidago houghtonii (T. & G.), Houghton's Goldenrod (B).

Solidago latifolia (L.), Broad-leaved Goldenrod (C); common.

Solidago neglecta (T. & G.), Swamp Goldenrod (C); common.

Solidago nemoralis (Ait.), Gray or Field Goldenrod (C); common.

Solidago rigida (L.), Stiff or Hard-leaved Goldenrod (C); common.

Solidago serotina (Ait.), Late Goldenrod (C); common.

Solidago stricta (Ait.), Wandlike or Willow-leaved Goldenrod (B).

Solidago ulmifolia (Muhl.), Elm-leaved Goldenrod (B).

Tanacetum vulgare (L.), Common Tansy (C); common.

Taraxacum officinale (Weber), Common Dandelion (C); common, introduced.

Vernonia fasciculata (Michx.), Western Ironweed (C).

Vernonia noveboracenis (Willd.), Flat Top or New York Ironweed (C).

Xanthium canadensis (Mill), American Cocklebur (B).
Xanthium commune (Britton), Cocklebur (B).

CELASTRACEAE.

Celastrus scandens (L.), Climbing Bittersweet (C).

CRASSULACEAE.

Penthorum sedoides (L.), Ditch Stonecrop (C).
Sedum acre (L.), Mossy Stonecrop (B).
Sedum purpureum (Tausch.), Garden Orpine, Live-for-ever (C); introduced.
Sedum roseum (L.), Rose Root (B); Rare.

CRUCIFERAE.

Alyssum alyssoides (L.), Yellow or Small Alyssum (C); common, introduced.
Arabis dentata (T. & G.), Toothed Rock Cress (C); common.
Brassica arvensis (L.) Ktze., Mustard (C); not uncommon.
Brassica juncea (L.), Indian Mustard (C); not uncommon.
Brassica nigra (L.) Koch., Black Mustard (C); very common.
Brassica alba (L.) Boiss., White Mustard (C); rare.
Capsella bursa pastoris (L.) Medic., Shepherds Purse (C); very common.
Cardamine bulbosa (Sehre) BSP., Spring Cress (C); Abundant.
Cardamine douglassii (Torr.) Britton, Purple Cress (C); common.
Dentaria laciniata (Muhl.), Pepper Root, Toothwort (C); common.
Draba cuneifolia (Nutt.), Wedge-leaved Whitlow Grass (C).
Erysimum chiranthoides (L.), Wormseed Mustard (C); common.
Erysimum parviflorum (Nutt.), Wild Mustard (C).
Hesperis matronalis (L.), Dame's Violet (B); occasional.
Lepidium campestre (L.) R. Br., Cow Cress (C); introduced.
Lepidium draba (L.), Hoary Cress (C).
Lepidium virginicum (L.), Wild Peppergrass (C); common.
Lunaria annua (L.), Honesty (B); Rare.
Raphanus sativus (L.), Radish (C); occasional.
Radicula armoracia (L.) Robinson, Horseradish (C); common.
Radicula nasturtium-aquaticum (Britton & Rondle), True Water Cress; common.
Radicula palustris (L.) Moench, Marsh Cress (C); common.
Radicula palustris hispida (Desv.) Robinson, Water Cress (C); scarce.
Roripa curvisiliqua, Curved-fruited Cress (C).
Sisymbrium altissimum (L.), Tumble Mustard (C).

Sisymbrium incisum (Engelm.), Western Mustard Tansy (C); common.

Sisymbrium officinale (L.) Scop., Hedge Mustard (C); common.

Sisymbrium sophia (L.), Flizweed (C); common.

EQUISETACEAE.

Equisetum arvense (L.), Common Horsetail (C); common.

Equisetum hymale (L.), Scouring Rush (C); common.

Equisetum pratense (Ehrh.), Thicket Horsetail (C); common.

ERICACEAE.

Chimaphila maculata (L.) (Pursh.), Spotted Wintergreen (B).

Monotropa hypopitys (L.), Pinesap (C); rare.

Monotropa uniflora (L.), Corpse Plant (C); rare.

Pyrola americana (Sweet), Wintergreen (B).

Pyrola elliptica (Nutt.), Shin Leaf (B); scarce.

Vaccinium stamineum (L.), Squaw Huckleberry (C).

EUPHORBIACEAE.

Euphorbia corrollata (L.), Flowering Spurge (C); abundant.

Euphorbia cyparissias (L.), Cypress Spurge (C).

Euphorbia geyeri (Engelm.), Geyer's Spurge (C); not rare.

Euphorbia heterophylla (L.), Painted Leaf (C); common.

Euphorbia humistrala (Engelm.), Hairy Spreading Spurge (C).

Euphorbia maculata (L.), Milk Spurge; not uncommon.

Euphorbia preslii (Guss.), Upright Spotted Spurge (C); common.

AMARANTHACEAE.

Amaranthus blitoides (Wats.), Amaranth (C); common.

Amaranthus palmeri (Wats.), Amaranth (C).

Amaranthus spinosus, Amaranth (C).

Amaranthus retroflexus.

ARALIACEAE.

Aralia nudicaulis (L.), Wild Sarsaparilla (B).

Aralia racemosa (L.), Spikenard (B).

Panax quinquifolium (L.), Ginseng (B).

APOCYNACEAE.

Apocynum androsaemifolium (L.), Dogbane (C).

CERATOPHYLLACEAE.

Ceratophyllum demersum (L.), Hornwort (B).

CYPERACEAE.

Cyperus erythrorhizos (Muhl.), Red-rooted Cyperus (C).
Cyperus aristatus (Rottb.), Awned Cyperus (C).

DIOSCOREACEAE.

Dioscorea villosa (L.), Wild Yam (B).

DROSERACEAE.

Drosera rotundifolia (L.), Sun-dew (B).

LINACEAE.

Linum floridanum (Planch.), Florida Yellow Flax (C).
Linum medium (Planch.), False Yellow Flax (B).
Linum usitatissimum (L.), Common Flax (B); common.

LYTHRACEAE.

Ammannia auriculata (Wild.), Loosestrife (B).
Lythrum alatum (Pursh.), Purple·Loosestrife (C).
Lythrum salicaria (L.), Spiked Loosestrife (L).

MELASTOMACEAE.

Rhexia virginica (L.), Deer Grass (B).

OROBANCHACEAE.

Orobanche uniflora (L.), One-flowered Cancer Root.

SPARGANIACEAE.

Sparganium eurycarpum (Engelm.), Bur-reed (C).

FUMARIACEAE.

Corydalis flavula (Raf.) DC., One-Spurred Yellow Dutchman's Breeches.
Corydalis sempervirens (L.) Pers., Pale Rose Pink Corydalis (C).
Dicentra canadensis (Goldie) Walp., Squirrel Corn (C).

FAGACEAE.

Quercus alba (L.), White Oak (C); common.
Castanea dentata (Marsh.) Borkh., American Chesnut (C); introduced.

GRAMINEAE.

Agrostis alba (L.), Red Top (C); common.
Agropyrum repens (L.) Beauv., Quick Grass (C); common.
Aristida basiramea (Englm.), Triple-awned Poverty Grass (C).
Aristida tuberculosa (Nutt.), Triple-awned Poverty Grass (C).

Arrhenatherum elatius (L.) Beauv., Tall Oat Grass (C).
Bouteloua curtipendula (Michx.) Torr., Mesquite Grass (C); common.
Calamvilfea longifolia (Hook.) Hack., C.
Cenchrus carolinianus (Walt.), Sand Bur (C); common.
Cynodon dactylon (L.) Pers., Bermuda Grass (C).
Dactylis glomerata (L.), Orchard Grass (C); common.
Digitaria sanguinalis (L.) Scop., Crab Grass (C).
Echinochloa crus-galli (L.) Beauv., Barnyard grass (C).
Eleusine indica (Gaertn.), Goose Grass (C).
Elymus canadensis (L.), Nodding Wild Rye (C); common.
Elymus glaucus (Buckley), Smooth Wild Rye (C).
Elymus virginicus (L.), Virginia Wild Rye (C); common.
Eragrostis frankii (Fisch., Mey., & Lall.) Steud., Frank's Eragrostis (C).
Eragrostis megastachya (Koeler) Link, Strong-scented Eragrostis (C).
Milium effusus (L.), Tall Millet-grass (C).
Muhlenbergia sylvatica (Torr.), Wood Muhlenbergia (C).
Paspalum compressum (Sw.) Nees, (C).
Phleum pratense (L.), Timothy (C); common.
Poa compressa (L.), Canada Blue Grass (C); common.
Poa pratensis (L.), June Grass (C), Kentucky Blue Grass; common.
Setaria glauca (L.) Beauv., Foxtail (C); common.
Setaria italica (L.) Beauv., Hungarian Grass (C); common.
Setaria viridis (L.) Beauv., Bottle Grass (C); common.
Sorghastrum nutans (L.) Nash., Indian Grass (C); common.
Spartina cynosuroides (L.) Roth., Salt Reed Grass (C).

GENTIANACEAE.

Gentiana andrewsii (Griseb.), Closed Gentian (C); rather rare.
Gentiana crinita (Froel.), Fringed Gentian (B); rare.
Gentiana quinquifolia (L.), Stiff Gentian (C).
Gentiana saponeria (L.), Soapwort Gentian (C).

GERANEACEAE.

Geranium maculatum (L.), Wild Cranesbill (C); common.

HYDROPHYLLACEAE.

Hydrophyllum appendiculatum (Michx.), Appendaged waterleaf (C).
Hydrophyllum macrophyllum (Nutt.), Large-leaved waterleaf (C).
Hydrophyllum virginianum (L.), Virginia waterleaf (C).
Ellisia nyctelea (L.), Nyctelea (C); common.

HYPERICACEAE.

Hypericum adpressum (Bart.). This specimen was found in Mid-River park in Johnson county and shows strongly punctate leaves. This characteristic is not mentioned in the description, but is unlike our specimens of *Hypericum cistifolium* (Lam.). Otherwise it answers the description of *Hypericum adpressum.*

Hypericum cistifolium (Lam.), St. John's Wort (C).

Hypericum canadense (L.), Canadian St. John's Wort (C).

Hypericum gentianoides (L.) BSP., Pineweed (C).

Hypericum virginicum (L.), Marsh St. John's Wort (C).

IRIDACEAE.

Iris versicolor (L.), Larger Blue Flag (C).

Sisyrinchium angustifolium (Mill.), Northern Blue-eyed Grass (C).

Sisyrinchium gramineum (Curtis), Common Blue-eyed Grass (C).

JUGLANDACEAE.

Carya alba (L.) K. Koch., White-heart Hickory (C).

Carya glabra (Mill.) Spach., Pignut (C).

Carya ovata (Mill.) K. Koch., Shag-bark Hickory (C); common.

Juglans nigra (L.), Black Walnut (C).

LABIATAE.

Agastache scrophulariaefolia (Willd.) Ktze., Figwort Giant Hyssop (C).

Collinsonia canadensis (L.), Richweed (C).

Hedeoma hispida (Pursh.), Rough Pennyroyal (C).

Hedeoma pulegioides (L.) Pers., American Pennyroyal (C).

Isanthus brachiantus (L.) BSP., False Pennyroyal (C).

Lamium amplexicaule (L.), Henbit (C).

Lycopus americanus (Muhl.), Cutleaved Water Hoarhound (C).

Lycopus europaeus (L.), Water Hoarhound (C).

Lycopus lucidus americanus (Gray), Western Water Hoarhound (C).

Lycopus virginicus (L.), Bugle Weed (C).

Mentha arvensis (L.), American Wild Mint (C).

Mentha longifolia (L.) Huds., Horsemint (C).

Mentha piperita (L.), Peppermint (C).

Mentha spicata (L.), Spearmint (C).

Monarda didyma (L.), Oswego Tea (B).

Monarda fistulosa (L.), Wild Bergamot (C).

Monarda punctata (L.), Horsemint (C).

Nepeta cataria (L.), Catnip (C).

Nepeta hederacea (L.) Trevisan, Ground Ivy (C).

Physostegia virginiana (L.) Benth., False Dragon-head (C).

Prunella vulgaris (L.), Healall (C).

Pycnanthemum flexuosum (Walt.) BSP., Narrow-leaved Mountain Mint (C).

Pycnanthemum pilosum (Nutt.), Hairy Mountain Mint (C).

Pycnanthemum virginianum (L.) Dur. & Jackson, Virginia Mountain Mint (C).

Scutellaria galericulata (L.), Marsh Skullcap (C).

Scutellaria lateriflora (L.), Mad-dog Skullcap (C).

Scutellaria versicolor (Nutt.), Heart-leaved Skullcap (C).

Stachys palustris (L.), Woundwort (C).

Stachys tenuifolia (Willd.), Smooth Hedge Nettle (C).

Teucrium canadense (L.), American Germander (C).

Teucrium occidentale (Gray), Hairy Germander (B).

LILIACEAE.

Allium canadense (L.), Wild Garlic (C).

Allium mutabile (Michx.), Wild Onion (C).

Allium schoenoprasum sibiricum (L.) Hartm., Chives (B); Escape.

Amianthium muscaetoxicum (Walt.) Gray, Fly Poison (C).

Erythronium albidum (Nutt.), Wild Dog's-tooth Violet (C); common.

Erythronium americanum (Ker.), Yellow Adder's Tongue (C).

Hemerocallis fulva (L.), Common Day Lily (C); rare, escape.

Lilium canadense (L.), Wild Yellow Lily (C).

Lilium philadelphicum (L.), Wild Orange-red Lily (C).

Lilium philadelphicum andinum (Nutt.) Ker., Western Red Lily (C).

Lilium superbum (L.), American Turk's Cap (C).

Trillium sessile (L.), Sessile-flowered Wake Robin (B).

Trillium declinatum (Gray) Gleason, Birthwort (C).

Trillium grandiflorum (Michx.) Salisb., Giant White Trillium (C); common.

Trillium nivale (Riddell), Wake Robin (C); common.

Trillium recurvatum (Beck.), Red Trillium (C); common.

Melanthium virginicum (L.), Bunch Flower (C); abundant.

Oakesia sessilifolia (L.) Wats., Sessile-leaved Bellwort (C).

Orinthogalum umbellatum (L.), Star-of-Bethlehem (C).

Polygonatum commutatum (R. & S.) Dietr., Smooth Solomon's Seal. (C).

Smilacina racemosa (L.) Desf., False Spikenard (C).

Smilacina stellata (L.) Desf., Star-flowered Solomon's Seal (C).
Smilax ecirrhata (Engelm.) Wats., Upright Smilax (C).
Smilax herbacea (L.), Carrion Flower (C).
Uvularia grandiflora (Sm.), Large-flowered Bellwort (C).

LOBELIACEAE.

Lobelia cardinalis (L.), Cardinal Flower (C).
Lobelia inflata (L.), Indian Tobacco (C).
Lobelia spicata (Lam.), Pale Spike Lobelia (C).
Lobelia siphilitica (L.), Great Lobelia (C).

LENTIBULARIACEAE.

Utricularia vulgaris (L.), Greater Bladderwort (C).
Utricularia vulgaris americana (Gray), Bladderwort (B).

LYCOPODIACEAE.

Lycopodium clavatum (L.), Common Club Moss (C).
Lycopodium complanatum flabelliforme (Fernald), Ground Pine (C); very rare.

LEGUMINOSAE.

Amorpha canescens (Pursh.), Lead Plant (C).
Amorpha fruticosa (L.), False Indigo (C).
Amphicarpa monoica (L.) Ell., Hog Peanut (C).
Apios tuberosa (Moench.), Groundnut (C).
Astragalus canadensis (L.), Canada Milk Vetch (C).
Astragalus distortus (T. & G.), Bent Milk Vetch (B).
Astragalus mexicanus (A.) DC., Ground Plum (C).
Astragalus plattensis (Nutt.), Platte Milk Vetch (C).
Baptisia australis (L.) R. Br., Blue False Indigo (C).
Baptisia bracteata (Muhl.) Ell., Large-bracted Wild Indigo (C).
Baptisia lanceolata, False Indigo.
Baptisia leucantha (T. & G.), Large White Wild Indigo (C)
Baptisia tinctoria (L.) R. Br., Wild Indigo (C).
Cassia chamaecrista (L.), Partridge Pea (C); common.
Cassia nictitans (L.), Wild Sensitive Plant (C); rare.
Desmodium bracteosum longifolium (T. & G.), Robinson, Long-leaved Tick Foil (C).
Desmodium canadensis (L.) DC., Showy Tick Foil (C).
Desmodium illinoense (Gray), Illinois Tick Foil (C).
Desmodium laevigatum (Nutt.) DC., Smooth Tick Foil (C).
Desmodium paniculatum (L.) DC., Panicled Tick Foil (C).
Desmodium rotundifolium (Michx.) DC., Prostrate Tick Foil (C).

Gleditschia triacanthus (L.), Honey Locust (C).
Lathyrus palustris (L.), Marsh Vetchling (C).
Lathyrus venosus (Muhl.), Veiny Pea (C).
Lespedeza capitata (Michx.), Round-headed Bush Clover (C).
Medicago sativa (L.), Alfalfa (C).
Melilotus officinalis (L.) Lam., Yellow Melilot (C).
Petalostemon candidum (Michx.), Tall White Prairie Clover (B).
Petalostemon multiflorum (Vent.) Rydb., Round-headed Prairie Clover (B).
Petalostemon purpureum (Vent.) Rydb., Violet Prairie Clover (B).
Robinia pseudo-acacia (L.), Common Locust (C), escape.
Strophostyles helvola (L.) Britton, Trailing Wild Bean (C).
Strophostyles pauciflora (Benth.) Wats., Small Wild Bean (C).
Strophostyles umbellata (Muhl.) Britton, Pink Wild Bean (C).
Tephrosia virginiana (L.) Pers., Goats Rue (C).
Trifolium hybridum (L.), Alsike Clover (C).
Trifolium pratense (L.), Common Red Clover (C).
Trifolium procumbens (L.), Low Hop Clover (C).
Trifolium reflexum (L.), Buffalo Clover (B).
Trifolium stoloniferum (Muhl.), Running Buffalo Clover (C).
Vicia americana (Muhl.), American Vetch (C).
Vicia caroliniana (Walt.), Carolina Vetch (C).
Vicia sativa (L.), Spring Vetch.

MALVACEAE.

Abutilon theophrasti (Medic.), Velvet Leaf (C); common.
Callirhoe involucrata (T. & G.) Gray, Purple Poppy Mallow (C).
Hibiscus militaris (Cav.), Halberd-leaved Rose Mallow (C).
Hibiscus trionum (L.), Flower-of-the-hour (C).
Malva rotundifolia (L.), Common Mallow, Indian Cheese (C).

MENISPERMACEAE.

Menispermum canadense (L.), Moon Seed (C).

NAJADACEAE.

Potamogeton perfoliatus (L.), Clasping-leaved Pond Weed (C).
Potamogeton pectinatus (L.), Fennel-leaved Pond Weed (C).
Potamogeton americanus (C. & S.), Long-leaved Pond Weed (C).
Potamogeton foliosus (Raf.), Leafy Pond Weed (C).

NYCTAGINACEAE.

Oxybaphus nyctagineus (Michx.) Sweet, Four O'clock (C); common.

NYMPHACEAE.

Castalia tuberosa (Paine) Greene, Pond Lily (C).
Nymphaea adventa (Ait.), Yellow Pond Lily (C).

OXALIDACEAE.

Oxalis filipes (Small), Slender Yellow Wood Sorrel (C).
Oxalis stricta (L.), Upright Wood Sorrel (C); common.
Oxalis violacea (L.), Violet Wood Sorrel (C).

ORCHIDACEAE.

Aplectrum hyemale (Muhl.) Torr., Putty Root (C).
Arethusa bulbosa (L.), Arethusa (B).
Corallorrhiza maculata (Raf.), Large Coral Root (C).
Cypripedium candidum (Muhl.), Small Lady's Slipper (C).
Cypripedium hirsutum (Mill.), Showy Lady's Slipper (B).
Cypripedium parviflorum (Salisb.), Smaller Yellow Lady's Slipper (C).
Cypripedium parviflorum pubescens (Willd.) Knight, Downy Lady's Slipper (C).
Habenaria bracteata (Willd.) R. Br., Long-bracted Orchis (C).
Habenaria dilatata media (Rydb.) Ames, Green-flowered Orchid (C).
Habenaria lacera (Michx.) R. Br., Ragged Fringed Orchid (B).
Habenaria peramoena (Gray), Fringless Purple Orchid (B).
Habenaria psycodes (L.) (Sw.), Purple-fringed Orchid (B).
Orchid spectabilis (L.), Showy Orchid (C).
Pogonia ophioglossioides (L.) Ker., Snakemouth (B).
Pogonia trianthophora (Sw.) BSP., Nodding Pogonia (C).
Spiranthes cernua (L.) Richard., Lady's Tresses (C).
Spiranthes vernalis (Engelm. & Gray), Lady's Tresses (B).

ONOGRACEAE.

Circaea intermedia (Ehrh.), Enchanter's Nightshade (B).
Epilobium coloratum (Muhl.), Purple-flowered Willow Herb (C).
Gaura coccinea (Pursh.), Scarlet Gaura (B).
Oenothera biennis (L.), Common Evening Primrose (C).
Oenothera fruticosa (L.), Sundrops (C).
Oenothera rhombipetala (Nutt.), Evening Primrose (C).
Oenothera speciosa (Nutt.), White Evening Primrose (B).

PORTULACACEAE.

Claytonia virginica (L.), Spring Beauty (C); abundant.

POLYGALACEAE.

Polygala cruciata (L.), Cross-leaved or Marsh Milkwort (B).
Polygala senega (L.), Seneca Snakeroot (C).
Polygala sanguinea (L.), Field or Purple Milkwort (C).

PONTEDERIACEAE.

Pontederia cordata (L.), Pickerel Weed (C).

PRIMULACEAE.

Dodecatheon media (L.), Shooting Star (C); abundant.
Lysimachia nummularia (L.), Moneywort (B); introduced, escape.
Lysimachia quadrifolia (L.), Loosestrife (B).
Lysimachia thyrsiflora (L.), Tufted Loosestrife (C).
Steironema ciliatum (L.) Raf., Fringed Loosestrife (C).
Steironema lanceolatum (Walt.) Gray, Lance-leaved Loosestrife (C).

POLEMONIACEAE.

Polemonia reptans (L.), Bluebell, Hairbell (C); abundant.
Phlox bifida (Beck.), Clawed Phlox (C).
Phlox divaricata (L.), Broad-leaved Phlox (C); abundant.
Phlox maculata (L.), Wild Sweet William (C).
Phlox paniculata (L.), Garden Phlox (C).
Phlox pilosa (L.), Wild Sweet William (C).
Phlox procumbens, Phlox (C).
Phlox subulata (L.), Moss pink (B).

PAPAVERACEAE.

Sanguinaria canadensis (L.), Bloodroot (C); abundant.

POLYGONACEAE.

Fagopyrum esculentum (Moench.), Buckwheat (C).
Polygonum acre (HBK.), Water Smartweed (C).
Polygonum aviculare (L.), Yard Knotgrass (C).
Polygonum douglasii (Greene), Douglas Smartweed (C).
Polygonum dumetorum (L.), Hedge Buckwheat (C).
Polygonum erectum (L.), Erect Knot Grass (C).
Polygonum hydropiper (L.), Common Smart Weed (C).
Polygonum longistylum (Small), Long-styled Persicaria (C).
Polygonum orientale (L.), Prince's Feather (C); escape.
Polygonum prolificum (Small) Robinson, (C).
Polygonum ramosissimum (Michx.), Bushy Knotweed (C).
Polygonum sagittatum (L.), Arrow-leaved Tear Thumb (C).

Polygonum scandens (L.), Climbing False Buckwheat (C).
Polygonum tenue (Michx.), Slender Knotweed (C).
Polygonum virginianum (L.), Virginia Knotweed (C).
Rumex acetosella (L.), Field Sorrel (C).
Rumex altissimus (Wood), Pale Dock (C).
Rumex britannica (L.), Great Water Dock (C).
Rumex crispus (L.), Yellow Dock (C).
Rumex obtusifolius (L.), Bitter Dock (C).
Rumex patientia (L.), Patience Dock (C).
Rumex verticillatus (L.), Swamp Dock (C).

PHRYMACEAE.

Phyrma leptostachya (L.), Lop Seed (C).

PLANTAGINACEAE.

Plantago aristata (Michx.), Large-bracted Plantain (C).
Plantago lanceolata (L.), English Plantain (C).
Plantago major (L.), Common Plantain (C).
Plantago media (L.), Hoary Plantain (B).
Plantago rugelii (Dcne.), Rugel's Plantain (B).

ROSACEAE.

Agrimonia gryposepala (Wallr.), Tall Hairy Agrimony (C).
Amelanchier canadensis (L.), Medic., Service Berry (C); common.
Crataegus coccinea (L.), Rough Thorn (C).
Crataegus crus-galli (L.), Hawthorne (C).
Crataegus macracantha (Lodd.), Long-spined Thorn (B).
Crataegus mollis (T. & G.) Scheele, Red-fruited Thorn (C).
Crataegus punctata (Jacq.), Large-fruited Thorn (C).
Crataegus tomentosa (L.), Pear Thorn (C).
Fragaria virginiana (Duchesne), Wild Strawberry (C); common.
Geum canadense (Jacq.), White Avens (C).
Physocarpus opulifolius (L.), Maxim., Ninebark (C).
Potentilla anserina (L.), Silverweed (B).
Potentilla arguta (Pursh.), Glandular Cinquefoil (C).
Potentilla canadensis (L.), Five Finger (C).
Potentilla fructicosa (L.), Shrubby Five Finger (C).
Potentilla monspeliensis (L.), Rough Five Finger (C).
Potentilla palustris (L.), Scop., Marsh Five Finger (B).
Potentilla pentandra (Engelm.) Wats., Five-stamened Five Finger (C).
Prunus americana (Marsh.), Wild Plum (C); common.

Prunus angustifolia (Marsh.), Plum, escape.
Prunus institia (L.), Blackthorn (C).
Prunus pennsylvanica (L. f.), Wild Red Cherry (C).
Prunus serotina (Ehrh.), Rum Cherry (C).
Prunus virginiana (L.), Choke Cherry (C).
Pyrus baccata (L.), Siberian Crab (C).
Rosa acicularis (Lindl.), Prickly Rose (C).
Rosa blanda (Ait.), Smoth Wild Rose (C).
Rosa carolina (L.), Swamp Rose (C).
Rosa humilis (Marsh.), Low or Pasture Rose (C).
Rosa setigera (Michx.), Climbing or Prairie Rose (C).
Rosa virginiana (Mill.), Dwarf Rose (C).
Rosa woodsii (Lindl.), Low Wild Rose (C).
Rubus canadensis (L.), Low Running Blackberry (C).
Rubus frondosus (Bigel.), High Bush Blackberry (C).
Rubus idaeus aculeatissimus (C. A. Mey.) Regal & Tiling.
Rubus villosus (Ait.), Dewberry (C).
Spiraea salicifolia (L.), Meadow Sweet (C).
Spiraea salicifolia (Variation), (C).
Spiraea tomentosa (L.), Hardhack (B).

RUBIACEAE.

Cephalanthus occidentalis (L.), Button Bush (C).
Galium aparine vaillantii (DC.) Koch., Cleavers (C).
Galium asprellim (Michx.), Rough Bedstraw (C).
Galium circaezans (Michx.), Wild Liquorice (C).
Galium concinnum (T. & G.), Shining Bedstraw.
Galium parisiense (L.), Wall Bedstraw (C).
Galium tricorne (Stokes), Rough-fruited Corn Bedstraw (C).
Galium triflorum (Michx.), Sweet-scented Bedstraw (C).
Houstonia caerulea (L.), Innocence (B).
Houstonia patens (Ell.), Small Bluets (C).
Houstonia minima, Bluet (C).

RHAMNACEAE.

Ceanothus americanus (L.), New Jersey Tea (C).

RANUNCULACEAE.

Actaea alba (L.), Mill., White Baneberry (B).
Anemone cylindrica (Gray), Long-fruited Anemone (C).
Anemone nemorosa (L.), Anemone (C).
Anemone parviflora (Michx.), Northern Anemone (C).

Anemone patens wolfgangiana (Bess.) Koch., Pasque Flower (C).
Anemone canadensis (L.), White Anemone (C).
Anemone quinquifolia (L.), Wood Anemone (C).
Anemonella thalictroides (L.), Spach., Rue Anemone (C); common.
Aquilegia canadensis (L.), Wild Columbine (C); common.
Caltha palustris (L.), Marsh marigold (C); common.
Clematis virginiana (L.), Virgin's Bower (B).
Clematis viorna (L.), Leather Flower (C); common.
Delphinium exaltatum, Tall Larkspur (C).
Delphinium penardi (Huth.), Prairie Larkspur (C).
Delphinium tricorne (Michx.), Dwarf Larkspur (C).
Hepatica triloba (Chaix.), Hepatica (C); common.
Hepatica triloba acutifolia, Liverwort (B).
Myosurus minimus (L.), Mousetail (C).
Ranunculus abortivus (L.), Small-flowered Crowfoot (C); abundant.
Ranunculus acris (L.), Tall Crowfoot (C).
Ranunculus aquatilis capillaceus (DC.), White Water Crowfoot (C).
Ranunculus bulbosus (L.), Bulbous Buttercup (C).
Ranunculus delphinifolius (Torr.), Yellow Water Crowfoot (C).
Ranunculus delphinifolius terrestris (Gray) Farwell, Large Water Crowfoot.
Ranunculus fascicularis (Muhl.), Northwestern Buttercup (C).
Ranunculus pennsylvanicus (LF.), Bristly Crowfoot (C).
Ranunculus purshii (Richards.), Yellow Water Buttercup (C); rare.
Ranunculus recurvatus (Poir.), Hooked Buttercup (C).
Ranunculus septentrionalis (Poir.), Swamp Buttercup (C).
Thalictrum dasycarpum (Fisch. & Lall.), Stinking Meadow Rue (C).
Thalictrum dioicum (L.), Early Meadow Rue (C).
Thalictrum polygamum (Muhl.), Tall Meadow Rue (C).

RUTACEAE.

Zanthoxylum americanum (Mill.), Northern Prickly Ash (C).

SAXIFRAGACEAE.

Heuchera hispida (Pursh.), Hairy Alum Root (C).
Mitella diphylla (L.), Bishop's Cap (C), common.
Parnassia caroliniana (Mx.), Grass of Parnassus (B).
Parnassia palustris (L.), Northern Grass of Parnassus (B).
Parnassia parviflora (DC.), Small-flowered Grass of Parnassus (B).
Ribes aureum (Pursh.), Missouri or Buffalo Currant (C).
Ribes cynosbati (L.), Prickly Gooseberry (C).
Ribes floridum (L'Her.), Wild Black Currant (C).

Ribes gracile (Mx.), Wild Gooseberry (C).
Ribes oxyacanthoides (L.), Smooth Gooseberry (C).
Ribes rotundifolium (Mx.), Eastern Wild Gooseberry (C).
Saxifraga micranthidifolia (Haw.) Britton, Lettuce Saxifrage (B).
Saxifraga pennsylvanica (L.), Swamp Saxifrage (C).
Sullivantia sullivantii (T. & G.) Britton, Sullivantia (B).

SANTALACEAE.

Comandra umbellata (L.), Nutt., Bastard Toad Flax.

STAPHYLEACEAE.

Staphylea trifolia (L.), American Bladder Nut (C).

SALICACEAE.

Populus deltoides (Marsh.), Cottonwood (C).
Salix petiolaris (Sm.), Slender Willow (C).
Salix tristis (Ait.), Dwarf Willow (C).

SCROPHULARIACEAE.

Castilleja coccinea (L.) Spreng., Scarlet Painted Cup (C).
Castilleja sessiliflora (Pursh.), Hairy Painted Cup (C).
Gerardia purpurea (L.), Purple Gerardia (B).
Gerardia tenuifolia (Vahl.), Slender Gerardia (C).
Gratiola virginiana (L.), Clammy Hedge Hyssop (C).
Linaria cymbalaria (L.) Mill., Coliseum Ivy (B).
Linaria vulgaris (Hill), Butter and Eggs (C).
Mimulus ringens (L.), Monkey Flower (C).
Pedicularis canadensis (L.), Lousewort (C).
Scrophularia leporella (Bicknell), Hare Figwort (C).
Scrophularia marilandica (L.), Heal-all (C).
Verbascum blattaria (L.), Moth Mullein (C).
Verbascum lychnitis (L.), White Mullein (C).
Verbascum thapsus (L.), Common Mullein (C).
Veronica longifolia (L.), Speedwell (B).
Veronica virginica (L.), Culver's Root (C).

SOLANACEAE.

Datura stramonium (L.), Stramonium (C).
Datura tatula (L.), Purple Thorn Apple (C).
Physalis ixocarpa (Brotero), Tomatillo (B).
Physalis lanceolata (Mx.), Prairie Ground Cherry (C).
Physalis pubescens (L.), Low Hairy Ground Cherry (C).

Physalis subglabrata (Mackenzie and Bush), Philadelphia Ground Cherry (C).
Solanum carolinense (L.), Horse Nettle (C).
Solanum dulcamara (L.), Bittersweet (C).
Solanum nigrum (L.), Common Nightshade (C).
Solanum rostratum (Dunal.), Buffalo Bur (C).
Solanum tuberosum (L.), Common Potato (C); escape.

TYPHACEAE.

Typha latifolia (L.), Common cat-tail (C).

THYMELAECEAE.

Dirca palustris (L.), Leatherwood (C); rare.

UMBELLIFERAE.

Angelica villosa (Walt.) BSP., Pubescent Angelica (C).
Carum carvi (L.), Caraway (C).
Chaerophyllium procumbens (L.) Crantz, Spreading Chervil (C).
Cicuta maculata (L.), Spotted Cowbane (C).
Conioselinum chinense (L.) BSP., Hemlock Parsley (C).
Conium maculatum (L.), Poison Hemlock (C).
Cryptotaenia canadensis (L.) DC., Honewort (C).
Heracleum lanatum (Mx.), Cow Parsnip (C).
Osmorhiza longistylis (Torr.) DC., Smooth Sweet Cicely (C).
Thaspium barbinode (Mx.) Nutt., Meadow Parsnip (C).
Zizia cordata (Walt.) DC., Heart-leaved Alexanders (C).

UTRICACEAE.

Boehmeria cylindrica (L.) Sw., False Nettle (C).
Cannabis sativa (L.), Hemp (C).
Humulus lupulus (L.), Common Hop (C).
Laportea canadensis (L.) Gaud., Wood Nettle (C).
Pilea pumila (L.) Gray, Clearweed (C).
Ulmus racemosa (Thomas), Rock Elm (C).
Ulmus americana, Elm (C).
Urtica urens (L.), Small nettle (C).

VITEACEAE.

Vitis cordifolia (Mx.), Frost or Chicken Grape (C).

VIOLACEAE.

Viola blanda (Willd.), Sweet White Violet (C).
Viola fimbriatula (Sm.), Ovate-leaved Violet (B).

Viola palmata (L.), Early Violet (C).
Viola pedata (L.), Bird-foot Violet (C).
Viola pedatifida (G. Don.), Cut-leaved Violet (C).
Viola pubescens (Ait.), Downy Yellow Violet (C).
Viola rotundifolia (Mx.), Yellow Violet (C).
Viola sagittata (Ait.), Arrow-leaved Violet (C).
Viola scabriuscula (Schwein.), Smooth Yellow Violet (C).
Viola sororia (Willd.), Wood Violet (C).

VERBENEACEAE.

Lippia lanceolata (Mx.), Fog-fruit (C).
Verbena angustifolia (Mx.), Narrow-leaved Vervain (C).
Verbena stricta (Vent.), Hoary Vervain (C).
Verbena urticaefolia (L.), White Vervain (C).

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"SUNFLECKS."

BY W. H. DAVIS.

On Sunday, June 28, 1908, between 9:27 a. m., and 12:41 p. m., there occurred a seven-eighths eclipse of the sun. Thinking that I might procure some eclipse pictures, I loaded my plate-holder with 5 inch by 7 inch Standard Orthonon plates.

While on my way to the spot chosen for photographing the eclipse, I noticed the eclipse was fast appearing and many small eclipse images were visible in a pool of water under some trees. I hurried to photograph this phenomenon but on my way for another camera, observed many eclipse images on the walk before my door. Plate VI, figure 1, shows some of those eclipse images as they appeared on the walk during the seven-eights eclipse. I then photographed the eclipsed sun by the aid of another holding my camera after focusing. I used the front combination of a Turner-Reich anastigmat lens of eight and one-half inch focus; stop, U. S., 64; speed, 1-100 second through a potassium bicromate solution ray-filter.

At the same time, I managed to photograph some of the maple leaf facies with the interleaf spaces directly above the eclipse images, all of which are shown in Plate V.

After the eclipse had passed, I photographed the same walk showing the normal sun images as shown in Plate VI, figure 2.

While the eclipse was on the sun, I held a cardboard, fastened to a pole, over some of the interleaf spaces and thus blocked the eclipse images, showing that the inter-leaf spaces acted similar to a pinhole in a camera, thus throwing an image of the sun on the walk, at one time eclipsed, at another, unobstructed and bright.

If a leaf containing worm holes is placed in a blocked window, on a bright day, a sun image will be thrown on the floor. I have seen clouds pass over this sun image thus formed. I have seen sun images formed under elm leaves punctured with worm holes, or by fungi, varying from one-eighth to one-fourth inch.

The eclipse images were due to the interleaf spaces acting as "pinholes." The same cause produces the sun images which we see so often under trees and in the shade during the summer months. Their sizes depend upon the size and the height of the interleaf spaces above the ground. These sun images occur abundantly under deciduous trees, under shrubs, frequently under conifers and sparingly under herbs.

They are usually absent on the forest floor underneath very dense forest but occur among the upper branches. They seem to be found most abundantly under shade trees during the summer months of June, July and August.

This seems to furnish proof that interleaf spaces and openings in leaves throw sun images in the shade underneath themselves. These I have termed sun images, contrary to the old term which was probably copied from the German, Der Sonnenfleck and spoken of in English as "sunfleck." This name would imply a "fleck" which is a dot, spot, streak of color, dapple or a patch,—a sun spot—and not an image.

Clements—Research Methods in Ecology, p. 60,—speaks of taking the "sunflecks" into account when taking photometric measure of the forest floor. Here he puts the word "sunflecks" in quotation marks, but in his bibliography, gives no references to it.

Sach—The Physiology of Plants, p. 302—says:

"Of course this limit of the intensity of light cannot be exactly given in the absence of suitable photometric methods and when Pringsheim makes circumstantial statements concerning behavior of cells containing chlorophyll in the focus of a lens, or in the sun's image, as he terms it, these purely pathological processes have about as much physiological value as if, for any reason whatsoever, a so-called sun's image were allowed to act on the retina of the eye through a burning glass.

"In the absence of photometric measurements of general value, I pass over these statements also."

Pringsheim—Jahrbücher, Vol. 12, I review with these brief results.

Pringsheim used a "burning" glass throwing very strong lights on many algae and leaves to see the effect of light on plastids, etc. Some chloroplastids were made functionless, lost their green; others retained their function but lost their green, etc. He also observed the movement of plastids and other phenomena. His experiment was not for the purpose of illustrating the action of "sunflecks" on chloroplastids and chlorophyll but the succession of strong and weak light—daylight and darkness. However, the effect of sunflecks would be similar to his experiment for they bring about the same conditions.

The following is a table showing the frequency of sun eclipses.

References:

Chamberlain—Astronomy—Vols. I, II. World Almanacs,—1871 to 1912. Todd's Astronomy.

There can be no less than two annual eclipses of the sun and no more than five.

One of the first eclipses photographed occurred July 28, 1851.

DATE OF ECLIPSES OF THE SUN VISIBLE AT SOME PLACE ON THE EARTH.

585 B. C., May 28—Herodotes records, most celebrated.
557 B. C., May ..—Xenophon records.
1842 A. D., July 18.
*1851 A. D., July 28—Clouds beautiful, Dr. Bush's first photograph.
1858 A. D., Aug. 1—First instance of a successful corona.
1869 A. D., Aug. 7.
*1870 A. D., Dec. 22—Syracuse photo.
1871 A. D., Dec. 16.
1873 A. D., April 1.
1875 A. D., April 5.
1878 A. D., July 29.
1882 A. D., May 17.
1883 A. D., May 6.
1885 A. D., Sept. ..
1886 A. D., Aug. 29.
1887 A. D., Aug. 19.
*1889 A. D., May ..—In U. S. but rained most places.
1901 A. D., May ..—Invisible.
1901 A. D., Oct. ..
1902 A. D., Nov. 10-11, May 7—Invisible.
1902 A. D., April 8.
1903 A. D., May 28.
1903 A. D., Sept. 20—Invisible.
1904 A. D., May 16—Invisible.
1904 A. D., Sept. 9—Invisible.
*1905 A. D., May 5.
1905 A. D., Aug. 30—Visible in Eastern United States.
1906 A. D., Feb. 25—Invisible.
1906 A. D., July 21—Invisible.
1907 A. D., Jan. 13—Invisible.
1907 A. D., July 10—Invisible.
*1908 A. D., June 28—Visible.
1909 A. D.
1910 A. D.
1911 A. D.
1912 A. D.
1840 to 1900—Three important eclipses where one-half or more of sun was eclipsed and only two universally visible in tropics.

During the last twelve years two eclipses of account, a three-fourths and a seven-eighths, one in the Eastern United States only.

Less than fifty per cent of these eclipses occurred when leaves were on the trees.

Deduction from this table:

*Visible in U. S.

1. In the last seventy years only five important eclipses, four visible in U. S. and three when leaves were on the trees.

2. The eclipse period here has been about six hours out of seventy years, one-half to total eclipse period, about two hours out of seventy years. Thus little chance has been given to observe the eclipse images.

Botanical value of sun images.—One of the greatest factors (if not the greatest) in photosynthetic assimilation is sunlight, and a variation in sunlight causes a variation in photosynthesis. It varies from zero on a dark night to a maximum in sunlight on a dark day, providing other conditions are suitable.

In Plate VI all gradations of light intensity can be observed in the sun images; some are as bright as the sunlight; some scarcely can be seen as they approach the intensity of light in the shade. Therefore, it is safe to state that the intensity of sun images varies from bright sunlight to the surrounding shade.

By placing a sheet of solio paper across the negative and printing several sheets with recorded times it takes the sun images to print, each having an equal intensity thereon, the intensities can be found. Taking sunlight as 1, recording one set of data, I found them to be 1 to 1-10, but this needs accurate experiment taken with a photometer.

Clements—Research Methods, p. 60, states concerning the readings of light intensity: "A very satisfactory place of reading intensity of light is to take readings in two or more spots where shade appears to be typical and to make a check reading in a 'sunfleck,' a spot where sunlight shows through." He gives no figures to show such measurements, he only suggests a method for measurement.

It is very easily seen from Plate VI, that the area of the sun images exceeds the shaded area, so the former must be of great consequence to the "shade plants" in carrying on photosynthesis, both in area and light intensity. They might have much to do with the survival of many species growing underneath forest and shade trees. Trees with overlapping and exceedingly dense foliage, I have noticed, have very scant ground vegetation save mosses and ferns.

It is generally conceded that leaves "absorb" the green and violet rays of white light. The light received by the shade plants is more or less screened, and composed of red and yellow rays; of course, much reflected and refracted light is received by them not of equal actinic composition. The sun images distribute the white light to the shade plants.

The angles at which the sun images strike the plant must have some effect on the light intensity. A table given by Clements is as follows:

90 degrees has an intensity of	1.00
80 degrees has an intensity of	.98
40 degrees has an intensity of	.64
10 degrees has an intensity of	.17

So an image on June 21 would have greater intensity than one on September 21.

The path of an image per one day is an arc, and on the following day the arc is north or south of that of the previous day, depending on whether the sun is increasing or decreasing its declination. So the sun image would make a series of concentric arcs, distributing sunshine on the shade plants in a new area for each day, of course, for a short duration.

It is possible for one plant to receive the sunlight from several images in one day and hundreds in a season.

Reflected light is of great value to shade plants, but is it enough? By putting a number of leaves on solio paper, and obtaining ''leaf prints'' something of the light absorbing power of leaves can be determined. This should also be checked with a photometer, which is preferable.

Leaves of *Capsella bursa-pastoris* allow rays to pass through readily and print quickly, while *Rosa carolina* and *Hepatica triloba* are difficult to print through. Maple leaves are very difficult to print through, which shows that they absorb a great amount of the actinic rays, blues, greens and violets, but allow the reds to pass through

Heliotropism.—As the stimulus of the sun images is greater than the reflected light stimulus in the shade, there must be some heliotropic movement, but just what, I cannot say as I have made no experiments.

Chloroplastids.—The following facts are conceded as generally true: See Sach and Yohst—

As light largely determines the shape, size and number of chloroplastids:

(b) Chloroplastids in the shade are generally hemispherical, those in the sunlight are plane.

(c) The position of the chloroplastids depends largely on the light.

(d) Light has a great effect on the movement of foods from cell to cell in a plant.

(e) Chloroplasts tend to place themselves at angles to different light and parallel to rays of sunlight.

The sun images must have an effect upon each of the above conditions as they vary the condition from shade to bright sunlight. Just what, remains for experimentation.

Clements, E. S.—Relation of Leaf Structures to Physical Factors, p. 84.

"Reduced light, besides decreasing the palisade and sponge tissues in amount, shortens and broadens the palisade cells and extends the sponge cells in a horizontal direction. The extreme of this tendency is to be seen in Sparganium which has exactly reversed the long axis of the palisade cells. By this means, the chloropastids are placed in a favorable position to utilize the weak light. The thinning of the leaf comes from the mobility of the chloroplastids."

So light in a sun image followed by shade must reduce the thickness of leaves after it passes over them.

Schimper—Plant Geography.

"Many herbs growing on the ground of the virgin forests are provided with wonderful markings on their foliage, in the way of white, silvery, golden, or red spots; E. g. Begonia. Amarantaceæ. Orchidaceæ."

M. Mobins—Pringsheim's Yahrbuch, V. 18, p. 530. Established hereditary traits more than cause for flecks. Stahl considered these "flecks" as devices for increasing transpiration.

Suggestions:

Could sun images cause the mottling of leaves with darker colors? With lighter colors? With bright colors?

Could they cause darker red spots on apples, and darker color on other fruit? This result is assigned to the sun shining through leaves, etc.

Perhaps they cause certain portions of fruits to ripen more quickly than others. What effects, if any, would they have on seed germination in the shade or on the forest floor?

Would these sun spots have a direct effect on the soil itself?

Could all plants exist in the shade without these sun images—as those under conifers, which receive reflected light?

Possible zoological values.—It is a known fact that horned owls perch among trees during the day and are mottled with white spots so that one looking at an owl in a tree, during a summer day, "looks through the owl" as the spots imitate the apparent openings between leaves.

Perhaps sun images may be the prime factors of this color pattern, the pattern of the owl corresponding to that of the sun images among the branches. The same is true of many other song birds, such as thrush, whip-poor-will, quail, etc.

In the tropics, most favorable conditions are found for sun images and there are found many spotted animals, leopard, giraffe and most of the cat tribe. Strangely enough, the young of the Virginia deer is spotted. The habitat of these animals is under trees or under limbs where sun images are abundant, and where the images are projected during the day. The deer lie rather quietly among them and thus show some relation between the two.

Fishes living in shaded streams and along shady banks sometimes bear white spots or silvery markings similar to sun images, as for example, perch, pickerel, pike, minnows, etc. These spots are very common among reptilia and amphibia; small ones occur on toads and frogs, salamanders and snakes. Animals dwelling in a habitat void of sun spots are not spotted; the polar bear, reindeer, walrus, etc., are examples. The intensity of light is not enough at high latitudes to make sun images of consequence even if other conditions did prevail. It is difficult to name a spotted animal that spends its time in open areas.

In conclusion: I think sun images are of great importance and need much experimentation to establish their exact values in the plant and animal kingdom.

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Iowa State Teachers' College,
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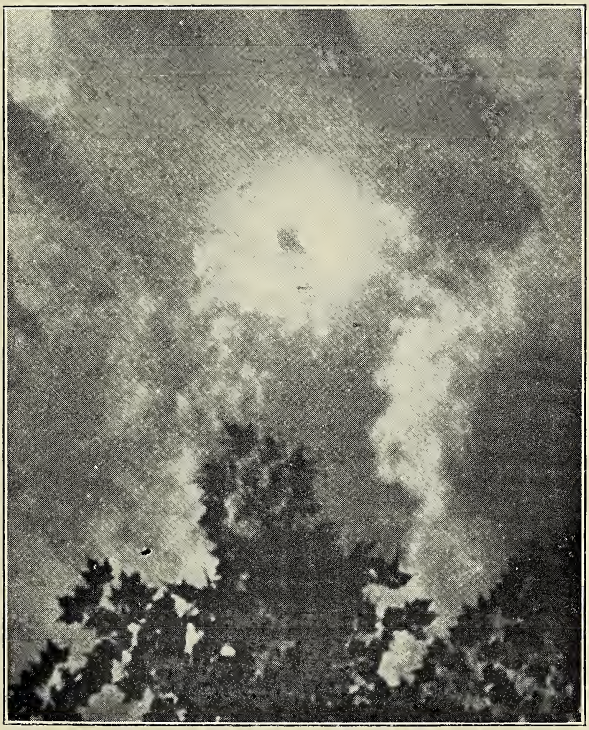

PLATE V. View of the sun and of the maple leaves and interleaf spaces.

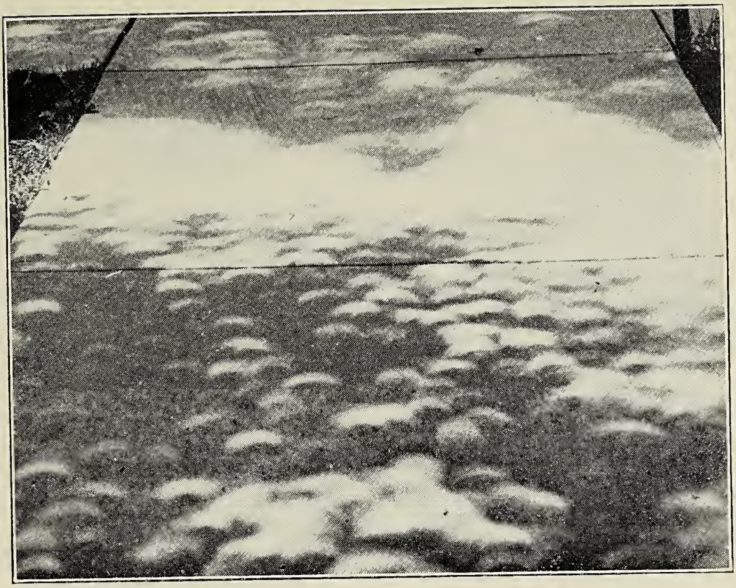

Fig. 1.—Eclipse images shown on sidewalk.

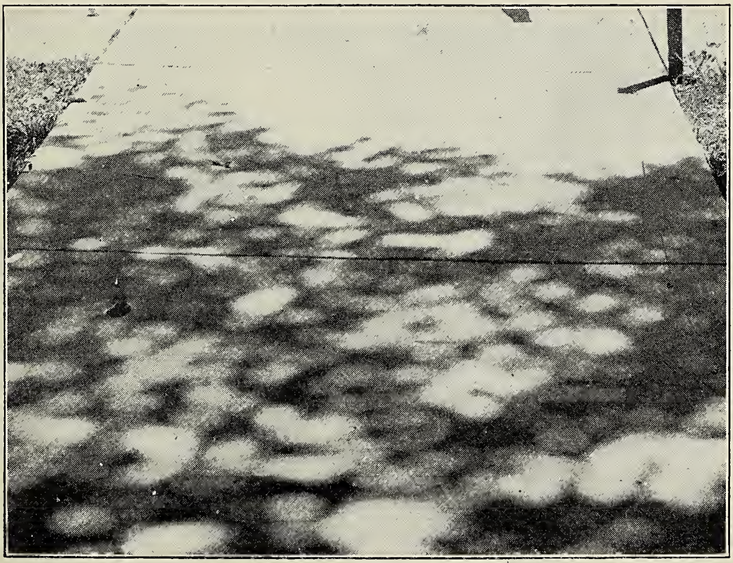

Fig. 2.—Normal images on sidewalk.

SOME OBSERVATIONS ON SYCAMORE BLIGHT AND ACCOMPANYING FUNGI.

J. P. ANDERSON.

Last spring (1913) the Sycamore blight (*Gnomonia veneta* (Sacc. & Speg.) Kleb.) was very prevalent and destructive in the vicinity of Ames. All the large trees along Squaw creek looked as though the young foliage and growth had been killed by frost except a few tufts in the extreme tops of the trees. Young trees several years planted suffered somewhat, but none to the extent that the large trees did. About one-half of these young trees showed some traces of the disease. During August the effects of its ravages were noted in eastern Nebraska and at Lamoni, Decatur county, Iowa. Doctor Pammel also reported it as destructive in Madison county, and in Decatur county at Leon.

The extreme destructiveness of the disease aroused considerable interest in it, and at the suggestion of Dr. L. H. Pammel, head of the Department of Botany at the Iowa State College at Ames, the writer undertook an investigation and he here wishes to acknowledge the help and suggestions received from Doctor Pammel. The plan was to make this investigation a thorough one but owing to a change of plans this could not be done. A few observations are hereby submitted hoping that they may be of interest to mycologists. It is to be hoped that at least part of the work originally planned may be carried out later. In making plate cultures for the purpose of isolating the fungus many other fungi occurred, including species of *Penicillum, Mucor, Aspergillus, Monilia, Macrosporium, Alternaira, Coniothyrium, Cephalothecium,* and several unidentified forms. *Cephalothecium roseum* proved very troublesome on all material kept in the damp chambers. *Coniothyrium mixtum* Fuckl., *Cytospora platani* Fuckl. and *Massaria platani* Ces. are found very commonly on twigs that have been killed by the blight. These will each receive brief consideration later in this paper.

Gnomonia veneta (Sacc. & Speg.) Kleb.

Plate VII, Figs. 1-4.

According to Edgerton[1] there are four conidial forms and an ascigerous stage connected with this fungus. The conidial forms are as follows:

1. The conidia may be borne in acervuli under the cuticle on short conidiophores. Long known as *Gloeosporium nervisequm* (Fuckel) Sacc.

2. The conidia may be borne in acervuli under the epidermis on long conidiophores. This has been known as *Gloeosporium platani* (Mont.) Oud.

3. The conidia may be borne in pustules on the twigs, being then known as *Myxosporium valsoideum* (Sacc.) All. and *Discula platani* (Peck) Sacc.

4. Pycnospores may be borne in cleistocarpous pycnidia on old leaves on the ground. This stage has been named *Sporonema platani* Bäumler, and *Fusicoccum veronense* C. Massalongo.

The acervuli on the leaves are found in the summer and fall. The fungus attacks the leaf veins and from these spreads out into the surrounding tissue. The acervuli are 100 to 300μ in diameter. The spores are generally described as 10 to 14x4 to 6μ, but the spores examined from leaves gathered in the fall and from cultures on agar were quite constant in size and about 10x4½μ. The spores from material gathered in the spring showed more variation, but the average size was about the same. The fungus attacks the petioles as well as the leaves and twigs. It seems probable that the mycelium travels down the petiole and from there enters the young stem. When the leaves fall the twigs of the current season's growth may appear perfectly healthy. But later, and especially toward spring, the presence of the disease is manifest. These diseased twigs may remain alive and send out young leaves, but when the leaves are about one-third grown they wither and die quite suddenly, owing to the cutting off of the source of supplies for growth. This is what gives the trees the appearance of blight and gives rise to the popular name. The twig figured in Plate VII, Fig. 4, is very typical. although many twigs show a much more extensive diseased area. In many cases a large portion of the twig is thus diseased. This Myxosporium or Discula stage may be found at any season of the year and is the one causing most destruction, as the annual loss of the greater part of the young foliage every spring cannot help but seriously weaken the tree.

The pycnidial or sporonema stage develops during late winter or very early spring on leaves that have been kept moist over winter. The stroma bearing the conidia continues to grow until it has surrounded the developing spores. As observations were discontinued about the first of the year, this stage was not observed. The ascigerous stage was not observed for the same reason.

The ascigerous stage develops on the fallen leaves that have wintered in the open. The perithecium is described as being subglobose, or slightly flattened, 150 to 200μ in diameter, with the upper side elongated into a beak. Asci long clavate 48 to 60x12 to 15μ, generally bent at right angles near the base. Ascus 8-spored; spores hyaline, 14 to 19x4 to 5μ, straight or slightly arcuate, unevenly 2-celled, the upper being several times as long as the lower one.

For further literature on this interesting species, the reader is referred to the excellent papers by Edgerton[1], Klebahn[2], and Von Tavel[3].

Coniothyrium mixtum Fuckel.

Plate VII, Figs. 5 & 6.

What appears to be this species was found to be quite common on twigs of the sycamore killed by the blight. It is also found on twigs killed by other causes. The pycnidia vary from 150 to 250μ in diameter, are nearly globose to much depressed, with a rather thick hymenium and short conidiophores. Spores are produced in abundance, fulgineous, appearing brown when in masses; about 7x4x4μ.

Cytospora platani Fuckl.

Plate VII, Figs. 7-12.

I have placed the forms examined promiscuously in this species, although the spores are about 50 per cent longer than the measurements given by Saccardo[4]. While this fungus is common on twigs of sycamore killed by blight, it is relatively more abundant on young trees that have died from the effects of transplanting. The stroma, as ordinarily found, are from 1 to 3 mm. in diameter. At first they are entirely covered by the epidermis, but later break through. When placed in a damp chamber the spores are forced out in light yellow, wormlike masses. At first the pycnidia are subglobular or slightly angular in outline, with the hymenium bearing conidiophores on all sides. Later the pycnidium enlarges, becomes very irregular and with a conical beak. The spores are decidedly allantoid, 10 to 12x3 to 4μ, and produced in very great abundance.

Massaria platani Ces.

Plate VIII.

This fungus is common near the base of sycamore twigs killed by the blight. It is not universally present and it is not probable that the two have any organic connection. Around Ames I have found the Massaria on one-third to one-half of the blight-killed branches. It seems never to develop far from the live wood, which indicates that it requires con-

[1]Edgerton, C. W. The physiology and development of some anthriacnoses. Bot. Gazette **45**: 367-408, 1908.
[2]Klebahn, H. Untersuchungen über einige Fungi imperfecti und die zugehörigen Ascomycetenformen. Jahrb. Wiss. Bot. **41**: 515-558. 1905.
[3]Tavel, Franz von. Contributions to the history of the development of the Pyrenomycetes. Jour. Myc. **5**: 53-58, 113-123, 181-184. 1889.
[4]Saccardo, P. A. Syllage Fungorum **3**: 267.

siderable moisture. It may be seen as black dots underneath the epidermis of the twig. These dots are one-half to one millimeter in diameter. Sometimes they are very thickly placed, and at other times quite scattered. When closely placed they may be connected by fungus hyphæ so as to almost appear to be in a stroma. The larger ones are perithecia, while the smaller ones are pycnidia.

The specimens examined conform exactly with the description given by Saccardo[5], but differ considerably from the description given by Ellis and Everhart.[6] The perithecia are depressed globose, three-fourths of a millimeter or more in diameter. Asci 8-spored, 240x42 to 60μ. Spores 55 to 60 x about 20μ, 5-septate, inequilaterally didymous, the upper and larger portion being 3-septate, the lower portion uniseptate. The spores are brown and surrounded by a hyaline gelatinous envelope. Paraphyses abundant, filiform.

The pycnidial stage has been known as *Hendersonia desmazierii* Mont. The pycnidia are smaller than the perithecia, being scarcely one-half millimeter in diameter. They are also much flatter, the diameter being 3 to 4 times the height. The conidia are dark colored, 3-septate, 40 to 45x14 to 16μ.

Under favorable conditions, such as exist in a moist chamber, both conidia and ascospores are exuded in black masses. I have found both forms in the same mass, which indicates that the pycinidium may, under favorable conditions, be transformed into a perithecium by enlargement, thickening of walls, and the arising of paraphyses and asci in the place of conidiophores. While evidence on this point is not conclusive, it is further supported by the fact that a twig, on being examined, showed only pycnidia, while after being in a damp chamber a few weeks most of the bodies proved to be perithecia. These perithecia seemed to occupy the positions previously occupied by the pycnidia.

Ellis and Everhart[6] give all the measurements too small to apply to any of the specimens examined. They also speak of the ascospores as being 3 to 6 (mostly 3 to 5)-septate. All of the fully mature ascospores examined were uniformly 5-septate, while all the mature conidia were 3-septate. Both are olive-brown in color.

The ascospores and conidia germinate by sending out a germ tube from one or more of the cells, most often from one end cell. The mycelium is at first light brown, later becoming dark brown and much branched. Attempts to isolate the fungus were unsuccessful for the reason that the mycelium is slow growing and the plates were overrun by rapid growing fungi. One unidentified form of very rapid grow-

[5]Saccardo, P. A. Syllage Fungorum 2: 6.
[6]Ellis, J. B., and Everhart, B. M. North American Pyrenomycetes, 403.

ing fungus made more growth in one hour while under observation than Massaria did in two days.

BOTANICAL LABORATORY,
IOWA STATE COLLEGE, AMES.

DESCRIPTION OF PLATES.

Plate VII.

Gnomonia veneta (Sacc. & Speg.) Kleb.
(*Gloeosporium nervisequm* (Fckl.) Sacc.)

Fig. 1. Portion of the under surface of a leaf of sycamore (*Platanus occidentalis*) showing pustules of the fungus. Leaf gathered October, 1913. Slightly enlarged.
Fig. 2. Section through a pustule. x 150.
Fig. 3. Spores. x 550.
Fig. 4. Myxosporium stage on twig. A leaf scar is shown where young growth had started but had been killed by the fungus. x 1¼.

Coniothyrium mixtum Fuckl.

Fig. 5. A pycnidium. x 150.
Fig. 6. Spores. x 550.

Cytospora platani Fuckl.

Fig. 7. Portion of a twig showing stromata and the wormlike spore masses being pushed out of some of them. x 1½.
Fig. 8. Stroma with wormlike spore mass. Somewhat enlarged.
Fig. 9. A stroma more enlarged.
Fig. 10. Section of a stroma with three pycnidia, only a portion of one pycnidium being shown. x 150.
Fig. 11. A large, irregular pycnidium. A cone-shaped beak is arising from the center. x 150.
Fig. 12. Spores. x 550.

Plate VIII.

Massaria platani Ces.

Fig. 1. Several perithecia growing close together and connected by fungus threads and almost appearing as if in a stroma. x 12. The small body at the right is a young pycnidium.
Fig. 2. A perithecium. x 65.

Fig. 3. A young ascus. x 150.
Fig. 4. Nearly mature ascus. x 150.
Fig. 5. A fully mature ascus. x 150.
Fig. 6. A young ascospore. x 550.
Fig. 7. Nearly mature ascospore. x 550.
Fig. 8. Fully mature ascospore. x 550.
Fig. 9. A pycnidium (*Hendersonia desmazierii* Mont.). x 150.
Fig. 10. Two mature conidia. x 550.
Fig. 11. Two conidia germinating. x 275.
All drawings are original.

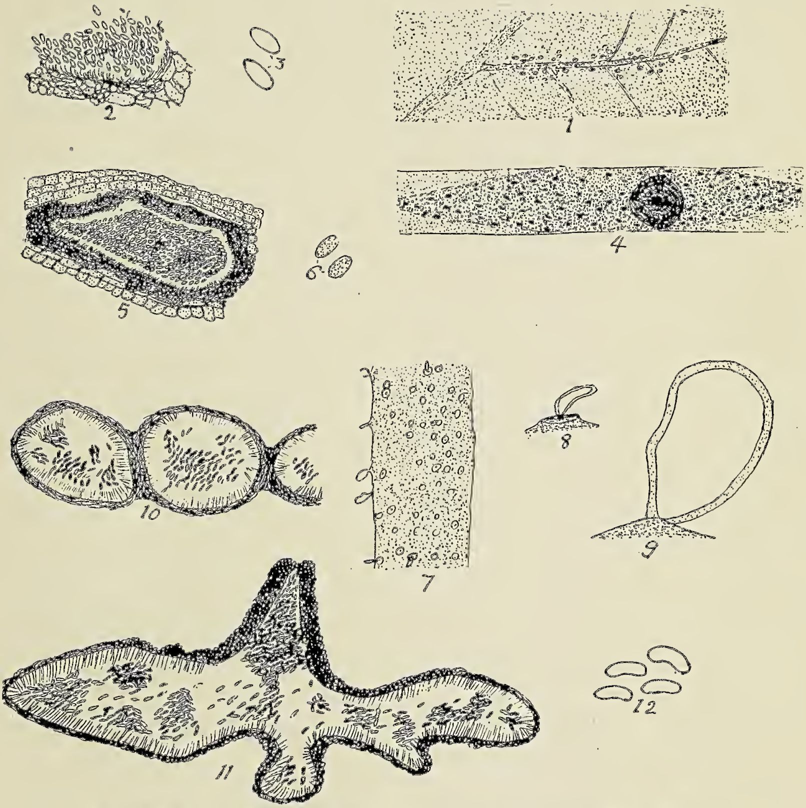

PLATE VII. Drawings of Sycamore blight and other fungi.

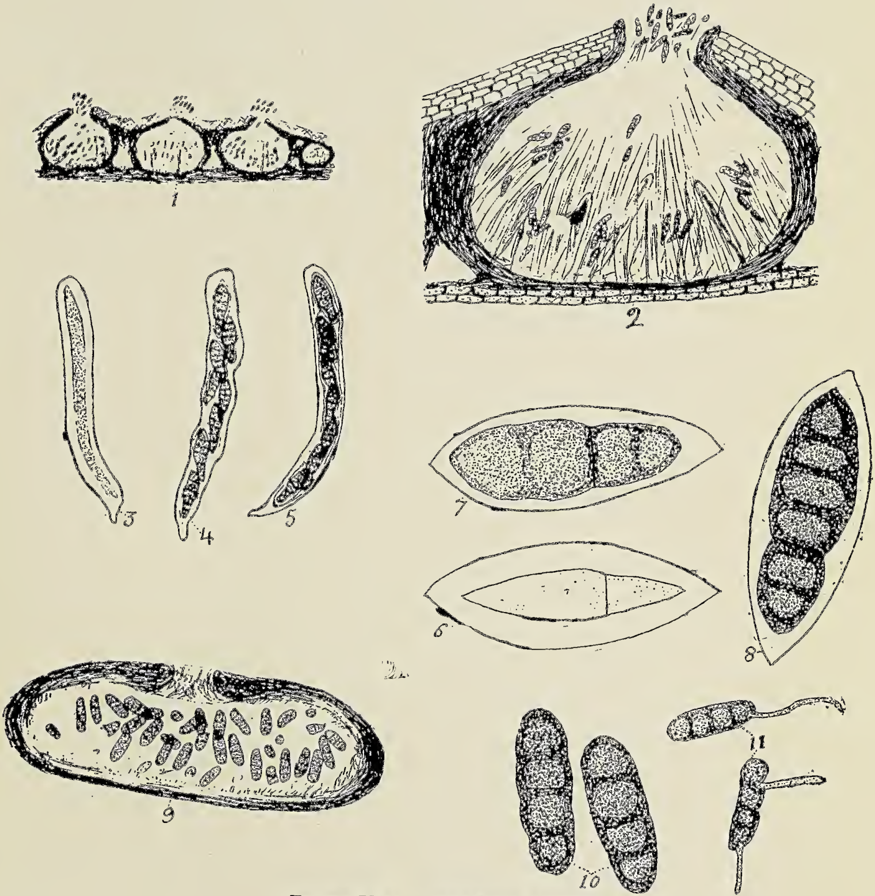

PLATE VIII. *Massaria platani.*

WEED SURVEY OF STORY COUNTY, IOWA.

BY L. H. PAMMEL AND CHARLOTTE M. KING.

The matter of the distribution of weeds is one of interest, not only to the phytogeographer, but to the farmer and horticulturist as well. Our alien flora, though Iowa is not an old state, is a large one. In 1879 Dr. Gray prepared a list of the predominant weeds of Eastern North America.* In a discussion of weed migration in The Weed Flora of Iowa, I made a comparison of weeds and alien plants in Iowa. In counting the weeds of Iowa I find that 172 of that list occur in Iowa. This list can be augmented by the addition of a great many more. We are safe in saying that not far from twenty per cent of our Iowa plants are alien. Dr. Fernald† states that only twenty-three per cent of the New England plants are native. In a paper which follows this, "Introduced Plants of Clear Creek Canon, Colorado," it will be seen that more than eighty-five per cent are indigenous. In other words, in spite of various disturbances, such as modern traffic, the burning of the forests, etc., a large per cent of species must be considered as indigenous. A few weeds like the Russian thistle, because of the xerophytic character, have been able to occupy large areas.

The case in Iowa is, however, far different. There are comparatively few plants of the native prairie that can overcome the difficulties of cultivation. It is true that the plants of the native prairies were plants of the sunshine, but the plants were firmly rooted in the sod, and, though they do well when protected, they cannot compete with European weeds and alien plants, even where cultivation has not occurred; but grass, timothy, and other alien plants have crowded the goldenrod, aster, etc., leaving little in the way of native vegetation. There are some notable exceptions, as that of the morning glory (*Convolvulus sepium*), artichoke (*Helianthus tuberosus* and *H. grosserratus*), the greater ragweed (*Ambrosia trifida*), milkweed (*Asclepias syriaca*), and others.

Our weed flora is not fixed, new weeds are not only coming in, but some of these newcomers are crowding out some of the old familiar weeds. The common prickly lettuce (*Lactuca scariola* var. *integrata*) is today being crowded out in Story county by the *Lactuca scariola*. The quack grass (*Agropyron repens*) in our meadows is crowding the foxtail (*Setaria viridis*). This has occurred in comparatively recent times.

*See L. H. Pammel "Weed Flora of Iowa" p. 714—references will be found here.
†l. c.

Quack grass in parts of Iowa has occurred for more than twenty-five years. It has occurred in the vicinity of Ames for twenty-seven years, and there are places in Iowa where, no doubt, it has occurred for forty years. During the last few years Johnson grass (*Andropogon Halepensis*) has been reported as persisting in Fremont county; there may also be other localities in the state. It is certainly true that with the purchase of certain kinds of agricultural seed (sweet clover) Johnson grass is spreading in the state. Much of it, of course, will not survive the severe winters. However, there is always a potentiality in plants. A very good illustration of this is the horse nettle, which, undoubtedly, is a weed of southern United States, and yet, today, this weed occurs pretty close to the northern border of this state. Quack grass was, undoubtedly, widely distributed in northern Iowa with awnless brome grass (*Bromus inermis*).

We have been interested in making a study of the weeds of fields in Iowa, under different conditions, with the view of determining the effect of different kinds of field treatment on the abundance of weeds.

Let us take a few typical Iowa fields in Story county, near Ames. We know that there is an antagonism between the roots of the different plants; there is also an antagonism brought about through root secretions, e. g., toxins; moreover, different crops influence weed growth by shading. There are weeds, of course, that are confined to special types of soils. It is certain that the geologists, as well as the soil men, can get many valuable suggestions from the plant covering. We should use these data more than we do. There are certain geological outcrops marked by definite types of plants. Does not the presence of the sheep sorrel always indicate a gravelly or sandy soil?

The data below were gathered by members of a class in weeds. Their names appear on the maps accompanying this paper.

The first field is the Osborne farm, located on the banks of Squaw creek. The oat field was in corn the previous season, and not well tilled, as evidenced from the weeds found on it. The figures represent percentages or abundancce of the weeds in different parts of the field: Artichoke (*Helianthus tuberosus*) 1-5, bull thistle (*Cirsium lanceolatum*) less than 5, Canadian lettuce (*Lactuca canadensis*) 5-10, curly dock (*Rumex crispus*) below 5, dandelion (*Taraxacum officinale*) 5-10, five-finger (*Potentilla monspeliensis*) 5-10, foxtail (*Setaria glauca*) 10-15, field thistle (*Cirsium discolor*) below 5, field sorrel or yellow sorrel (*Oxalis corniculata*) 5-10, pepper grass (*Lepidium virginicum*) 15-25. There were some thirty-five different species of weeds found. In some places some species were more predominant than others.

The corn field, comprising some thirty acres, had been in clover meadow for five years previous. Here twenty-two species of weeds occurred in different parts of the field. Quadrats in different parts of the field gave the following figures in regard to the predominant weeds: Milkweed (*Asclepias syriaca*) below 5, sour dock (*Rumex crispus*) below 5, tickle grass (*Panicum capillare*) below 5, smartweed (*Polygonum pennsylvanicum*) below 5, sheep sorrel (*Rumex acetosella*) 5-10, sandy soil, northern nut grass (*Cyperus esculentus*) 5-10, field thistle (*Cirsium discolor*) below 5, small ragweed (*Ambrosia artemisiifolia*) 5-10, pigeon grass (*Setaria glauca*) 10-15, green foxtail (*Setaria viridis*) 5-10.

An ecological study was made of another field, a portion of the College Dairy Farm. First an oat field: Pigeon grass (*Setaria viridis*) 43.9, crab grass (*Digitaria sanguinalis*) 17.5, lamb's-quarter (*Chenopodium album*) 6.5, the other percentages need not be enumerated; they appear on the map.

In the pasture the following weeds appeared: Dandelion 56, small ragweed 2.5, sandbur (*Cenchrus tribuloides*) 3.5; only fourteen different weeds were found in this field.

In another field, the Harper farm, of sixty acres, a part was devoted to corn, a part to pasture, and a third area was in meadow. The weeds observed in the meadow, near the small drainage depression, were: Artichoke (*Helianthus tuberosus*) 80, *Stachys aspera* 15, morning glory (*Convolvulus sepium*) 3, timothy (*Phleum pratense*) 2; on the flat leading to the depression: Prickly lettuce 25, red clover (*Trifolium pratense*) 25, morning glory 15, timothy 15, pigweed (*Amaranthus retroflexus*) 10, velvet weed (*Abutilon Theophrasti*) 5, stink grass (*Eragrostis major*) 5. The weeds in the meadow on the flat varied according to the sources of the weeds, cultivation, and treatment. The south end of the meadow had 40 per cent covered with morning glory, 30 with timothy, 20 with clover, 4 with knotweed (*Polygonum ramosissimum*), 3 with dandelion (*Taraxacum officinale*), and 3 with sour dock (*Rumex crispus*). The middle portion of the field had 30 per cent of timothy, 65 of northern nut grass (*Cyperus esculentus*), 5 of clover. Along the north end of the field were a great deal of volunteer oats, 30 per cent, 30 of morning glory, 35 of northern nut grass, 5 of clover.

In the corn field there were some striking differences in the character of the weed flora. In two of the quadrats there were very few weeds, almost a clean field. However, in one of the quadrats the growth of corn was seriously interferred with by Muhlenberg's smartweed or devil's shoestring (*Polygonum Muhlenbergii*) 25 per cent, Spanish needle (*Bidens frondosa*) 5. In the pasture there were present dandelion (*Taraxacum officinale*) 10 per cent, blue vervian (*Verbena stricta*) 25.

The railroad is an important factor in the dissemination of weeds. Mr. H. L. Eels and Mr. H. J. Shutts determined the weed flora of the Chicago and North Western railway for a little more than one-half mile between Ames and Ontario. Brome grass (*Bromus inermis*) along parts of the right of way occupied 50 to 75 per cent. This was, of course, planted to hold the banks, and is a most useful grass, since it excludes such weeds as sweet clover (*Melilotus alba*), small ragweed, squirreltail, curled dock, smooth dock, and many others which were common on the right of way not planted with brome grass. Near the west end of the right of way of which this was a study from 25 to 75 per cent of the space was occupied with sweet clover, next to the ballast. Beyond this zone there was pigweed (*Amaranthus retroflexus*) below 5, Indian hemp (*Apocynum androsaemifolium*) below 5, three-seeded mercury (*Acalypha virginica*) below 5, Iowa tumble weed (*Amaranthus graecizans*) below 5. Next to the fence there was cup plant (*Silphium perfoliatum*) below 5, sedge (*Carex*) 5-10, Spanish needle (*Bidens frondosa*) below 5, tickle grass (*Panicum capillare*) below 5, burdock (*Arctium major*) below 5.

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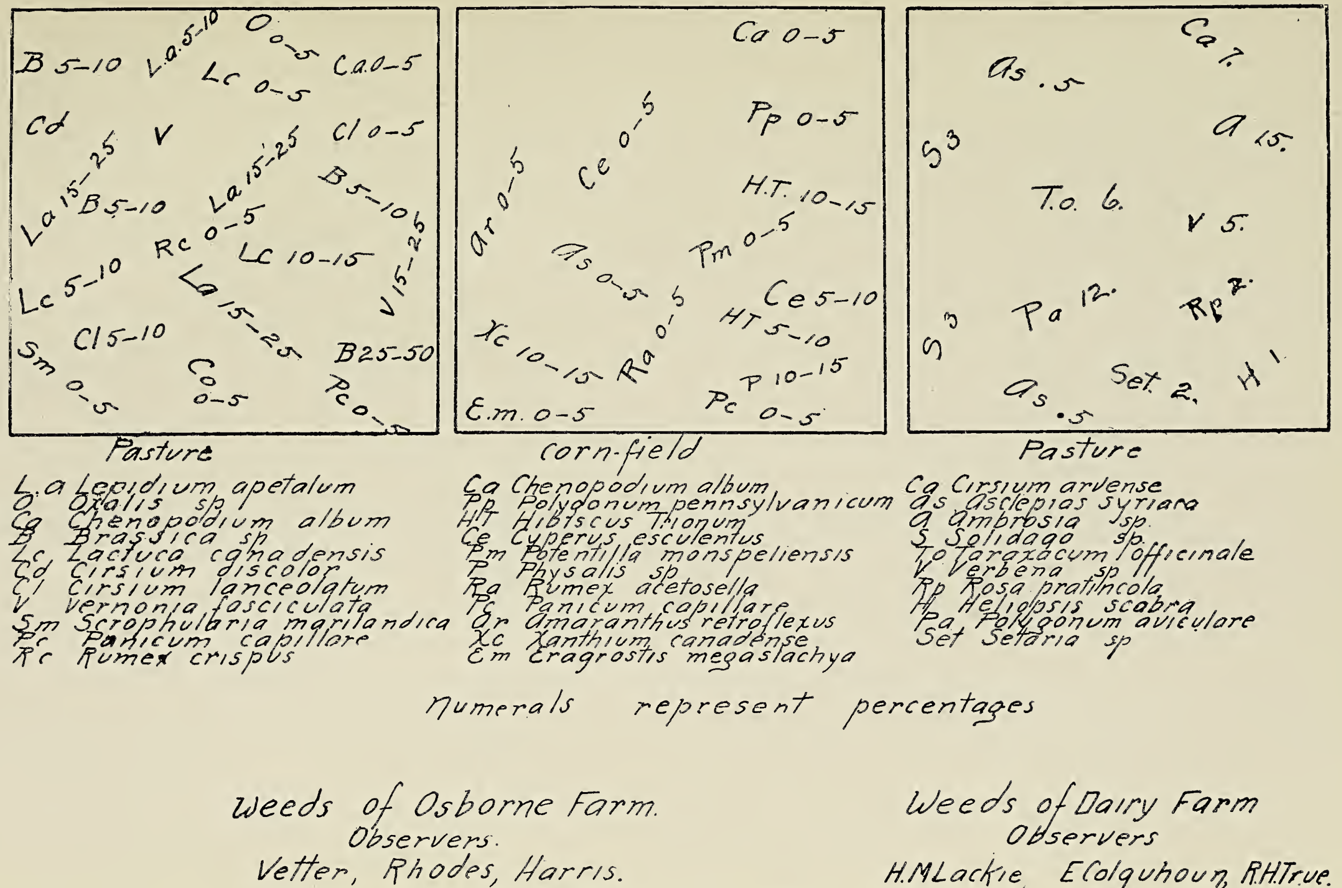
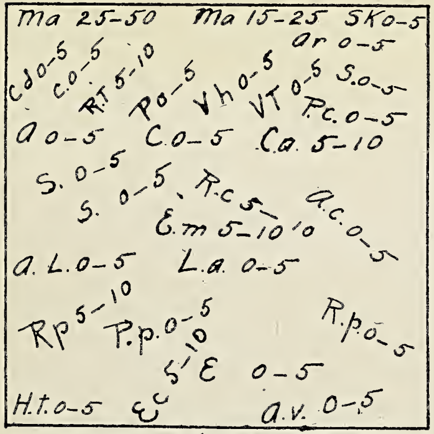


PLATE IX. Weeds of Osborne and Dairy farms.

PLATE X. Weeds of Harper farm.

Weeds of Chicago & North-Western Right of Way, north of I.S.C.

Observers H. L. Eells – H. J. Shutts



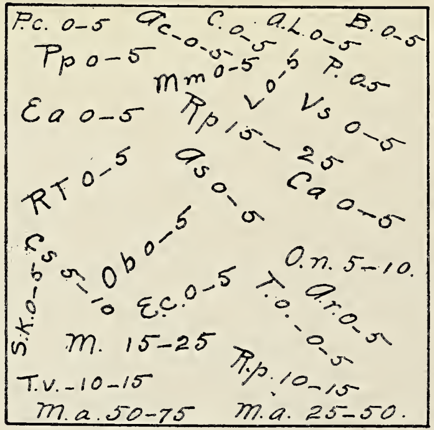
South Side of Track.

AL Arctium Lappa
Ma Melilotus alba
Aa Ambrosia artemisiaefolia
Ab Amaranthus blitoides
Ar Amaranthus retroflexus
SK Salsola Kali var tenuifolia
Cd Cirsium discolor
Cs Convolvulus sepium
P Physalis — A Artemisia —
RT Rhus toxicodendron
Vh Verbena hastata
VT Verbascum Thapsus
Pc Panicum capillare
C Cyperus S. Solidago
Ca Chenopodium album
H a Helianthus grosse-serratus
S. Setaria sp E Elymus sp
Rc Rumex crispus
Ra Rumex altissimus
H.t. Helianthus tuberosus

Rp Rosa pratincola
A.c. Apocynum cannabinum
E. m Euphorbia maculata
B Bromus
A. v Acalypha virginica
L.a. Lepidium apetalum
P.p Polygonum pennsylvan-

Weeds of Area north of Tracks

S.p. Silphium perfoliatum
C.s. Convolvulus sepium
Mo Melilotus alba
RT Rhus toxicodendron
Chenopodium album Ca
Physalis P
On Oxybaphus nyctagineus
Ar Amaranthus retroflexus



North Side of Track.

VT Verbascum Thapsus
As Asclepias syriaca
Ob Oenothera biennis
Rp Rosa pratincola
SK Salsola Kali var tenuifolia
Pc Panicum capillare
Pp Polygonum pennsylvan-
Ac Astragalus canadensis
Vs Verbena stricta
Vu Verbena urticaefolia
L. Lithospermum
C Cyperus
L Lactuca
B Brassica
E.a. Equisetum arvense
A L Arctium Lappa
Mm Muhlenbergia mexicana
P.a Psedera quinquefolia
T.v Tradescantia virginica
E.c. Erigeron canadensis

Numerals represent percentage of ground at location of plant, occupied by it.

PLATE XI. Weeds of Chicago and North Western right of way.

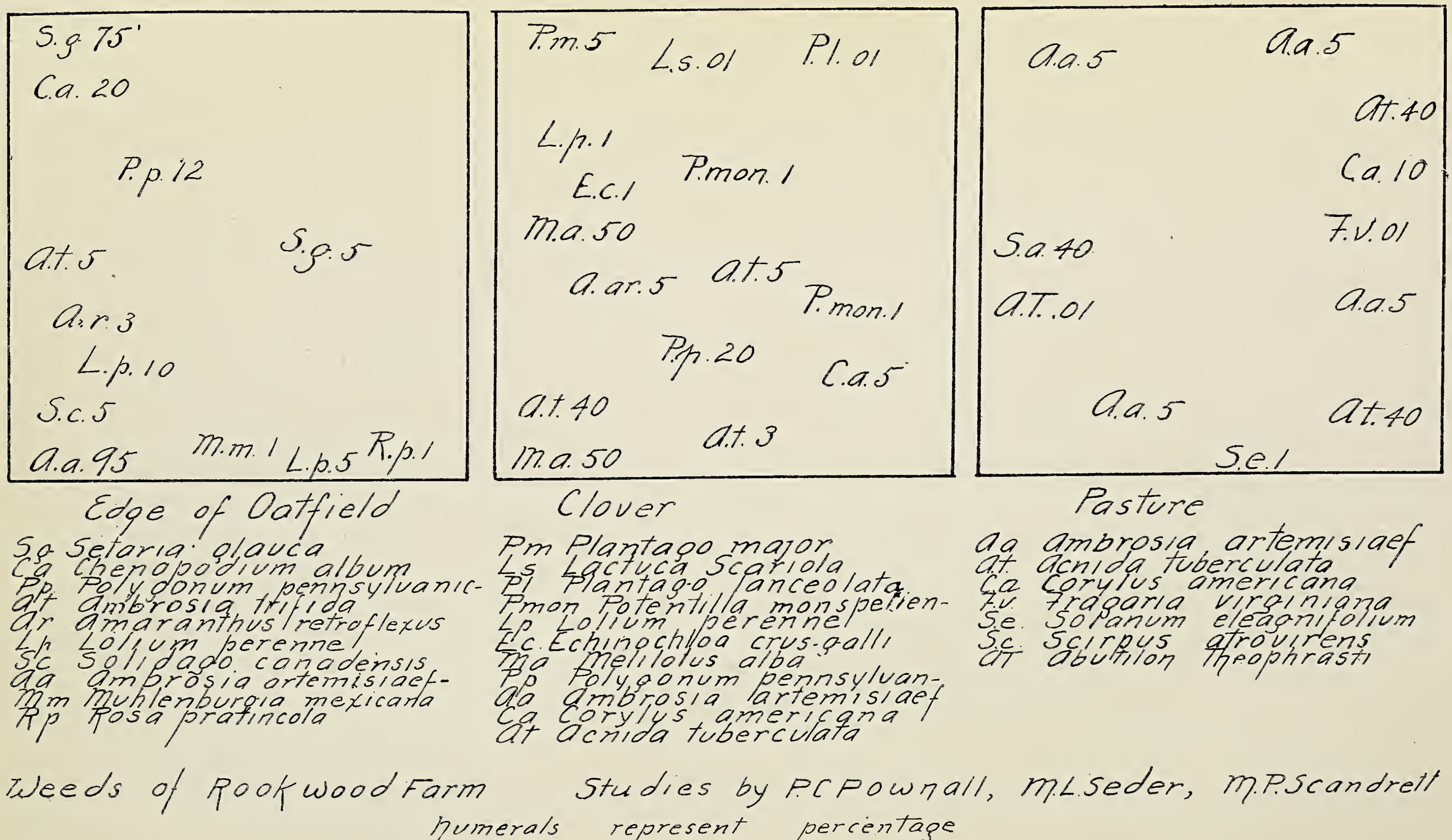


PLATE XII. Weeds of Rookwood farm.

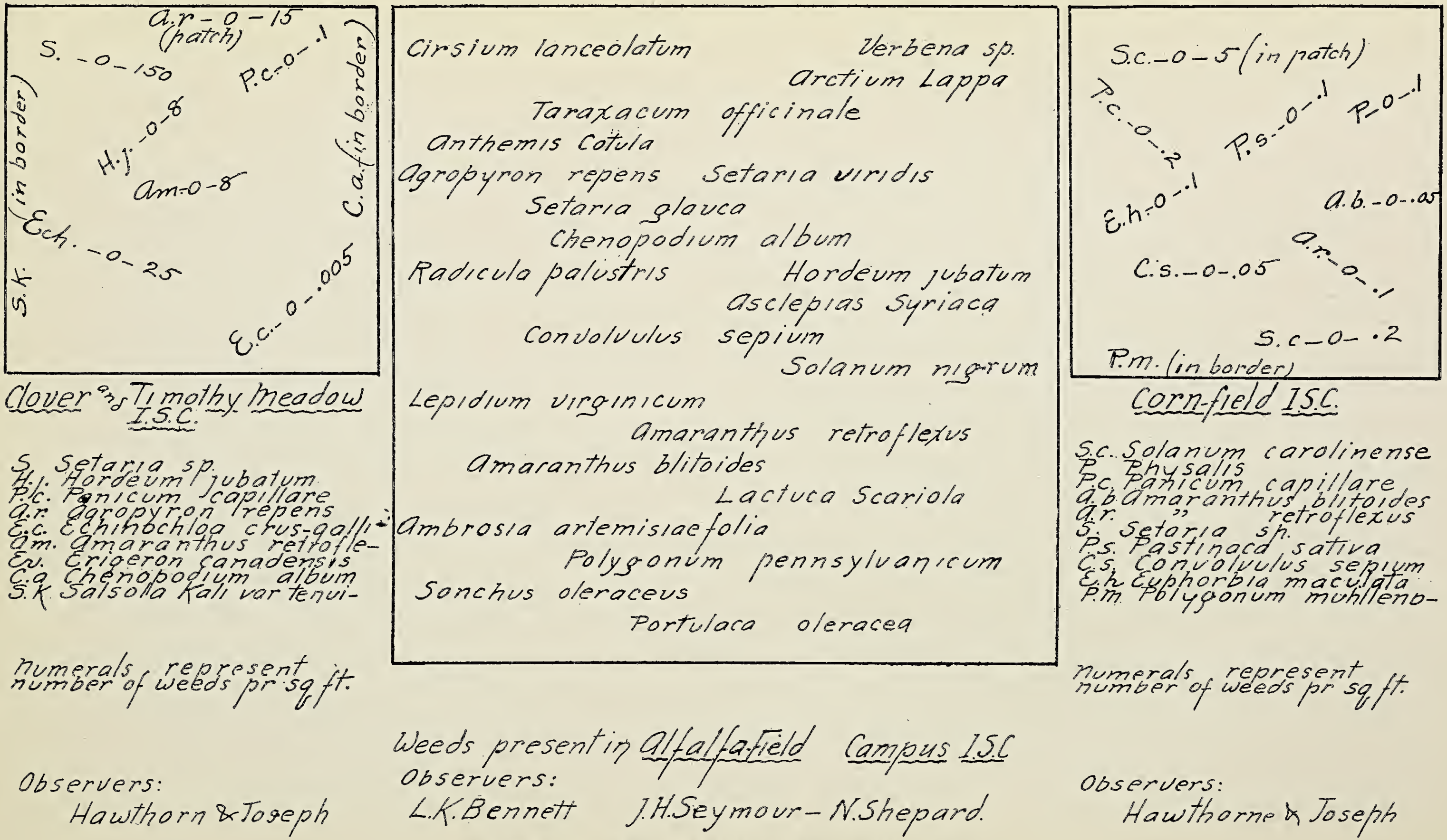


PLATE XIV. Weeds of fields at Iowa State College.

INTRODUCED PLANTS OF THE CLEAR CREEK CANON, COLORADO.

BY L. H. PAMMEL.

It is always interesting to note changes in the flora since the advent of man. With this end in view, the writer made some notes on the plants found in the Clear Creek Canon, Colorado.

The first settlement was made in the vicinity of Idaho Springs. A small monument marks the discovery of gold in this region in 1859, on what is known as Chicago creek.* Gold mining has been carried on in this vicinity continuously since.

The first botanist to visit this region was Dr. C. C. Parry†, who explored the region in 1861. Doctor Parry named the twin peaks after the two distinguished botanists, Dr. Asa Gray and Dr. John Torrey. He named a third conspicuous peak Mt. Engelmann; this name is, however, no longer used. These peaks are at the head waters of several little branches of Clear creek. At one time there was a small settlement at Graymont, which is now abandoned. The Colorado Southern Railroad used this as a terminus, but the road between Silver Plume and Graymont was abandoned because of the burden of taxation.

There are some evidences of introduced plants at Graymont and around the mines up the canon, such weeds as shepherd's purse (*Capsella bursa-pastoris*), and a few other boreal weeds. However, the list of introduced weeds is comparatively small, nor are there many introduced weeds in the vicinity of Silver Plume: White clover (*Trifolium repens*), timothy (*Phleum pratense*) and an occasional red clover plant (*Trifolium pratense*), shepherd's purse (*Capsella bursa-pastoris*), are among the common plants. Dr. Parry‡, in his account of the plants collected in this region, mentions only the following plants, which are more or less weedy: Marsh elders (*Iva xanthiifolia* and *I. axillaris*), gum weed (*Grindelia squarrosa*), blue lettuce (*Lactuca pulchella*), stink weed (*Cleome integrifolia*), cranesbill (*Geranium Carolinianum*), *Froelichia Floridana,* tumble weed (*Cycloloma platyphyllum*), buffalo bur (*Solanum rostratum*). All these were undoubtedly collected at lower altitudes by Doctor Parry.

*Bull. U. S. Geol. Survey, 285: 36.

†Physiographic account of that portion of the Rocky Mountain Range, at the head waters of South Clear Creek and east of Middle Park; with an enumeration of the plants collected in this district in the summer months of 1861. Amer. Jour. Sci. II, **33**:231, 404; **34**:249, 330.

‡loc. cit.

In this list of Doctor Parry I do not find a single exotic plant, although there had been some permanent settlements in Colorado some years before. The exotic weeds, as well as the native weedy plants, undoubtedly spread much later.

At Georgetown, having an altitude of about 9000 feet, the common prairie sunflower (*Helianthus petiolaris*), gum weed (*Grindelia squarrosa*), dandelion (*Taraxacum officinale*) and stink weed (*Cleome integrifolia*), were common. There is an abundance of common timothy, white clover, and an occasional red clover plant, and the little meadows contain much blue grass, probably a native grass. The weedy flora between Georgetown and Idaho Springs contains, in addition to the above plants, Russian thistle (*Salsola kali* var. *tenuifolia*) an abundance of the common western sunflower (*Helianthus petiolaris*), stink weed (*Cleome integrifolia*), yarrow (*Achillea Millefolium*), shepherd's purse (*Capsella bursa-pastoris*), some pepper grass (*Lepidium sp*), some curled dock (*Rumex crispus*), timothy (*Phleum pratense*), white clover (*Trifolium repens*), alfalfa (*Medicago sativa*), plantain (*Plantago major*). The list of the alien weeds is not large, though communication with the plains is frequent.

In the vicinity of Idaho Springs the common marsh elder (*Iva xanthiifolia*), a weed originally found on the plains near streams, is not infrequent; stink weed (*Cleome integrifolia*), also a weed of the plains, is abundant. The related stink weed (*Polanasia trachysperma*) also belongs to the plains flora, but it is not common. An occasional mullein (*Verbascum Thapsus*) and the three-flowered nightshade (*Solanum triflorum*), also species of the plains, occur. Evening primrose (*Oenothera biennis*), a weed of the Mississippi valley and eastward, was common at the Forks. The prickly lettuce (*Lactuca scariola*) is common everywhere in the region, especially near Golden and in the region adjacent to the foothills. The buffalo bur (*Solanum rostratum*) is abundant, as is the tumbleweed (*Cycloloma platyphyllum*); both are weeds of the open on the plains. Purslane (*Portulaca oleracea*) is common everywhere in the gardens, as is the common pigweed (*Amaranthus retroflexus*), which has been brought in from the east and south. The Indian hemp (*Apocynum androsaemifolium*) is a weed of irrigation ditches at the mouth of the canon. The following eastern and European weeds were common in the vicinity of Golden: Simpson honey plant (*Scrophularia nodosa*), green foxtail (*Setaria viridis*), pigeon grass (*Setaria glauca*), dropseed grass. (*Muhlenbergia glomerata*), cocklebur (*Xanthium canadense*), horehound (*Marrubium vulgare*), everywhere growing under dry conditions, horseweed (*Erigeron canadense*), yellow sweet

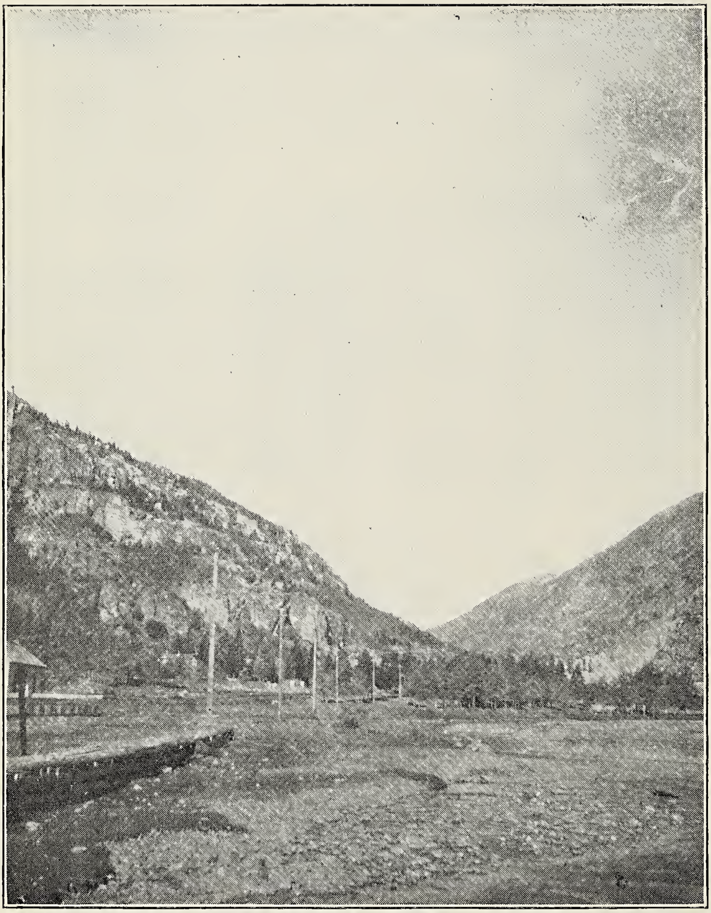


PLATE XV. Clear Creek Canon near Idaho Springs, Colorado. Photograph by L. H. Pammel.

PLATE XVI. Silver Plume, Clear Creek, Colorado. Altitude 9,000 feet. Photograph by L. H. Pammel.

clover (*Melilotus officinalis*), and white sweet clover (*Melilotus alba*), wild licorice (*Glycyrrhiza lepidota*), milkweed (*Asclepias speciosa*), common sunflower (*Helianthus annuus*), sour dock (*Rumex crispus*), greater ragweed (*Ambrosia trifida*), also some small ragweeds (*Ambrosia artemisiaefolia*). The native perennial ragweed (*A. psilostachya*) is much more abundant. The meadow sunflower (*Helianthus grosseserratus*), wormwood (*Artemisia ludoviciana*), goldenrod (*Solidago canadensis*), smooth dock (*Rumex altissimus*), and Mexican fireweed (*Kochia scoparia*) are everywhere in Denver and Golden. Blue vervain (*Verbena hastata*), morning glory (*Convolvulus sepium*), European morning glory (*Convolvulus arvensis*), parsnip (*Pastinaca sativa*), lamb's-quarters (*Chenopodium album*), burdock (*Arctium major*) are common.

Quite a large number of the weedy plants of the valley belong to the region, like the blue lettuce (*Lactuca pulchella*), not abundant except as the plains are reached, *Chrysopsis villosa, Gaura parviflora, Cirsium ochrocentrum,* stick-seed (*Echinosperma floribunda*), *Mentzelia ornata,* Rocky Mountain poppy (*Argemone platyceras*).

In the vicinity of Denver, only some twelve miles from Golden, there are a great many more exotic weeds. The list can be materially augmented, the following weeds being abundant: Small ragweed (*Ambrosia artemisiaefolia*), biennial wormwood (*Artemisia biennis*), buckhorn (*Plantago lanceolata*), smartweed (*Polygonum Persicaria*), dooryard knotweed (*Polygonum aviculare*).

It will be seen from the above account of the weeds that Europe has not contributed largely to the weeds of this region, except at the mouth of the canon. It is not an agricultural region. The weeds of the canon are largely confined to gardens, streets, or roadsides.

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NOTES ON VARIATION IN MICRANTHES TEXANA.

L. A. KENOYER.

In the spring of 1900 I discovered near Independence, southeastern Kansas, a plant which had hitherto been unreported in the state. On submitting specimens to the National Herbarium, I determined it to be Buckley's Saxifraga texana, which was discovered in Texas about 1861. The plant has since been placed in Small's segregated genus, Micranthes, and has been reported from a few widely scattered localities in north Texas, Arkansas, and southeast Missouri.

The locality from which the Kansas samples come is a low and damp but open pasture area with sandy soil and some outcropping sandstone, which rock underlies the soil. There are not more than five hundred to a thousand specimens growing on this area of less than a hundred square rods. Yet there is among the plants a diversity of form that is remarkable inasmuch as it appears to represent a struggle on the part of a dying species to perpetuate its existence.

Specimens collected on March 28, 1914, showed some mature seed, for the plant had taken advantage of the earliest warm days of an unusually early spring. The scape is generally solitary, but there may be three or four to a plant. Sometimes a small, weak one comes out from the base of a stouter one. The flower cluster is of the determinate type—in some cases a compact, compound cyme, and in others much more loosely branching. The leaves range in form from ovate to linear-oblong, or spatulate, in margin from deeply crenate-serrate to entire. In these respects my specimens conform closely to the type description.

The most remarkable thing about the plants of this plot is the variation in the number of floral parts, particularly in carpels. It is the normal thing for Saxifragaceae to have two carpels to a flower. Small and Rydberg, in "North American Flora," say for the order, "rarely three," but make no mention of any departure from the normal number for the genus Micranthes, or for the species *Micranthes texana.* But our Kansas plant has virtually adopted the three-carpellate habit, this number being far more frequent than two. Four-carpellate flowers are about half as frequent as two-carpellate. There are a few fives, and observation on previous years has shown an occasional six. These larger numbers, when they occur, are not symmetrically arranged—as are the carpels of Sedum—but some carpels appear to be somewhat thrust aside by others. Sometimes one or more are small or abortive. The six-carpellate flowers that I have seen have two fairly definite rows of three each.

This spring I selected at random 140 plants for statistical study. These plants bore on an average thirteen flowers each, the number per plant ranging from one to forty-two. Of a total of 1831 blossoms, 233, or 12.7 per cent, had two carpels each; 1500, or 81.9 per cent, had three each; eighty-nine, or 4.9 per cent, had four each, and nine, or .5 per cent, five each. Very evidently the three-carpellate condition is so far in the lead as to be typical for this little colony of the species; three is what the statistician would call the modal number of carpels.

Another interesting series of figures is that representing the average number of carpels per plant for the 140 plants investigated. The accompanying curve, in which the abscissas represent the 140 plants consecutively arranged in the order of their average carpel number and the ordinates represent the average carpel numbers, shows a very typical conformance to Galton's Law, being nearly vertical at the ends and horizontal at the part which represents the three-carpellate condition. The lowest average is 2, the highest, 4.25. There were four plants with the flowers all two-carpellate, while thirty-five had them all three-carpellate, and six others averaged three each. The slight offset on either end of the long horizontal line on three can easily be understood when it is remembered that we are dealing with plants having such small numbers of flowers that the addition or subtraction of one carpel in a single flower makes a considerable difference in the average.

No rule could be established concerning the relative position or age of the flowers having the varying numbers of carpels. Sometimes the four and five-carpellate ones were older and sometimes younger than the average.

Another tendency was that toward multiplication of the floral parts. Saxifrages are normally pentamerous, but this colony affords not a few hexamerous and even heptamerous specimens. Even more common, perhaps, is the addition of a petal or two, the other parts remaining normal. As a general thing those flowers with more than three carpels are most likely to have a superabundance of the other floral organs.

I was led to make this preliminary study by the hypothesis of Standfuss, that species, like individuals, have life cycles, and that a period of mutation, or species-reproduction, precedes the period of death for the species. Since this species is so rare and so widely scattered, it would seem to be a disappearing species. The three-carpellate condition seems clearly to be a mutation, for we find here a newly established average about which fluctuation occurs. I hope by propagation of the plant and by further investigation to receive light on some of the many interesting problems of heredity and variation.

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Leander Clark College, Toledo.

Plate XVII. Curve showing average number of carpels in *Micranthes texana.*

VARIATION IN EVAPORATION IN LIMITED AREAS.

D. H. BOOT.

During a study made at the Macbride Lakeside Laboratory in the summer of 1913 a series of observation stations were set up on the hill known as "Twin Mounds," on the south shore of East Okoboji lake. This hill rises from the lake front to a height of about 100 feet and has a dense growth of timber on the protected face of its north slope. The top is bare of trees, as also is the entire south slope, which is exposed to the prevailing southwest winds of summer. Seven stations were arranged, located as follows: one on the summit of the hill, and three at equal distances down each of the two sides of the hill. At these stations there were made observations of the evaporation, using both pan and Pische evaporimeters; of the direction of the wind and its velocity, as measured by two standard types of anemometers; of the relative humidity of the air, as indicated by sling psychrometers; of the percentage of sky cloudiness, and of other factors that might influence the local flora. Sets of plants were taken at each level studied on the north and south sides of the hill. The accompanying chart shows the curves of evaporation, wind movement, and relative humidity for the 9th and 10th of July. The instruments were put in operation on the 8th, so that the record might be complete for the 9th and 10th.

At station number 17, which was located on the margin of the lake, the record of the relative humidity is comparatively high on the morning of the 9th, rises somewhat during the forenoon, and drops in the afternoon. This was with a northerly wind of low velocity coming directly across the lake. On the 10th the relative humidity at this station was much higher in the morning, and rapidly went down during the day. The velocity of the wind was not high at any time, but when, on the second day, its direction was from the south, its velocity at this point went down to almost nothing, although at station number 20, at the top of the hill, the wind velocity was nearly twenty-four miles per hour. This great difference in wind velocity at nearby stations is due to the protection afforded by the hill and by the heavy timber growing on its north slope. Very similar records were obtained for stations numbers 18 and 19, located in the timber on the north side of the hill. Station number 20, located on the summit of the hill, was exposed to all the winds that blew. At this station the relative humidity was low on the morning of the 9th, rose steadily till midday, and declined steadily till evening, was high on the morning of the 10th, and declined toward the evening. The wind velocity at this point was only two miles an hour on the morning of the first day, rose to about five miles at noon, and went down to zero in the evening. On the second day it blew from the south, rose steadily throughout the day, and reached a velocity of twenty-four miles per hour late in the afternoon. The evaporation at this point was low on the morning of the first day, rose to a high figure at noon, and declined through the afternoon. On the second day it rose steadily with the increase of wind velocity until about two o'clock, and then declined slightly. The figures obtained for the three stations on the south side of the hill follow the same general course as those from station 20, at the top of the hill, so that we have for the two sides of this bluff two widely differing groups of figures to indicate the amount of the evaporation. The curves of evaporation on the two sides are apparently determined by the velocity of the wind plus a secondary factor in the percentage of relative humidity. The effect on the plant life is very marked, the north face of the mound being covered with forest, which ranges from willows at the bottom to bur oak at the top, with elms, maples, hickories, plums, etc., in between. On the extreme top and on the whole of the south slope there are no trees of any kind, but only the hardiest of our xerophytic prairie plants, such as the asters, goldenrods, mesquite grasses and the like, which are able to stand the extreme drying effects of the hot southerly winds of summer. These effects are observed in a very limited area, for the average distance between stations did not exceed two hundred feet.

Botanical Laboratory,
State University, Iowa City.

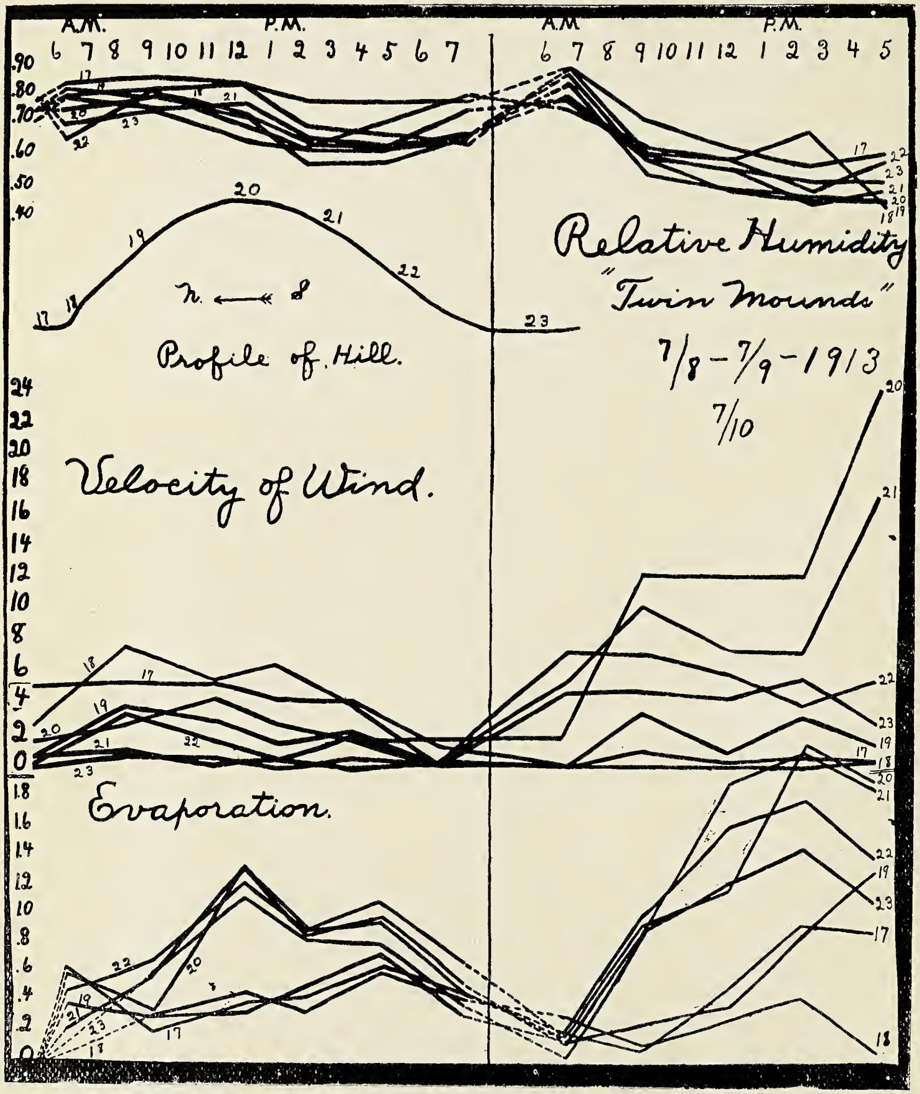

Plate XVIII. Chart showing evaporation data at Twin Mounds, Okoboji.

UNUSUAL DOLOMITES.

NICHOLAS KNIGHT.

The rock formation of Northeast Iowa belongs to the Niagaran period and is dolomitic in character. The various layers show slight differences, but, on the whole, they are typical dolomites, having the formula $CaCO_3$, $MgCO_3$. The analysis of a fair sample shows:

	PER CENT
$CaCO_3$	54.35
$MgCO_3$	43.65
SiO_2	1.00
Fe_2O_3 and Al_2O_3	1.00
Total	100.00

About a year ago our attention was called to a peculiar dolomite from the Simplon tunnel, reported by Gabriele Lincio (Reale Academia delle Science di Torino, 1911). On analysis, the specimen was found to have the formula $3CaCO_3$, $2MgCO_3$, $FeCO_3$, and so is called a ferriferous dolomite.

At our suggestion Mr. C. B. Smith analyzed specimens from a number of different layers of dolomite rock in Mount Vernon and vicinity. He found a peculiar looking specimen at the "Palisades," on Cedar river, about six miles from Mount Vernon. The specimen is coarse granular, pinkish to reddish brown, resembling iron rust, with white crystals disseminated throughout. It is quite a deep red in certain portions. The specimen occurs in pockets in the regular dolomite rock. The analysis by Mr. Smith resulted as follows:

	PER CENT
$CaCO_3$	64.50
$MgCO_3$	33.87
SiO_2	0.57
Fe_2O_3 and Al_2O_3	0.96
Total	99.90

The analysis did not show the amount of iron that the appearance of the rock led us to expect. The figures correspond quite closely to the formula $3CaCO_3$, $2MgCO_3$, the iron, alumina and silica replacing the equivalent amount of magnesium carbonate.

Other specimens from the same locality that seemed to differ in appearance from the typical layers resulted as follows:

		PER CENT
(1)	$CaCO_3$	52.81
	$MgCO_3$	46.15
	SiO_2	0.37
	Fe_2O_3 and Al_2O_3	0.68
	Total	100.01

		PER CENT
(2)	$CaCO_3$	51.52
	$MgCO_3$	47.06
	SiO_2	0.53
	Fe_2O_3 and Al_2O_3	0.58
	Total	99.69

The analyses show how small are the amounts of silica, iron and aluminum—these three constituents aggregate about one per cent.

Attention has been called to another iron-bearing dolomite from the Simplon Tunnel by Mario Delgrosso (Riv. Min. Crist. Ital. **41**. 56-64). This differs from all the foregoing specimens. The analysis leads to the formula $4CaCO_3$, $3MgCO_3$, $(Fe, Mn)CO_3$. O. Killauner Prague (Chem. Zeit. XXXVII, 1317) has studied the thermal dissociation of normal dolomite. He found that dissociation into the two constituents $CaCO_3$ and $MgCO_3$ begins at 500° and reaches a maximum between 710° and 730.° At higher temperatures the $MgCO_3$ and $CaCO_3$ dissociate.

It might prove interesting and instructive to study the thermal dissociation of some of the abnormal specimens.

Chemical Laboratory,
Cornell College, Mount Vernon.

THE SAND OF SYLVAN BEACH, NEW YORK.

NICHOLAS KNIGHT.

The locality is the eastern shore of Oneida lake, in central New York. The entire territory was formerly a lake bottom, at the time when the water was discharged into Mohawk river. An elevation of the land seems slowly to have taken place, the lake was projected farther north, and the water now reaches Lake Ontario through Oneida and Oswego rivers. The soil of the territory for twenty-five or thirty square miles is almost pure sand, and is unadapted to agricultural purposes. There are a number of the usual forest trees, including the pine, oak, elm, hemlock, and maple upon the sand, that attain a slow growth, and there is a dense undergrowth and shrubbery. It is lacking in fertility, and it does not add materially to the wealth of its owners.

Sylvan Beach has become quite a popular summer resort, and its population during the season reaches about five thousand. There is no system of sewage disposal at the resort, but it was long ago observed that all forms of organic matter in the sand quickly decomposed. It is not necessary to remove the sewage from the cesspools, but it is taken care of in some way in the sand. Refuse from the kitchen, including corn husks and cobs, banana and orange peels, apple and potato parings, quickly disappear, and in the course of a few weeks a black substance is found in their place. The leaves from the trees, when buried in the soil, soon are transformed into a black vegetable mold.

It occurred to us, as for a number of years we had observed these rapid changes in the organic refuse buried in the soil, that possibly there is a considerable quantity of iron, which oxidizes the refuse, and serves as a carrier of oxygen. Accordingly we made an analysis of two different portions of the soil:

		PER CENT
(1)	SiO_2	91.88
	Al_2O_3	6.28
	Fe_2O_3	1.71
	CaO	0.65
	MgO	0.39
	K_2O	0.04
	Na_2O	0.03
	Nitrogen	0.00
	Phosphates	0.00
	CO_2	0.00
	Total	100.98

		PER CENT
(2)	SiO_2	94.48
	Al_2O_3	2.17
	Fe_2O_3	1.76
	CaO	1.17
	MgO	0.47
	K_2O	0.04
	Na_2O	0.07
	Nitrogen	0.00
	Phosphates	0.00
	CO_2	0.00
	Total	100.16

Number (1) was taken from a depth of eighteen inches about fifty rods from the lake, while No. (2) was close by the shore. Number (1) presumably arose from the lake centuries before No. (2), and so the elements have had a longer time to work it up into a soil, and it is finer grained than No. (2), yet the analysis does not reveal the difference we expected. The elements of soil fertility—phosphorous, nitrogen and potash—are sadly lacking in both specimens. The analysis scarcely discloses why the organic matter so quickly decays in the sand. We expected to find a much higher percentage of iron in both samples by which to explain the rapid disappearance. Doubtless the iron present is an important factor in the changes, but it does not explain all. The bacteria content must also be small, because there is little if any nitrogen present. Possibly the greatest reason for the change is the free access of the air. The sand does not form a hard crust on the top in any kind of weather, and the atmosphere is always accessible. Cameron* says, "The atmosphere within the soil contains normally a somewhat smaller proportion of oxygen than does the air above the soil. Rain in falling through the air absorbs or dissolves relatively more oxygen than nitrogen. Therefore, when the rain water has penetrated the soil to any considerable depth, there should be, and probably is, a liberation of dissolved oxygen into the atmosphere of the soil interstices."

By the free use of leaves, barnyard manure, and various forms of organic refuse, it seems to us possible that a fairly rich and productive soil might be formed in this territory. The experiment might be interesting and profitable. As the population of the country increases and land values multiply, it will be necessary to use all available land, and bring it to the highest possible degree of cultivation.

We have talked with farmers on the north coast of Ireland in the worst days of the English landlord system, when they could not own their land, but were obliged to pay excessive rents. They were thus living on five or ten acres of poor land, and supporting their large families. Men so trained might be able to reclaim some of our sandy areas and make them fit to support a share of our growing population.

We desire to express our thanks to Mr. Euclid Marston for making the analyses described in the foregoing.

CHEMICAL LABORATORY,
CORNELL COLLEGE, MOUNT VERNON.

*"The Soil Solution" page 53.

THE ELECTRICAL CONDUCTIVITY OF SOLUTIONS OF CERTAIN ELECTROLYTES IN ORGANIC SOLVENTS.

J. N. PEARCE.

The study of the electric conductivity of solutions in organic solvents has brought to light many interesting relations. In many such solvents the same general relation obtains as is found in the case of aqueous solutions, viz., the molecular conductivity increases regularly with increasing dilution. In the great majority of these no limiting value of the molecular conductivity is obtainable, however great the dilution employed.

On the other hand, a large number of instances have been found in which the behavior is apparently just the opposite, the molecular conductivity in these cases increasing as the concentration increases. Instances of this kind are to be observed in the molecular conductivity of solutions of hydrogen chloride in benzene[1], xylene, hexane, and ether; the alkaline halides in benzonitrile[2]; mercuric cyanide in liquid ammonia[3]; aluminium bromide in ethyl bromide[4]; in all the more concentrated solutions of methyl-, ethyl-, ^{n}-propyl-, amyl-, and allyl alcohols; phenol, carvacrol, thymol, α- and β-naphthol and resorcinol in liquid hydrogen bromide[5]; various aliphatic and aromatic acids in liquid hydrogen bromide and hydrogen chloride[6]; solutions of the ammonium bases and non-salt organic compounds in the liquid halogen halides and hydrogen sulphide[7]; and solutions of various salts in aniline, methyl aniline, and di-methyl-aniline[8].

Instances are also known in which the molecular conductivity may both increase and then decrease as we proceed from the more dilute to the more concentrated solutions, as for example, solutions of silver nitrate and cadmium iodide in amylamine[9]. Such cases, the authors state, are not to be explained on the basis of the Arrhenius theory. The molecular conductivity of potassium iodide in liquid iodine[10] at first increases with dilution, passes through a maximum and then decreases rapidly.

[1]Kablukoff: Z. physik. Chem., *4*, 429; Cattaneo, Real. Accad. Lincei, 1893, ii, 112.
[2]Euler: Z. physik. Chem., *28*, 619, 1899.
[3]Franklin and Kraus: Amer. Chem. Journal, *23*, 277, 1900.
[4]Plotnikoff: J. Russ. Phys. Chem. Soc., *34*, 466, 1902.
[5]Archibald: J. Amer. Chem. Soc., *29*, 665, 1907.
[6]Ibid., *29*, 1416, 1907.
[7]Steele, McIntosh and Archibald: Z. physik. Chem., *55*, 179, 1907.
[8]Sachanov: J. Russ. Phys. Chem. Soc., *42*, 683, 1910.
[9]Kahlenberg and Ruhoff: J. Physical Chem., *7*, 254, 1903.
[10]Lewis: Proc. Acad. Arts and Sci., *41*, 419.

The molecular conductivity of solutions of silver nitrate in methylamine[11] first increases with dilution, then decreases and afterward again increases with further dilution. Solutions of lithium chloride in ethylamine[12] give molecular conductivities which increase with dilution up to about 0.8 N and then diminish rapidly with further dilution, while the molecular conductivities of solutions of silver nitrate and ammonium chloride in the same solvent decrease with dilution throughout and finally appear to attain minimum values in the very dilute solutions. Cadmium iodide[13] in certain organic solvents was found to be strikingly abnormal in that its molecular conductivity varies neither with the dilution nor with the temperature.

Many theories have been advanced to explain this apparently abnormal effect of dilution upon the molecular conductivity. Euler[14] explains the increase in the molecular conductivity of solutions in benzonitrile as being due to the presence of the ions. Franklin and Gibbs[15] explain the abnormal results for solutions of silver nitrate in methylamine by means of a slightly modified form of the hypothesis proposed by Lewis[16] for solutions of potassium iodide in liquid iodine. Their hypothesis and explanation is this: "Salts dissolved in a weak ionizing solvent may be expected to give solutions in which the self-ionization of the salt shows itself conspicuously. Methylamine dissolves silver nitrate abundantly, forming solutions, which, when very concentrated, are possessed of a high degree of viscosity. The conductivity of the most concentrated solutions, in that they approach the condition of the melted salt, is therefore, for the most part, due to the autoionization of the salt. As the solution is diluted its viscosity diminishes rapidly with the result that the increasing speed of the ions more than counteracts the effect of diminishing autoionization, which may be assumed to accompany dilution, and which of itself would cause a diminution of the conductivity. The observed conductivity therefore increases. The viscosity, however, falls off at a rapidly diminishing rate as the dilution increases, so that after a time the opposing effects of viscosity and selfionization balance each other, when a maximum of the molecular conductivity is reached. From this point on, for a time, increasing dilution is most conspicuous in its effects on the autoionization of the salt. The rate at which the autoionization diminishes becomes smaller as the dilution continues to increase with the result that, beyond a certain point, the dissociating action of the solvent becomes conspicuous as the curve passes through

[11]Franklin and Gibbs: J. Amer. Chem. Soc., *29*, 1389, 1907.
[12]Shinn: J. Physical Chem., *11*, 537, 1907.
[13]Dutoit and Friderich: Bull. Soc. Chim., 1898, iii, 321.
[14]loc. cit.
[15]loc. cit.
[16]loc. cit.

the minimum and then ascends after the familiar manner of salts in aqueous solution.''

Cady[17] noted the similarity between the crystalline compounds of water and copper sulphate on the one hand and ammonia and copper sulphate on the other. Experiments proved that the latter pair also give conducting solutions. It might be inferred from this that whenever a solute and solvent are capable of separating from a solution as a crystalline ''solvate'' solutions of the two components will conduct electricity.

Kahlenberg and Schlundt[18] ventured the idea that the conducting power of a solution is dependent upon a mutual reaction between the solvent and solute resulting in the formation of a compound which conducts the current. This solvent-solute compound theory was further apparently confirmed by Walden and Centnerszwer[19] in their work with solutions in liquid sulphur dioxide. Solutions of lithium chloride in pyridine have remarkably low molecular conductivities. Laszczynski and Gorski[20] explain this as due to the formation of the compound, $LiCl.2C_5H_5N$. That such a theory is useful is very evident, since it can be used in explaining phenomena which are of an opposite nature.

According to Steele, McIntosh and Archibald[21] the power to form conducting solutions is a function of both the solvent and the solute. This belief was strengthened by the fact that amines, alcohols, ether, acetone, etc., which give conducting solutions in the liquid hydrogen halides and hydrogen sulphide, all have the power of forming compounds with these solvents. In their paper they state that it is their object to show that the anomalous behavior of these solutions can be explained upon the basis of the Arrhenius theory, if we assume that the original dissolved substance, of itself incapable of dissociation, may either become polymerized or unite with the solvent to form a compound which can then behave as an electrolyte. For both assumptions, viz., that of polymerization of the solute, or the formation of a solvent-solute compound, they arrive at the general relation,

$$\lambda_v = {}^{\alpha}K^1 = kV^n,$$

where $^{\alpha}$ represents the degree of dissociation, k the specific conductance, V the volume, K^1 a constant, and ^{n} the number of molecules of the solute combining with m molecules of the solvent, or the number of simple molecules of the solute combining to form one molecule of the polymerized solute. Their results when calculated according to this formula show an increase in molecular conductivity with increasing

[17] J. Physical Chem., *1*, 707, 1897.
[18] Ibid., *6*, 447, 1903.
[19] Z. Physik. Chem., *42*, 432, 1903.
[20] Z. Elektrochem., *4*, 290, 1897.
[21] Z. Physik. Chem., *55*, 179, 1907.

dilution, whereas when calculated according to the relation $\lambda_v = kV$, the molecular conductivity decreases with dilution.

Similar results were obtained by Archibald[22] alone for solutions of paraffin and aromatic alcohols in liquid hydrogen bromide and for organic acids in liquid hydrogen bromide and hydrogen chloride.

Sachanov [23] has made an extended study of the conductivity of solutions in some organic solvents. The solvents used were aniline, methylaniline, dimethylaniline, acetic and propionic acids and a few esters. In all of these solvents, except the esters, the molecular conductivity of the various salts used decreases very rapidly with dilution, and this phenomenon is especially marked in the more concentrated solutions. Walden had previously shown that the dissociating power of solvents is in a high degree independent of their chemical nature and is determined chiefly by the dielectric constant of the solvent. The dielectric constants of the solvents used by Sachanov are small. Those of the amines, viz., aniline, methylaniline and dimethylaniline, are 4.79, 6.62 and 4.99, respectively. According to him, the chief factor determining the ability to give conducting solutions is the chemical nature of the solvent. He divides solvents in which diminution of the molecular conductivity is observed into two classes: (1) those in which all solutes, independently of their nature, exhibit such diminution, and (2) those few in which the molecular conductivity, as a rule, increases with dilution, but with certain dissolved substances diminishes. In general, solvents with low dielectric constants are characterized by divergence from the Nernst-Thomson rule. He also states that the decrease of molecular conductivity on dilution is as characteristic a property of solvents with low dielectric constants and slight dissociating power as is the increase of molecular conductivity for solvents with high dielectric constants. The electrolytic dissociation does not depend solely upon the magnitude of the dielectric constant, but also upon the formation of solvates and complex ions, e. g.,

$$Li_2Br_2.xC_6H_7N = \overset{+}{Li}.yC_6H_7N + \overset{-}{LiBr_2}.zC_6H_7N.$$

The formation of such ions favors electrolytic dissociation because the electroaffinity of these ions is greater than that of the primary ions. In solvents with low dielectric constants only complexes which yield ions of greatly enhanced electroaffinity can undergo electrolytic dissociation. The decomposition of these complex solvates and complex ions explains the decrease of molecular conductivity on dilution and also, so he states, why the Nernst-Thomson rule is not applicable for solvents with low dielectric constants.

[22] J. Amer. Chem. Soc., *29*, 665, 1416, 1907.
[23] J. Russ. Phys. Chem. Soc., *42*, 683, 1363, 1910; *43*, 526, 534, 1911; *44*, 324, 1912. Z. Physik. Chem. *80*, 13, 20, 1912.

In his study of the dielectric constants of dissolved salts Walden[24] finds that the dielectric constant of a feebly ionizing solvent is increased by dissolving in it certain binary electrolytes and that this increase is apparently dependent upon the constitution of the dissolved salt. On the basis of their specific influence he divides the binary salts chosen into two classes, viz., the strong and the weak. Strong salts, e. g., the tetra-alkylated ammonium salts, which are characterized by a great dissociation tendency, possess also a very high dielectric constant. For weak salts, e. g., the monoalkylated ammonium salts, the reverse is true. They have a slight tendency to dissociate and small dielectric constants. The degree of ionization of a salt depends both on the ionizing power of the solvent and the tendency of the solute to ionize. Since both factors increase with the dielectric constant, the highest degree of ionization will be found in a system where both the solvent and the solute possess large dielectric constants. The presence of free ions was also found to increase the dielectric constant.

A large number of the solutes cited in the introduction, if not all of them, exhibit a strong tendency to polymerize and this tendency obviously increases with the concentration. Depolymerization resulting from dilution may proceed either in separate steps, or directly down to the simplest products. According to Walden, the minimum degradation of the polymeric molecules will be obtained when we dissolve a binary salt with low dielectric constant in a solvent, also with low dielectric constant. In this case the solution will contain an extremely small number of ions, but a very large number of associated salt molecules. The increase in the dielectric constant must therefore be due to the presence of polymerized molecules. These solutions show a weak molecular conductivity. With progressive dilution the dielectric constant falls rapidly and approaches that of the pure solvent. This will result in a rapid decrease in the ionizing power of the solvent and therewith a simultaneous decrease in the molecular conductivity.

It is a well known fact that for a given temperature the complexity of hydrates and of solvates, whether molecules or ions, decreases rapidly with increasing concentration. Furthermore, it has been found that the complexity of these solvates decreases with rise in temperature. On the other hand, the complexity of the solute molecules and ions, due to polymerization, increases with increase in concentration. The effect of temperature would therefore appear in the temperature coefficients of the molecular conductivity.

[24]Bull. Acad. Sci. St. Petersburg, 1912, 305-332, 1055-1086. Translated by H. C. B. Weber, J. Amer. Chem. Soc., *35*, 1649, 1913.

The present work was undertaken with the idea of making a detailed study of the molecular conductivity of solutions of electrolytes in various organic solvents over the widest possible range of concentration and to determine the effect of temperature upon the molecular conductivity. This seemed advisable since the previous investigators have limited their work to one temperature.

EXPERIMENTAL.

The conductivity measurements were made by means of the well known Kohlrausch method. The bridge wire was carefully calibrated according to the method of Strouhal and Barus. During the latter part of the work we were fortunate in securing a new Kohlrausch roller bridge of the type devised by Washburn. All of the measuring flasks, burettes, weights and resistance boxes bore the certificate and stamp of the Bureau of Standards, or of the Reichsanstalt. Four glass-stoppered conductivity cells with sealed-in electrodes were used.

The two cells of large resistance capacity were standardized against a 0.02 N potassium chloride solution at 25°C. This solution was prepared from twice recrystalized Kahlbaum's "C.P.", potassium chloride and conductivity water, having a specific conductance of 1.2×10^{-6}, and the specific conductance of the solution was taken as 2.768×10^{-3}. With the cell constants thus obtained the molecular conductivity of a 0.002 N potassium chloride solution was obtained at 25°C. The value of λ_{500} found was: Cell *2=147.64; cell *3=147.60. The constants of the two cells of small capacity were then determined against the 0.002 N solution, and the constants of all four cells checked against a 0.01 N acetic acid solution at 25°.

The temperatures chosen for the work were 0°, 25°, and 35° or 50°C. The zero-bath consisted of clean, finely crushed ice, moistened with distilled water. Large water thermostats, electrically heated and electrically controlled, gave temperatures constant to 25°±.01, 35°±.02 and 50°±.02, respectively.

An attempt was made to use only those salts which are very soluble in the solvent used, in order to get the greatest possible range in concentration, but unfortunately the number of typical salts are few. The salts used were either Kahlbaum's C. P. (best grade), or they were specially prepared. In every case they were carefully purified and dehydrated by the methods recommended for the individual salts and preserved in glass-stoppered weighing bottles over phosphorus pentoxide. The solubility of each salt at 25° was approximately determined and a convenient maximum normality chosen. Whenever possible, the mother solution was made up by direct weighing and then diluted to the concentrations desired, the utmost care being taken to prevent contact with the moisture of the air.

SOLUTIONS IN ANILINE.

The aniline used was of an especially good grade from Merck. It had been allowed to stand over fused potassium hydroxide for several weeks. It was then decanted into a clean dry distilling flask and distilled; only the middle portion passing over at 181°-182°C. (uncorr.) was collected. This portion was then further purified according to the method of Hantzsch. The aniline was refluxed for ten hours with a quantity of pure anhydrous acetone, the acetone was distilled off and the middle portion collected. It was finally twice redistilled from pure, powdered zinc. When first distilled the aniline was practically colorless; its specific conductances at 0°, 25° and 35° were $.9 \times 10^{-8}$, 2.4×10^{-8} and 8.2×10^{-8}, respectively. In spite of all precautions taken in its purification, the aniline gradually darkened on standing, but no noticeable change in the specific conductance was to be observed.

Owing to the extremely high resistances it was found impossible to work satisfactorily with solutions more dilute than 0.005 N, while in some cases 0.01 N is the highest dilution measurable.

SILVER NITRATE

TABLE I.—MOLECULAR CONDUCTIVITY.

V.	$\lambda 0°$	$\lambda 25°$	$\lambda 35°$
200	.182	.372	----
100	.159	.349	.423
40	.156	.338	.414
20	.194	.407	.494
10	.299	.650	.738
4	.464	.869	1.418
2	.725	1.984	2.600

TABLE II.—TEMPERATURE COEFFICIENTS.

V.	$\frac{\lambda_{25}-\lambda_0}{\lambda_0 . 25}$	$\frac{\lambda_{35}-\lambda_0}{\lambda_0 . 35}$	$\frac{\lambda_{35}-\lambda_{25}}{\lambda_{25} . 10}$
100	.049	.048	.021
40	.047	.047	.022
20	.044	.044	.021
10	.047	.046	.021
4	.055	.057	.026
2	.069	.078	.031

ANILINE HYDROBROMIDE.

TABLE III.—MOLECULAR CONDUCTIVITY.

V.	$\lambda 0^\circ$	$\lambda 25^\circ$	$\lambda 35^\circ$
200	.159	.306	.311
100	.124	.213	.230
40	.109	.183	.185
20	123	.199	.199
10	.170	.263	.264
4	.361	.556	.564
2	----*	.971	1.009

TABLE IV.—TEMPERATURE COEFFICIENTS.

V.	$\frac{\lambda 25^\circ - \lambda 0^\circ}{\lambda_0 .\ 25}$	$\frac{\lambda_{35} - \lambda_c}{\lambda_0 .\ 35}$	$\frac{\lambda_{35} - \lambda_{25}}{\lambda_{25} .\ 10}$
200	.037	.027	.001
100	.029	.025	.008
40	.027	.019	.008
20	.025	.017	.000
10	.022	.016	.000
4	.022	.016	.001
2	----*	----*	.003

ANILINE HYDROCHLORIDE.

TABLE V.—MOLECULAR CONDUCTIVITY.

V.	$\lambda 0^\circ$	$\lambda 25^\circ$	$\lambda 35^\circ$
40	.051	.085	.098
20	.048	.079	.088
10	.056	.087	.095
4	.095	.143	.154
2	----*	.265	.286

TABLE VI.—TEMPERATURE COEFFICIENTS.

V.	$\frac{\lambda_{25} - \lambda_0}{\lambda_0 .\ 25}$	$\frac{\lambda_{35} - \lambda_0}{\lambda_0 .\ 35}$	$\frac{\lambda_{35} - \lambda_{25}}{\lambda_{25} .\ 10}$
40	.026	.025	.014
20	.025	.024	.012
10	.021	.019	.009
4	.020	.017	.007
2	----*	----*	.008

*Solidified.

MONO-ETHYL-ANILINE HYDROCHLORIDE.

TABLE VII.—MOLECULAR CONDUCTIVITY.

V.	$\lambda 0°$	$\lambda 25°$	$\lambda 35°$
100	.064	.112	.119
40	.048	.092	.102
20	.021	.079	.093
10	.053	.084	.089
4	.083	.125	.134

TABLE VIII.—TEMPERATURE COEFFICIENTS.

V.	$\frac{\lambda_{25}-\lambda_0}{\lambda_0 . 25}$	$\frac{\lambda_{35}-\lambda_0}{\lambda_0 . 35}$	$\frac{\lambda_{35}-\lambda_{25}}{\lambda_{25} . 10}$
100	.030	.024	.006
40	.037	.032	.011
20	.109	.097	.018
10	.023	.020	.007
4	.020	.018	.007

MERCURIC IODIDE.

TABLE IX.—MOLECULAR CONDUCTIVITY.

V	λ_0	λ_{25}	λ_{35}
10	.0033	.0076	.0097
2	.0014	.0036	.0046
1	.0012	.0032	.0046

TABLE X.—TEMPERATURE COEFFICIENTS.

V.	$\frac{\lambda_{25}-\lambda_0}{\lambda_0 . 25}$	$\frac{\lambda_{35}-\lambda_0}{\lambda_0 . 35}$	$\frac{\lambda_{35}-\lambda_{25}}{\lambda_{25} . 10}$
10	.053	.053	.027
2	.063	.066	.025
1	.069	.084	.043

AMMONIUM SULPHOCYANIDE.

TABLE XI.—MOLECULAR CONDUCTIVITY.

V.	λ_0	λ_{25}	λ_{35}
100	.187	.2588	.312
40	.130	.251	.2919
20	.1647	.313	.3669
10	.267	.506	.8063
4	.647	1.271	1.502

TETRAETHYLAMMONIUM IODIDE.

TABLE XII.—MOLECULAR CONDUCTIVITY.

V.	λ_0	λ_{25}	$\frac{\lambda_{25}-\lambda_0}{\lambda_0 .\ 25}$
200	.910	2.021	.0488
100	.850	1.910	.0498
40	.964	2.195	.0510
20	1.234	2.842	.0521
10	1.689	3.943	.0534
4	2.244	5.631	.0603
2	2.650	6.849	.0633
1	1.801	5.445	.0809
0.8	1.334	4.477	.0942

SUMMARY OF THE RESULTS IN ANILINE SOLUTIONS.

As might be expected from the nature of the solvent, all of the salts used give poor conducting solutions. In respect to the molecular conductivity these salts may be divided into three classes. In the first class, which includes by far the larger number, are silver nitrate, aniline hydrobromide, aniline hydrochloride, methylaniline-hydrochloride, ammonium sulphocyanide and lithium iodide. With these the molecular conductivity decreases with dilution in the concentrated regions, passes through a minimum and finally increases normally with further dilution. Mercuric iodide, whose molecules usually exhibit a great tendency to polymerize, gives values for the molecular conductivity which apparently increase normally with the dilution. For tetraethylammonium iodide, on the other hand, the molecular conductivity first increases with the dilution to a maximum, then decreases rapidly, passes through a minimum and finally again increases normally with the dilution. The behavior of tetraethylammonium iodide is similar to that found by Franklin and Gibbs[25] for solutions of silver nitrate in methylamine. Of the salts studied tetraethylammonium iodide gives the best and mercuric iodide the poorest conducting solution.

The effect of temperature varies with the nature of the dissolved salt. The temperature coefficients of the molecular conductivity of solutions of silver nitrate, aniline hydrochloride, and aniline hydrobromide decrease with dilution in the concentrated regions and pass through a minimum in those solutions which give the minimum value for the molecular conductivity. Methylaniline hydrochloride, on the contrary, gives a maximum temperature coefficient in that concentration which gives the minimum molecular conductivity. Although but three concentrations of mercuric iodide were studied, the temperature coefficients show a distinct increase with increasing dilution, while for tetraethylammonium iodide the temperature coefficients decrease throughout with increasing dilution, the decrease being most rapid in the regions of greatest concentration.

SOLUTIONS IN QUINOLINE.[26]

Schuchardt's chemically pure, synthetic quinoline was allowed to stand over fused potassium hydroxide for several weeks and then twice redistilled. Only that portion passing over at 227-229° C. was used in the work. In order to make the effect of the temperature greater, the molecular conductivities were determined at 50°, instead of at 35°, as in the case of aniline. The specific conductivities of the quinoline at 0°, 25° and 50° were found to be 1.6×10^{-8}, 2.2×10^{-8} and 7.4×10^{-8}, respectively.

Rough determinations of the solubility of many salts in quinoline showed that only a very few are sufficiently soluble to make work with them worth while. Of these the three chosen are aniline hydrobromide, silver nitrate and cobalt chloride.

[25] loc. cit.

[26] The work with solutions in quinoline was performed by Mr. E. H. Conroy.

ANILINE HYDROBROMIDE.

TABLE XIII.—MOLECULAR CONDUCTIVITY.

V.	λ_0	λ_{25}	λ_{50}
1,000	.596	.918	1.319
500	.480	.760	.988
200	.340	.528	.666
100	.267	.416	.527
20	.207	.324	.412
5	.264	.464	.642

TABLE XIV.—TEMPERATURE COEFFICIENTS.

V.	$\frac{\lambda_{25}-\lambda_0}{\lambda_0 . 25}$	$\frac{\lambda_{50}-\lambda_0}{\lambda_0 . 50}$	$\frac{\lambda_{50}-\lambda_{25}}{\lambda_{25} . 25}$
1,000	.0216	.0243	.0175
500	.0236	.0212	.0151
200	.0221	.0192	.0105
100	.0233	.0195	.0107
20	.0266	.0198	.0109
5	.0303	.0286	.0153

SILVER NITRATE.

TABLE XV.—MOLECULAR CONDUCTIVITY.

V.	λ_0	λ_{25}	λ_{50}
1,000	2.327	----	----
500	2.158	3.254	4.101
200	1.951	3.115	4.005
100	1.669	2.574	3.178
20	1.443	2.273	2.842
10	1.397	2.246	2.896
5	1.270	2.275	3.197

TABLE XVI.—TEMPERATURE COEFFICIENTS.

V.	$\frac{\lambda_{25}-\lambda_0}{\lambda_0 . 25}$	$\frac{\lambda_{50}-\lambda_0}{\lambda_0 . 50}$	$\frac{\lambda_{50}-\lambda_{25}}{\lambda_{25} . 25}$
500	.0204	.0180	.0104
200	.0239	.0210	.0114
100	.0217	.0181	.0094
20	.0231	.0194	.0100
10	.0244	.0215	.0116
5	.0317	.0303	.0162

COBALT CHLORIDE.

TABLE XVII.—MOLECULAR CONDUCTIVITY.

V.	λ_0	λ_{25}	λ_{50}
266.6	.1042	.1933	.3110
500	.253	.464	.599
1,000	.293	.499	.653

TABLE XVIII.—TEMPERATURE COEFFICIENTS.

V.	$\frac{\lambda_{25}-\lambda_0}{\lambda_0 . 25}$	$\frac{\lambda_{50}-\lambda_0}{\lambda_0 . 50}$	$\frac{\lambda_{50}-\lambda_{25}}{\lambda_{25} . 25}$
266.6	.0342	.0398	.0245
500	.0334	.0274	.0116
1,000	.0281	.0246	.0123

In view of the fact that quinoline has a higher dielectric constant than aniline, we should expect that solutions in it should give higher molecular conductivities. This is found to be true for silver nitrate and aniline hydrobromide. The minimum of molecular conductivity is displaced toward the region of higher concentration and the molecular conductivity increases rapidly with the dilution. The temperature coefficients pass through a minimum, but at dilutions which are greater than those which give the minimum molecular conductivity. Owing to the rather slight solubility of the cobalt chloride, only three concentrations of this salt were studied. In these the molecular conductivity increases with dilution, while the temperature coefficients decrease under the same conditions.

SOLUTIONS IN PYRIDINE.[27]

Merck's best grade of pyridine was allowed to stand over fused potassium hydroxide for several months, then decanted and twice redistilled. Only the middle portion passing over at 115°-116.1° and 745 mm. was retained for the work. Its specific conductances at 0°, 25° and 50° were found to be $.57 \times 10^{-7}$, $.74 \times 10^{-7}$ and 1.2×10^{-7}, respectively. Lincoln[28] found the specific conductance of the pyridine which he used to have the much higher value of 7.6×10^{-7}.

Those salts which do not show hygroscopic properties were weighed directly, transferred to a certified volumetric flask and made up to

[27]The data for the pyridine solutions are taken from a thesis begun by Mr. E. X. Anderson. Since the completion of the thesis appeared doubtful, it was thought advisable to include the data in the present paper.

volume, but for those salts which do absorb moisture the method of weighing by difference was used. The pyridine was added directly to the flask from a specially devised filling apparatus, whose open ends were always protected by phosphorus pentoxide tubes. The dilute solutions were made by diluting the mother solution, the utmost care being taken to prevent contact with the moisture of the air.

SILVER NITRATE.

TABLE XIX.—MOLECULAR CONDUCTIVITY.

V.	λ_0	λ_{25}	λ_{50}
1	1.05	1.53	2.01
2	14.77	19.38	23.28
10	20.68	25.38	27.25
20	22.38	27.05	29.17
100	27.80	34.49	37.92
500	37.31	47.63	55.10

TABLE XX.—TEMPERATURE COEFFICIENTS.

V.	$\frac{\lambda_{25}-\lambda_0}{\lambda_0 . 25}$	$\frac{\lambda_{50}-\lambda_0}{\lambda_0 . 50}$	$\frac{\lambda_{50}-\lambda_{25}}{\lambda_{25} . 25}$
1	.0149	.0133	.0121
2	.0125	.0114	.0081
10	.0091	.0064	.0029
20	.0084	.0061	.0031
100	.0096	.0073	.0040
500	.0111	.0095	.0063

The values for λ_{25} here given agree very closely with those given by Lincoln[28] for the same salt at 25°. The molecular conductivity increases at first very rapidly with slight changes in dilution in the concentrated regions and then more slowly at higher dilutions. The temperature coefficients show a very rapid decrease in the concentrated solutions.

It will be seen that the molecular conductivities at first increase very rapidly with slight increase in dilution, and then less rapidly, with further dilution for all three temperatures. The temperature coefficients show distinct minima, the effect of temperature upon the conductivity being greatest in the concentrated solutions.

Although solutions of silver nitrate in pyridine possess a relatively high molecular conductivity, Walden and Centnerszwer[29] have found that the molecular weights of silver nitrate in dilute solutions of pyridine are normal, while in the concentrated solutions the molecular weights are greater than normal, thus indicating association. By the

[28] J. Physical Chem., *3*, 457, 1899.
[29] Z. physik. Chem., *55*, 321, 1906.

same method Schmujlow[30] found that this salt is apparently non-ionized, but, since transference experiments made by Neustadt and Abegg[31] showed that both the $\overset{+}{Ag}$ ion and the NO_3 radicle migrated toward the cathode, it was assumed that, if ionization does take place, it does so according to the equation,

$$2AgNO_3 = \overset{+}{Ag_2NO_3} + \overset{-}{NO_3}$$

It is obvious that if the amount of polymerization just compensates for the effect due to ionization, the total number of dissolved particles will be the same as they would be if neither polymerization nor ionization had occurred. The molecular weights obtained by the boiling point-method should be normal. As the concentration is increased, on the other hand, polymerization rapidly increases, while the degree of dissociation decreases, a result which is interpreted by some to indicate the presence of polymerization and the absence of ionization. That the simple $\overset{+}{Ag}$ ions are also present even in the concentrated solutions is not to be doubted.

LITHIUM CHLORIDE.

The pure salt was heated at 160° for several days, it was frequently pulverized in a hot agate mortar and the heating continued until the tendency to cake had ceased. It was then transferred to a weighing bottle and heated to constant weight.

TABLE XXI.—MOLECULAR CONDUCTIVITY.

V.	λ_0	λ_{25}	λ_{50}
0.58	.143	.199	.239
1.6	.218	.264	.282
2	.254	.290	.299
10	.279	.322	.346
100	.519	.573	.613
1,000	1.47	1.600	1.680

TABLE XXII.—TEMPERATURE COEFFICIENTS.

V.	$\frac{\lambda_{25}-\lambda_0}{\lambda_0 \cdot 25}$	$\frac{\lambda_{50}-\lambda_0}{\lambda_0 \cdot 50}$	$\frac{\lambda_{50}-\lambda_{25}}{\lambda_{25} \cdot 25}$
0.586	.0160	.0135	.0079
1	.0083	.0058	.0028
2	.0056	.0035	.0012
10	.0061	.0047	.0030
100	.0041	.0036	.0028
1,000	.0037	.0029	.0020

[30] Z. f. anorgan. Chem., *15*, 1897.
[31] Z. Physik. Chem., *69*, 436, 1910.

Lithium chloride is at best a very poor conductor and is but slightly dissociated at all dilutions and temperatures. In other solvents it shows a high tendency to polymerize and doubtless does so in pyridine solutions. The molecular conductivities do increase gradually with increasing dilution throughout the whole range of concentration. The values found by Laszczynski and Gorski[32] for the same solution are about four times larger, due, perhaps, to the presence of traces of moisture. The temperature coefficients decrease with dilution throughout, the greatest changes being in the most concentrated solutions.

LITHIUM BROMIDE.

The anhydrous salt was prepared in a manner similar to that used for lithium chloride.

TABLE XXIII.—MOLECULAR CONDUCTIVITY.

V.	λ_0	λ_{25}	λ_{50}
0.977	----*	1.29	1.65
2	.98	1.72	1.98
10	2.29	2.44	2.40
100	5.43	5.34	4.89
1,000	13.68	14.15	13.58
10,000	24.80	28.70	29.9

TABLE XXIV.—TEMPERATURE COEFFICIENTS.

V.	$\frac{\lambda_{25}-\lambda_0}{\lambda_0 . 25}$	$\frac{\lambda_{50}-\lambda_0}{\lambda_0 . 50}$	$\frac{\lambda_{50}-\lambda_{25}}{\lambda_{25} . 25}$
0.97	----	----	.0109
2	.0298	.0202	.0061
10	.0026	.0009	-.0006
100	-.0007	-.0020	-.0034
1,000	.0013	-.0001	-.0016
10,000	.0063	.0041	.0017

*Solidified.

For all temperatures the molecular conductivity increases steadily throughout with increasing dilution, but not at all dilutions with a rise in temperature, there being at certain dilutions a decrease in conductivity with increase in temperature. The temperature coefficients are in all except the most concentrated solutions very small. They pass through minima of negative value.

[32] Z. Elektrochem., *4*, 290, 1897.

LITHIUM IODIDE.

This salt, after several months' standing over phosphorus pentoxide, was heated for nearly one week at 150°.

TABLE XXV.—MOLECULAR CONDUCTIVITY.

V.	λ_0	λ_{25}	λ_{50}
1	4.40	7.04	9.82
2	7.79	10.98	13.82
10	12.76	16.40	18.62
100	18.34	23.35	25.98
1,000	27.10	35.99	42.65
10,000	31.20	44.4	50.50
inf.	(31.2)*	(44.9)	(50.5)

*Extrapolation.

TABLE XXVI.—TEMPERATURE COEFFICIENTS.

V.	$\frac{\lambda_{25}-\lambda_0}{\lambda_0 . 25}$	$\frac{\lambda_{50}-\lambda_0}{\lambda_0 . 50}$	$\frac{\lambda_{50}-\lambda_{25}}{\lambda_{25} . 25}$
1	.0224	.0246	.0158
2	.0164	.0155	.0103
10	.0114	.0092	.0054
100	.0109	.0083	.0045
1,000	.0131	.0115	.0074
10,000	.0169	.0124	.0055

From Table XXV it will be observed that lithium iodide is a good conductor. The molecular conductivity increases very rapidly for slight dilution in the concentrated regions and then more slowly, but steadily up to a maximum at ten thousand liters. The temperature coefficients pass through a minimum at a dilution of one hundred liters.

SODIUM IODIDE.

TABLE XXVII.—MOLECULAR CONDUCTIVITY.

V.	λ_0	λ_{25}	λ_{50}
1.33	.11*	.70	.84
5	10.00	11.14	11.20
10	14.56	16.15	15.80
100	21.66	23.81	22.87
1,000	32.99	39.53	41.28
10,000	42.20	56.70	63.20

TABLE XXVIII.—TEMPERATURE COEFFICIENTS.

V.	$\frac{\lambda_{25}-\lambda_0}{\lambda_0 . 25}$	$\frac{\lambda_{50}-\lambda_0}{\lambda_0 . 50}$	$\frac{\lambda_{50}-\lambda_{25}}{\lambda_{25} . 25}$
1.33	.2084*	.1279*	.0076
5	.0046	.0024	.0002
10	.0044	.0017	–.0009
100	.0040	.0011	–.0016
1,000	.0079	.0050	.0018
10,000	.0137	.0099	.0046

*Solid phase present.

Sodium iodide solutions in pyridine are good conductors at all dilutions, except those near the point of saturation, where the molecular conductivities are very small at all temperatures. By extrapolation λ *inf.* was found to be 43.3 at 0°. Laszczynski and Gorski[33] obtained 44.32 for the value of $\varkappa$ *inf.* at 18°. For 25° and 50° no limiting values of the molecular conductivity could be found; at these temperatures the conductivity continues to increase with dilution more rapidly than at 0°. The temperature coefficients exhibit well defined minima with negative values appearing for temperatures between 25° and 50°.

POTASSIUM THIOCYANATE.

The sample was recrystallized from absolute alcohol, washed with the alcohol and dried at 95°. This salt differs from the others that have been studied in that its solubility in pyridine decreases as the temperature rises.

TABLE XXIX.—MOLECULAR CONDUCTIVITY.

V.	λ_0	λ_{25}	λ_{50}
7	5.97	7.12	7.75
14	7.20	8.45	9.00
70	11.40	13.36	14.54
140	14.17	16.77	18.14
1,400	27.32	33.70	38.31
14,000	42.86	58.51	71.30
inf.	46.5*	----	----

TABLE XXX. TEMPERATURE COEFFICIENTS.

V.	$\frac{\lambda_{25}-\lambda_0}{\lambda_0 . 25}$	$\frac{\lambda_{50}-\lambda_0}{\lambda_0 . 50}$	$\frac{\lambda_{50}-\lambda_{25}}{\lambda_{25} . 25}$
7	.0077	.0060	.0035
14	.0069	.0050	.0026
70	.0070	.0055	.0035
140	.0073	.0056	.0033
1,400	.0093	.0081	.0055
14,000	.0146	.0133	.0087

*By extrapolation.

Apparently the conditions which tend to produce a decrease in solubility with rise in temperature are those which have to do with rapid increase in conductivity at higher temperatures. The temperature coefficients here also pass through a minimum.

[33] loc. cit.

AMMONIUM THIOCYANATE.

The anhydrous salt was prepared in the same manner as was the potassium salt.

TABLE XXXI.—MOLECULAR CONDUCTIVITY.

V.	λ_0	λ_{25}	λ_{50}
.33	2.10	4.46	7.43
1	8.21	11.70	15.12
2	10.45	13.76	16.53
10	11.96	14.56	16.29
100	17.00	20.33	22.18
1,000	33.57	41.80	47.76

TABLE XXXII.—TEMPERATURE COEFFICIENTS.

V.	$\frac{\lambda_{25}-\lambda_0}{\lambda_0 . 25}$	$\frac{\lambda_{50}-\lambda_0}{\lambda_0 . 50}$	$\frac{\lambda_{50}-\lambda_{25}}{\lambda_{25} . 25}$
.33	.0451	.0508	.0266
1	.0170	.0169	.0117
2	.0127	.0116	.0081
10	.0087	.0072	.0048
100	.0078	.0061	.0036
1,000	.0098	.0085	.0057

The molecular conductivity curves for ammonium thiocyanate are peculiar in that they rise rapidly with slight increase in dilution, then rise slowly for a considerable change in dilution, and finally increase rapidly as the dilution is further increased. The values for λ_v are considerably larger than those found by Laszczynski and Gorski. Working up to dilution of 2080 liters, these men calculated the value of λ *inf.* at 18° to be 40.22. In the curves for the above tables it is clearly seen that the 0° curve gives promise of a limiting value for λ_v, but the 25°- and 50°-curves give no signs of such a behavior.

The initial rapid increase in the molecular conductivities and decrease in the temperature coefficients are undoubtedly due to a rapid decrease in the viscosity of the concentrated solutions with slight increase in dilution. The concentrated solutions here used are very viscous.

MERCURIC CHLORIDE.

TABLE XXXIII.—MOLECULAR CONDUCTIVITY.

V.	λ_0	λ_{25}	λ_{50}
.5	.009*	.036	.045
1	.019	.025	.030
2	.016	.021	.025
10	.016	.021	.027
100	.037	.061	.067
1,000	.130	.260	.400

TABLE XXXIV.—TEMPERATURE COEFFICIENTS.

V.	$\frac{\lambda_{25}-\lambda_0}{\lambda_0 . 25}$	$\frac{\lambda_{50}-\lambda_0}{\lambda_0 . 50}$	$\frac{\lambda_{50}-\lambda_{25}}{\lambda_{25} . 25}$
.5	.1176*	.0793	.0104
1	.0136	.0119	.0076
2	.0126	.0105	.0065
10	.0126	.0141	.0119?
100	.0260	.0162	.0038
1,000	.0400	.0415	.0215

MERCURIC BROMIDE.

TABLE XXXV.—MOLECULAR CONDUCTIVITY.

V.	λ_0	λ_{25}	λ_{50}
.5	.012*	.034	.043
1	.020	.026	.032
2	.018	.023	.026
10	.017	.023	.028
100	.031	.047	.053
1,000	.130	.280	.290

MERCURIC IODIDE.

TABLE XXXVI.—MOLECULAR CONDUCTIVITY.

V.	λ_0	λ_{25}	λ_{50}
.66	*	.013	.018
1	.009	.013	.018
2	.008	.012	.015
10	.013	.019	.024
100	.069	.102	.117
1,000	.266	.364	.448

*Solid phase present.

The conductivities of the mercuric halide salts are extremely poor. With increase in dilution the molecular conductivity varies but little and only begins to show an appreciable increase at a dilution of one hundred liters. All three of the salts show faint but distinct minima in the molecular conductivity. Since the molecular conductivities are so small, any slight errors in them will be highly magnified in the temperature coefficients. The values of the latter are all of the same order of magnitude as those given for mercuric chloride and all three salts give minima for temperature coefficients.

The value for λ_v for mercuric iodide are much smaller than those obtained by Lincoln[34] at 25°.

COPPER CHLORIDE.

Kahlbaum's C. P. cupric chloride was heated for several hours in a current of pure dry hydrogen chloride at 160°, then heated in a current of dry hydrogen, and cooled in a current of the latter; lastly, it was quickly transferred to a weighing bottle and further heated in an air-bath at 160°.

TABLE XXXVII.—MOLECULAR CONDUCTIVITY.

V.	λ_0	λ_{25}	λ_{50}
25	.053	.062	.074
50	.066	.076	.086
100	.088	.098	.111
200	.130	.146	.171
500	.203	.216	.216?
1,000	.302	.365	.410

TABLE XXXVIII.—TEMPERATURE COEFFICIENTS.

V.	$\frac{\lambda_{25}-\lambda_0}{\lambda_0 . 25}$	$\frac{\lambda_{50}-\lambda_0}{\lambda_0 . 50}$	$\frac{\lambda_{50}-\lambda_{25}}{\lambda_{25} . 25}$
25	.0073	.0082	.0076
50	.0059	.0059	.0052
100	.0045	.0053	.0055
200	.0050	.0063	.0068
500	.0027	.0014	.0000
1,000	.0084	.0072	.0049

The molecular conductivities for all temperatures increase steadily with increase in dilution. While more or less irregular, the temperature coefficients exhibit a minimum value in the dilute regions.

[34] loc. cit.

Kohlschuetter[35] states that cupric chloride dissolved in pyridine gives a blue solution, and since its molecular weight, as determined by the boiling point method, is normal, its color may be attributed to that of the undissociated cupric chloride. Naumann[36] has also observed this blue color in his work and assumes it to be due to the presence of the complex, $CuCl_2.2Pyr$. All of the cupric chloride solutions used in this work gave a beautiful, deep green color without the least indication of a bluish tint and, furthermore, the solutions remained green for several months. On the other hand, in making one of the trial solubility tests an attempt was made to weigh the salt directly. The salt absorbed moisture so rapidly that this was impossible. Although it was noticed that the edges of the salt mass had taken on a greenish blue color, it was quickly transferred and dissolved in pyridine and, as might be expected, the solution was perfectly blue. When, however, the salt was quickly weighed by difference, a deep green solution was always obtained. It is evident, therefore, that the blue solutions reported by Kohlschuetter and Naumann owe their blue color to traces of water.

COPPER NITRATE.

A .1N solution of silver nitrate was treated with an excess of finely divided, reduced metallic copper and allowed to stand until the solution gave no test for silver.

TABLE XXXIX.—MOLECULAR CONDUCTIVITY.

V.	λ_0	λ_{25}	λ_{50}
10	9.68	12.94	14.96
20	5.00	7.21	8.88
40	8.57	11.60	14.16
100	12.08	16.43	20.43
1,000	16.41	23.88	29.71
10,000	19.42	27.24	35.71

TABLE XL.—TEMPERATURE COEFFICIENTS.

V.	$\frac{\lambda_{25}-\lambda_0}{\lambda_0 . 25}$	$\frac{\lambda_{50}-\lambda_0}{\lambda_0 . 50}$	$\frac{\lambda_{50}-\lambda_{25}}{\lambda_{25} . 25}$
10	.0135	.0109	.0062
20	.0176	.0155	.0093
40	.0142	.0131	.0088
100	.0144	.0138	.0097
1,000	.0158	.0162	.0119
10,000	.0161	.0168	0124

Copper nitrate gives far better conducting solutions than does the chloride.

[35]Ber., 37, 1153, 1904.
[36]Ber., 37, 4609, 1904.

COBALT CHLORIDE.

The pure salt was first partially dehydrated by long standing over phosphorus pentoxide and then successfully treated according to the method employed for copper chloride. The final product was of a pale blue color. Reitzenstein[37] prepared the compound $CoCl_2.4Pyr$. Pearce and Moore[38] found that within their respective temperature limits we may have the three compounds, $CoCl_2.6Pyr$, $CoCl_2.4Pyr$, and $CoCl_2.2Pyr$.

Cobalt chloride dissolved in pyridine gives a red solution at 0°, a violet at 25°, and a deep purple at 50°. These color changes at different temperature are doubtless closely associated with changes in the amount of pyridine combined with the salt, since the colors of the solid phases in contact with the saturated solutions at these temperatures are aproximately the same as those of the solutions.

TABLE XLI.—MOLECULAR CONDUCTIVITY.

V.	λ_0	λ_{25}	λ_{50}
10	.009*	.012	.021
20	.015	.015	.022
40	.021	.020	.024
100	.042	.045	.041
1,000	.220	.230	.310
10,000	.600	1.00	------

TABLE XLII.—TEMPERATURE COEFFICIENTS.

V.	$\frac{\lambda_{25}-\lambda_0}{\lambda_0 . 25}$	$\frac{\lambda_{50}-\lambda_0}{\lambda_0 . 50}$	$\frac{\lambda_{50}-\lambda_{25}}{\lambda_{25} . 25}$
10	.0148*	.0393	.0319*
20	.0019	.0101	.0174
40	-.0021	.0028	.0082
100	.0028	-.0005	-.0036
1,000	.0018	.0082	.0139

*Solid phase present.

Cobalt chloride in pyridine solutions gives at best exceedingly poor conducting solutions. By some its solutions are considered as non-conductors. Consequently, slight errors are highly magnified. The results obtained show a continuous increase in molecular conductivity with dilution for all temperatures. Lincoln's values for λ_v at corresponding

[37]Ann. Phys. Chem., *43*, 839.
[38]Amer. Chem. Jour., *50*, 231, 1913.

dilutions are very much higher than the values here given. The temperature coefficients, although subject to error, show definite minima at which negative coefficients are observed. As is evident from table XLII, the effect of temperature is greater between 25° and 50° than at the lower temperatures. This is, no doubt, due to the greater instability of the solvated ions at higher temperatures.

CADMIUM NITRATE.

The solution of the pure salt was prepared by displacing the silver of a .1N solution of silver nitrate by means of pure metallic cadmium.

TABLE XLIII.—MOLECULAR CONDUCTIVITY

V.	λ_0	λ_{25}	λ_{50}
10	.141	.160	.122
20	.322	.348	.288
40	.402	.433	.340
100	.694	.733	.630
1,000	2.370	2.310	2.440
10,000	7.400	8.600	9.800

TABLE XLIV.—TEMPERATURE COEEFFICIENTS.

V.	$\frac{\lambda_{25}-\lambda_0}{\lambda_{25}.\ 25}$	$\frac{\lambda_{50}-\lambda_0}{\lambda_0.\ 50}$	$\frac{\lambda_{50}-\lambda_{25}}{\lambda_{25}.\ 25}$
10	.0052	-.0028	-.0095
20	.0033	-.0021	-.0070
40	.0031	-.0031	-.0086
100	.0023	-.0018	-.0056
1,000	-.0010	.0006	.0023
10,000	.0065	.0065	.0056

Solutions of cadmium nitrate would be classed as poor conductors; the values of λ_v increase with dilution throughout. For the concentrated solutions increase of temperature above 25° produces a rapid decrease in conductivity and, as the temperature coefficients show, this decrease is greater between 25° and 50° than between 0° and 25°. An explanation for this phenomenon will be given in the discussion.

SUMMARY OF THE RESULTS IN PYRIDINE SOLUTIONS.

The molecular conductivities of fourteen salts and their temperature coefficients have been determined in pyridine solutions. These salts may be divided into two classes, the strong and the weak. Among the former are silver nitrate, lithium iodide, sodium iodide, potassium and ammonium thiocyanates and copper nitrate. The values for λ_v of these salts are very small in the most concentrated solutions, but they increase rapidly with slight initial dilutions and then more slowly with further increase in dilution. All of them give minima in the temperature coefficients, except copper nitrate whose temperature coefficients seem to increase steadily with dilution.

The weak salts are lithium chloride, lithium bromide, the three mercuric halides, copper chloride, cobalt chloride and cadmium nitrate. Only the mercuric salts give minimum values for λ_v; the molecular conductivity of the others increases slowly with increasing dilution. All but one of the salts of this group give minimum values for the temperature coefficients; those of lithium chloride decrease with dilution. Negative temperature coefficients have been found for solutions of sodium iodide, lithium bromide, cobalt chloride and cadmium nitrate.

DISCUSSION.

The molecular conductivity of a solution of an electrolyte is dependent first upon the nature of the solvent and primarily upon its dielectric constant, or specific inductive capacity. According to the Nernst-Thomson rule, the dissociating power of a solvent will be greater, the greater is its dielectric constant.

Walden[39] has found that the dielectric constants of solvents of feeble ionizing power are increased by dissolving in them certain binary salts. The amount of this increase depends upon the constitution of the salt used. According to him salts may be divided into two classes, the strong and the weak. Strong salts exhibit a great tendency to ionize and possess large dielectric constants, while in a weak salt both of these are small. The degree of ionization of a salt depends both on the ionizing power of the solvent and the tendency of the salt to ionize. As both of these factors increase with the dielectric constant, the highest degree of ionization will be found in a system where both the solvent and the solute possess large dielectric constants.

The molecular conductivity also depends upon the degree of dissociation of the electrolyte, the nature of the ions, their speeds and the viscosity of the solutions. The degree of dissociation depends upon the magnitude of the electroaffinities of the ions formed. It will also be more or less affected by the degree of solvation of the molecules and ions present, since, doubtless, the energy of the simple and polymerized

[39]Bull. Accad. Sci. St. Petersburg, 1912, 305-332.

molecules, as well as the electroaffinities of the ions must be somewhat modified by combination with the solvent. If degradation of energy accompanies an increase in electroaffinity, then, as Sachanov[40] states, the electroaffinity of the ions must increase with solvation and, for a given electrolyte, will be greater, the more dilute is the solution.

The speeds of the ions, if they have the power of combining with the solvent, must also be greatly affected by solvation; the greater the amount of solvation, the greater will be their mass, or volume, and, therefore, the smaller will be their migration velocities. Since, according to the Law of Mass Action, the degree of solvation of the ions must increase with increasing dilution, the effect of solvation upon the ionic velocities will be greatest in the most dilute solutions.

The stability of the solvated ions (also molecules) decreases with rise in temperature. If we consider solutions which are dilute with respect to a given ion, we should expect to find the effect of temperature to increase with dilution. That this is true may be seen from a study of the temperature coefficients given in this paper.

According to Noyes and Coolidge[41], the molecular conductivity of aqueous solutions for a given concentration, increases steadily with rise in temperature up to 306°, the increase being due chiefly to a steady decrease in viscosity. The rate of decrease in dissociation of the salt is small between 18° and 100°, but becomes much larger for higher temperatures. This decrease is evidently due to a change in the nature of the solvent, i. e., a decrease in its degree of association and, hence, in its dissociating power.

If the formation of ions depends to any extent upon the power of these ions to combine with the solvent, an increase in temperature should be accompanied by a decrease in ionization and likewise in molecular conductivity. It has been noted that lithium bromide, sodium iodide, cobalt chloride and cadmium nitrate in pyridine give negative temperature coefficients. For lithium bromide the value of λ for a .01 N solution decreases slowly from 0° to 25° and then more rapidly up to 50°, while the same values for the other three salts increase up to 25° and then decrease with rise in temperature. All of these show a tendency not only to form polymeric molecules in pyridine, but also the power to form pyridine-solute complexes. The effect of temperature on these solvates is clearly indicated by the color changes in the cobalt chloride solutions. These salts also have the power to form complex ions which, doubtless, also have a great tendency to form solvates. It will be ob-

[40] loc. cit.
[41] Z. physik. Chem., *46*, 323, 1903.

served also that these negative temperature coefficients are those of minimum value. They are likewise found in those concentrations in which the concentration of the complex ions is least and hence most highly solvated. The effect of temperature upon the unstable solvent-ion complexes will therefore be greatest at this point. If, again, the formation of these ions depends upon their power to combine with the solvent, then the degree of ionization should decrease with rise in temperature. This assumption agrees perfectly with the results obtained.

It was for a time believed that the molecular conductivity of an electrolyte in solution must increase with dilution. Then appeared the above cited work in organic solvents which, in the minds of some chemists, completely overthrew the whole electrolytic dissociation theory. In practically all of these cases the molecular conductivity was found to decrease with increasing dilution. Unfortunately, these investigators seem to have stopped too soon. Had they but continued their work at greater dilutions, they would probably have found that in very dilute solutions in these solvents the molecular conductivity behaves normally as in aqueous solutions.

This has been found to be true for solutions in aniline, quinoline and pyridine, without exception. There are also solutes which in these three solvents show increase in conductivity throughout the whole range of dilution.

The three solvents chosen are but slightly, if at all, associated and they have small dielectric constants, viz., aniline=7.31[42], quinoline=8.8[43], pyridine=12.4[43]. The ionizing power of the solvents and the conductivity of their solutions increase from aniline to pyridine. Salts dissolved in them give, for the most part, low molecular conductivities and exhibit a great tendency not only to polymerize, but also to combine with the solvent. It is probable that there are present at all dilutions to a greater or less extent both the simple and polymeric molecules and their ions, as well as the solvated forms of each.

We may represent the condition of equilibrium existing in a solution by the following scheme:

$$\overset{+}{Li}.S_1+\overset{-}{Br}.S_2=LiBr.S_3=(LiBr)_2.S_4=\overset{+}{Li}.S_1+\overset{-}{LiBr_2}.S_5,$$

where S_1, S_2, S_3, etc., represent the number of molecules of combined solvent. The two molecular forms are in equilibrium with each other and also with their respective ions.

Unfortunately, we have no means of arriving at any conclusions as to the complexity of the solute in these solvents, except by the boiling-

[42]Turner: Z. Physik. Chem., 35, 385, 1900.
[43]Schlundt: J. Physical Chem., 5, 157, 1901.

point method and this is not applicable in the very dilute solutions. The assertion that simple molecules predominate in the dilute solutions is supported by experiments upon the molecular weights of alcohol, acetic acid and phenol in benzene. The molecular weights are smallest in the dilute regions and increase rapidly with increase in concentration, e. g.,

	Concentration percent.	Mol. Weight found.	Mol. weight Theory.
Alcohol	.161	46	46
	32.50	318	
Phenol	.34	144	94
	26.8	252	
Acetic acid	.465	110	60
	22.8	153	

Most of the salts used in this work show by the boiling-point method either normal molecular weights or slight association. That these solutions contain ions is obvious from the fact that they conduct electricity. It is obvious also that the phenomena of ionization, polymerization and solvation may all exist at the same time and still give normal molecular weights, since the effect due to polymerization of the solute molecules under the conditions need only be just sufficient to counteract the effects due to ionization and solvation.

Returning to our equilibrium equation, it is evident that, if we begin with the most dilute solutions and increase the concentration, there will be a repression of the simple ionization with the formation of simple molecules. The molecular conductivity in the dilute solutions should, and does, decrease with increase in concentration.

With the increase in concentration of the simple molecules there is an accompanying increase in the number of the more easily ionizing polymerized molecules.

Normally, the molecular conductivity of any salt, whether simple or complex, should decrease with increase in concentration, whereas in many solvents the reverse is true. One way of explaining this phenomenon seems to have been overlooked, one which at least seems logical and in harmony with the facts.

Let us take a solution of a salt at a dilution which is far beyond that dilution which just gives complete dissociation or maximum molecular conductivity. If now we begin to remove the solvent (say, by evaporation) the molecular conductivity calculated for the successively increasing concentrations will remain constant up to that concentration which first gives the maximum molecular conductivity. If, however, we should start with that initial great dilution and, while removing solvent, add the ions of the salt sufficiently rapidly, we should find for each successively greater concentration an increase in the molecular conductivity until that concentration is again reached which first gives the maximum value. After this the molecular conductivity must again decrease with increase in concentration.

Since the amount of polymerization of the solute molecules need only be very small in order to compensate for the effect due to ionization, as determined by the boiling-point method, we can not be far wrong in assuming that the polymerized molecules are highly dissociated and that their ionic product,

$$\overset{+}{Li}.S_1 \times \overset{-}{LiBr_2}.S_5 = K,$$

is relatively very large. Furthermore, according to Walden's views upon the dielectric constant, the dissociation should increase with increase in the concentration of the salt. We may consider, therefore, that those dilutions which give minimum values of molecular conductivity are far beyond the dilution at which the polymerized molecules are completely dissociated. Normally, the molecular conductivity of these should remain constant with removal of solvent until that concentration is reached which just gives the maximum value for the molecular conductivity of the polymerized solute. With the increase in concentration of the highly dissociated polymer there is an abnormally rapid increase in the number of ions with the result that, from the minimum on, the molecular conductivity increases with concentration. If it is possible to exceed the ionic product which the ions of the polymerized molecules would give at the concentration giving the maximum molecular conductivity, then from this point on the molecular conductivity should decrease with further increase in concentration.

Starting then with the most concentrated solutions, the molecular conductivity should first increase with dilution to a maximum, due to an increase in the dissociation of the solute and a decrease in the viscosity of the solution. From the maximum the molecular conductivity decreases abnormally, due to a rapid decrease in the number of ion-forming molecules which in its effect more than counterbalances the effect due to increase in dissociation. At the minimum the influences due to the two kinds of molecules and their respective dissociations just balance each other. From the minimum on the molecular conductivity continues to increase with further dilution due to the ionization of the simple salt.

A curve representing such a phenomenon would have a maximum in the concentrated regions, a minimum at higher dilutions and, if complete dissociation is possible, a second maximum at infinite dilution. The data for the molecular conductivity of tetraethylammonium iodide in aniline, when plotted, give exactly this form of curve. The same may be said for the data obtained by Franklin and Gibbs for solutions of silver nitrate in methylamine.[44] They, however, explain the phenomenon as due to the autoionization of the salt.

If, on the other hand, it is not possible to exceed the value for the ionic product at complete dissociation, the molecular conductivity should continue to increase with the concentration up to the concentration of the saturated solution. This should be true unless, perhaps, the viscosity of the solutions at these very high concentrations should be great enough to cause a decrease in conductivity. All of the most concentrated solutions in the solvents studied possess a relatively high degree of viscosity, yet for all, with the single exception of tetraethylammonium iodide, the molecular conductivity increases along with the viscosity as the concentration is increased.

Silver nitrate is the only salt that has been used in all three solvents; aniline hydrobromide has been used in aniline and quinoline. While these two can scarcely be considered as a basis for comparison, a study of their molecular conductivities brings out one or two interesting points. It will be observed that as the dielectric constant of the solvent increases the dilution at which the value of the molecular conductivity is a minimum is displaced toward solutions of higher concentration. The tendency for molecular conductivity to increase with concentration, likewise, becomes less. If this tendency is due to the presence of easily dissociating polymeric molecules, then we can say that the tendency of a solute to polymerize in different solvents becomes greater, the smaller the dielectric constant of the solvent. In the dilute solutions the molecular conductivity and, hence, the dissociation of the solute, for a given normality, increases with the dielectric constant of the solvent. In so far as these salts and solvents give us a clue, we are justified in saying that the Nernst-Thomson rule does hold for dilute solutions in solvents with low dielectric constants.

This work will be continued with solutions in other organic solvents.

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[44] loc. cit.

EQUILIBRIUM IN THE SYSTEM: MERCURIC IODIDE AND ANILIN.

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Those who have worked with anilin have no doubt observed its extraordinary high solvent power upon many of the inorganic salts.

Like ammonia it also has the power of combining with salts to form stable crystalline compounds containing from one to as high as six molecules of anilin of crystallization.

Among the large number of crystalline compounds which have been prepared are $CoCl_2.2C_6H_7N$, $NiCl_2.2C_6H_7N$,[1] $Cu_2Cl_2.2C_6H_7N$, $Cu_2Br_2.2C_6H_7N$, $Cu_2I_2.2C_6H_7N$[2]. Tombeck[3] produced the corresponding compounds of the chlorides, bromides, iodides, and nitrates of zinc and cadmium and magnesium nitrate. He also prepared similar compounds of zinc, cadmium, magnesium, nickel, cobalt, and copper sulphates, all of which combine with two molecules of anilin, except nickel sulphate, which crystallizes with six molecules, and cobalt sulphate, which crystallizes with four molecules of anilin. Grossman and Hunter[4] prepared the compounds of the thiocyanides of cadmium, cobalt, nickel, iron, manganese, and zinc, each combining with two molecules of the base. Upon further treatment of the addition compounds thus formed with thio-cyanic acid double thio-cyanides corresponding to the formula $Cd\ (Ph.NH_3)_2\ (SCN)_4$ were obtained. The dichromates of cobalt, nickel, copper, cadmium, zinc, and manganese, each with four molecules of anilin, were prepared by Parravaus and Pasta[5]. Franquoise[6] contributed the compound $HgI_2.2C_6H_7N$.

The usual method of preparing these compounds has been to treat alcoholic solutions of anilin with the salt, or vice versa. No reference to compounds made by direct combinations of anilin with the inorganic salts was found.

Only one system containing anilin and an inorganic salt has been studied quantitatively. This was worked out by Menchutkin[7] for the system magnesium bromide and anilin. These two substances react with the liberation of much heat and produce three compounds. The tempera-

[1]Lippmann and Vortmann, Ber., *12*, 79, 1889.
[2]Saglier, C. r., *106*, 1422-25.
[3]C. r., *124*, 961; *126*, 967.
[4]Z. anorgan. Chem., *46*, 361, 1903.
[5]Gazzetta, *37*, ii, 252-264, 1907.
[6]J. Pharm. Chem. VI, 21-24, 1906.
[7]Gazzetta, *37*, i, 252-264, 1907.

ture-solubility equilibrium curve consists of three branches, viz., $MgBr_2.6C_6H_7N$ in equilibrium with its saturated solution at all temperatures up to 103°C; that of $MgBr_2.4C_6H_7N$ between 103° and 237° C; and probably the compound $MgBr_2.2C_6H_7N$ or $MgBr_2.C_6H_7N$ at still higher temperature, but owing to decomposition the investigation could not be carried higher than 250° C. or 260° C.

OBJECT.

Owing to the relatively high solubility of mercuric iodide in anilin at ordinary temperatures, the dimorphic nature of the solid mercuric iodide and the power of the two to form crystalline compounds, it was thought worth while to make a careful study of this system over the maximum possible range of temperature. For this purpose the regular solubility method was used.

MATERIALS.

Kahlbaum's anilin "I" was dehydrated over fused potassium hydroxide for two weeks and carefully distilled, only that portion passing over at 180°-182° C. (uncor.) being collected for the work, while the first and last portions were rejected.

The mercuric iodide was precipitated from a saturated solution of chemically pure mercuric chloride by means of an equivalent weight of pure potassium iodide. The precipitate was allowed to settle and then washed by decantation, using large volumes of distilled water, until all traces of chlorine were removed. It was then transferred to a large Büchner funnel, washed with distilled water, sucked dry, and finally spread upon porous plates and thoroughly dried.

APPARATUS.

The solubility determinations were made in an apparatus similar to the one used by Pearce and Moore.[8]

For all temperatures between 0° C. and 42.9° C. an electrically heated and electrically controlled water thermostat was used; a cooling coil for running water was added for all temperatures below that of the room. In this way temperatures constant to within a few hundredths of a degree could be kept for any desired period of time. For temperatures above 42.9° C. the saturation tube was immersed in the vapor of a boiling liquid whose boiling point was approximately equal to the temperature desired. The tube containing the motor-driven spiral was inserted through a tightly fitting cork into a large boiling vessel containing the

[8] Amer. Chem. Jour., *50*, 220, 1913.

liquid and this was fitted with a long vertical condenser to prevent the loss of the boiling liquid by evaporation. The liquid was maintained at the boiling temperature by means of an electrically heated platinum spiral. In order to prevent variation in the temperature, due to radiation, which increases with rise in temperature, the whole apparatus, excepting the condenser, was inclosed in an asbestos case fitted with a glass door through which the temperature readings could be taken. In order to still further prevent loss of heat by radiation, the inside of the case was heated by means of incandescent electric lights. By this means even the highest temperatures could be held constant to within ±.05° C., any variation being due to changes in barometric pressure only. For temperatures below 0° C., the saturation tube and stirrer were transferred to a larger tube, which was surrounded by a freezing mixture of salt and ice. These temperatures could likewise be kept constant for four to six hours by the careful addition of salt and ice. All temperatures were read on a certified mercury thermometer passing through the cork and kept at the same level as the material in the saturation tube. All thermometers used were graduated in 0.1° C., permitting estimations accurate to ±.05° C.

Repeated tests showed saturation to be complete in about one and one-half hours. In most cases, however, a much longer time was allowed for saturation, except at the three highest temperatures, where, owing to decomposition, the time had to be limited somewhat.

After saturation was complete the stirrer was stopped, the solid phase was allowed to settle for a few minutes and a sample of the liquid phase was removed by a small tube covered at one end by a double thickness of muslin. In order to prevent solidification within the tube, the latter was heated to a temperature slightly higher than that of the saturated solution. All samples were run at once into dry glass-stoppered weighing bottles and kept in dry desiccators at room temperatures until analyzed.

The difficulties in the analysis of either phase of the system are readily appreciated by one familiar with the extremely volatile nature of the iodide and its inertness in the ordinary acids. The complications are still further increased by the difficulties of eliminating the easily oxidized anilin and its oxidation products.

Three possible methods for the determination of the mercury seemed available. An attempt was made to dissolve out the anilin with dilute hydrochloric acid and to weigh the mercuric iodide directly, but the iodide was found to be appreciably soluble in the anilin hydrochloride formed. Likewise, the electrolytic method was found to be unsatisfactory, owing to the formation of anilin black at the anode. This was deposited upon the surface of the mercury and exposed platinum and could not be removed. The method finally adopted was to dissolve the sample in a solution of acetic acid containing an excess of potassium iodide and to precipitate the mercury as the sulphide by passing in hydrogen sulphide to complete precipitation. This method proved very satisfactory and was used in all determinations.

Samples taken at the three highest temperatures seemed to be more difficultly soluble, and complete transformation to the sulphide was accomplished by placing the solid mass in the acetic acid-potassium iodide solution and passing in hydrogen sulphide for two or three hours until portions of the filtrate gave no test for mercury on further treatment with hydrogen sulphide. The precipitate was transferred to a weighed Gooch crucible, washed with water and dried. The free sulphur was removed by carbon bisulphide in an electrically heated extraction apparatus of the form recommended by Treadwell and Hall.[9]

The quantities of acetic acid or potassium iodide added did not seem to affect the speed of transformation of mercuric iodide to sulphide, but the physical nature of the precipitate seemed to be a little better, if the solution was heated slightly before being filtered.

However, the nature of the mercuric sulphide precipitated from the anilin solutions made it necessary to do all drying at temperatures below 70° C. to avoid loss due to the volatilization of mercuric sulphide. In order to test the effect of temperature upon the extent of volatilization of the sulphide, weighed Gooch crucibles containing the pure dry sulphides were heated for intervals of one to three hours at 70°, 80° and 110 ° C., the temperature recommended by Treadwell and Hall.[10]

TABLE I.

HgS	One hour at 110° C.	Two hours at 110° C.
1.4352 gr.	1.4201	1.2784
2.3076	2.2321	2.0375
HgS	Two hours at 80° C.	Three hours at 80° C.
.5412	.5378	.5300
.6879	.6765	.6685
HgS	One hour at 70° C.	Three hours at 70° C.
.1311	4311	.4311
.4432	.4432	.4432
.2054	.2054	.2054
.1802	.1801	.1801

[9] Analytical Chemistry, Vol. II, 3d Ed., 169.
[10] loc. cit.

By observing these precautions, results were obtained which leave little to be desired as to the accuracy of the method. Analyses made on known weights of mercuric iodide in anilin gave results for mercuric iodide averaging to within less than .01 per cent.

TABLE II.

ANALYSIS ON KNOWN WEIGHTS OF HgI_2.

Gr. taken	Gr. found
.4325	.4323
.2936	.2930
.5872	.5872

Results of analyses are found in table III and are graphically represented by the curve, Plate XIX.

TABLE III.

Temp. ° C.	Sample	HgS	HgI_2	Gr. HgI_2 per 100 Gr. of Anilin	Mean
–6.5	4.0110	.3910	.7636	23.52	23.61
–6.5	3.7128	.3667	.7162	23.10	
–6.5	3.8273	.3719	.7264	23.42	
.4	1.6667	.2054	.4012	28.72	28.69
.4	2.8167	.3214	.6277	28.68	
.4	1.5798	.1802	.3519	28.66	
17.8	2.8032	.4311	.8420	42.94	42.83
17.8	2.8818	.4432	.8670	42.80	
17.8	2.8667	.4396	.8586	42.81	
21.10	3.0095	.4937	.9867	47.43	47.55
21.10	2.7408	.4543	.8848	47.67	
26.9	3.7408	.6842	1.3365	55.58	55.47
26.9	2.7353	.4987	.9707	55.35	
30.1	3.5303	.6927	1.3530	62.14	62.05
30.1	3.3077	.6478	1.2650	61.96	
36.2	2.4979	.5512	1.0770	75.76	75.80
36.2	2.9044	.6456	1.2610	76.03	
36.2	3.1347	.6879	1.3435	75.72	
42.9	3.2802	.8204	1.6025	96.60	96.49
42.9	3.4225	.8604	1.6805	96.47	
42.9	3.5057	.8812	1.7210	96.40	
48.8	3.6347	1.0447	2.0480	128.4	128.1
48.8	3.6440	1.0509	2.0530	128.0	
48.8	3.8001	1.0901	2.1290	127.9	

TABLE III—Concluded.

Temp. ° C.	Sample	HgS	HgI_2	Gr. HgI_2 per 100 Gr. of Anilin	Mean
63.6	2.4242	.7680	1.5000	162.9	163.8
63.6	2.0912	.6652	1.2990	164.0	
63.6	2.1322	.6833	1.3350	163.6	
70.82	7.4980	2.4870	4.8580	184.0	184.1
70.82	7.4982	2.4890	4.8600	184.2	
76.2	4.3407	1.4910	2.9120	202.5	201.8
76.2	3.6806	1.2586	2.4590	201.2	
77.35	.7988	.2779	.5428	211.45	211.5
77.35	.7902	.2747	.5365	211.60	
95.9	1.5092	.5500	1.874	246.8	246.7
95.9	1.5092	.5497	1.072	246.5	
97.2	4.1847	1.4658	2.863	216.2	214.9
97.2	4.0332	1.4095	2.7525	214.3	
97.2	3.7170	1.2950	2.5292	213.0	
99.1	4.2948	1.4540	2.8400	220.7	221.0
99.1	3.7840	1.3339	2.6055	221.5	
99.1	4.6574	1.6415	1.4514	221.0	
105.9	1.1751	.4179	.8343	239.5	239.1
105.9	1.5432	.5566	1.0870	238.3	
105.9	2.4114	.8707	1.7010	239.4	
111.0	4.3550	1.6221	3.0960	245.9	245.0
111.0	4.4086	1.6030	3.1310	245.2	
111.0	4.8830	1.7470	3.4120	243.5	
115.7	2.2389	.8456	1.6520	281.8	281.8
115.7	1.3955	.5274	1.0300	281.8	
137.2	.6997	.2648	.5172	284.9	285.2
137.2	.1893	.0720	.1490	286.5	
181.1	.9820	.3763	.7350	297.6	297.9
181.1	2.4612	.9823	1.9180	298.3	

The freezing point of pure anilin has been found to be —8° C.,[11] hence that part of the curve between —8° and —11.8° represents the freezing point curve for solution in equilibrium with solid anilin.

At —11.50° C. solid anilin and the compound $HgI_2.2C_6H_7N$ separate out in the form of a eutectic mixture. This point was determined three times by determining the cooling curve of the saturated solution. In a freezing point tube fitted with a thermometer and stirrer and surrounded

[11] E. Lucuis, Ber. V, 154-155, 1872.

by an air jacket was placed the saturated solution. The whole was surrounded by a freezing mixture of salt and ice and gently stirred until a slight under-cooling was obtained. The temperature then quickly rose to —11.6° C., where it remained constant until the entire mass solidified and then fell slowly to the temperature of the bath, which was kept at a temperature of —16°. The points obtained were —11.5°, —11.55°, —11.4°, the mean being —11.483°.

Beginning with the eutectic point, the solubility increases gradually to 10°, then more rapidly to 42.9°. The white crystalline solid in equilibrium with the saturated solution has the composition $HgI_2.2C_6H_7N$. These crystals have parallel cleavage and parallel extinction, and melt at 58.6°. They are third or fourth system crystals, but it was impossible to determine exactly which. At 42.9° we have a quadruple point representing an equlibrium between HgI_2, $HgI_2.2C_6H_7N$, saturated solution and anilin vapor.

The solubility curve rises rapidly with the rise in temperature up to approximately 108°, the solid phase in equilibrium being red mercuric iodide. At approximately 108° we have another quadruple point, the solids being the red and yellow mercuric iodides in equlibrium with saturated solution and vapor. The transition point from red mercuric iodide to yellow mercuric iodide is apparently lowered by the influence of the solvent from 126° to 108°. This is in accord with the work done by J. H. Kastle,[12] in which he finds that the transition point of the iodide is affected by the solvent used.

An insoluble greenish yellow solid begins to appear at this point and the solution assumes a violet permanganate color.

From 108° the increase in solubility with rise in temperature is but slight up to approximately 200°, where the substance passes into a state of fusion, and the decomposition of the anilin prevented the investigation being carried further. The entire mass solidified into a sort of pasty solid on being allowed to cool. The solid in equilibrium with the solution above 105° is yellow mercuric iodide.

The insoluble solid coming in at 108° and above was isolated, thoroughly washed with distilled water and alcohol. It is a greenish yellow, flaky, micalike solid having oblique extension angles and no cleavage, belonging to the fifth or sixth system; it is insoluble in water, alcohol, hot anilin, or the ordinary acids, but dissolves in potassium cyanide, liberating metallic mercury. It will precipitate silver iodide from strong acid solution of silver nitrate and was found to contain 35.7

[12]Am. Chem. Jour., 22-473, 1899.

per cent of iodine and 56.9 per cent mercury, corresponding very closely to a compound of the composition $C_6H_5N.Hg_2I_2$, which would contain 34.02 per cent iodine and 53.77 per cent mercury.

SUMMARY.

A complete curve representing the conditions of equilibrium between mercuric iodide and anilin has been plotted for temperatures between —11.48° and 199.9°.

The region of stability of the three solids $HgI_2.2C_6H_7N$, red mercuric iodide, and yellow mercuric iodide, has been established.

Sixteen solubility measurements of mercuric iodide in anilin are given, all in duplicate and mostly in triplicate.

A new compound corresponding to the formula $C_6H_7N.Hg_2I_2$ has been identified and described.

The compound $HgI_2.2C_6H_7N$ has been made by direct combination of mercuric iodide and anilin.

A method for the determination of mercuric iodide as mercuric sulphide in the presence of an easily oxidized organic solvent has been tested.

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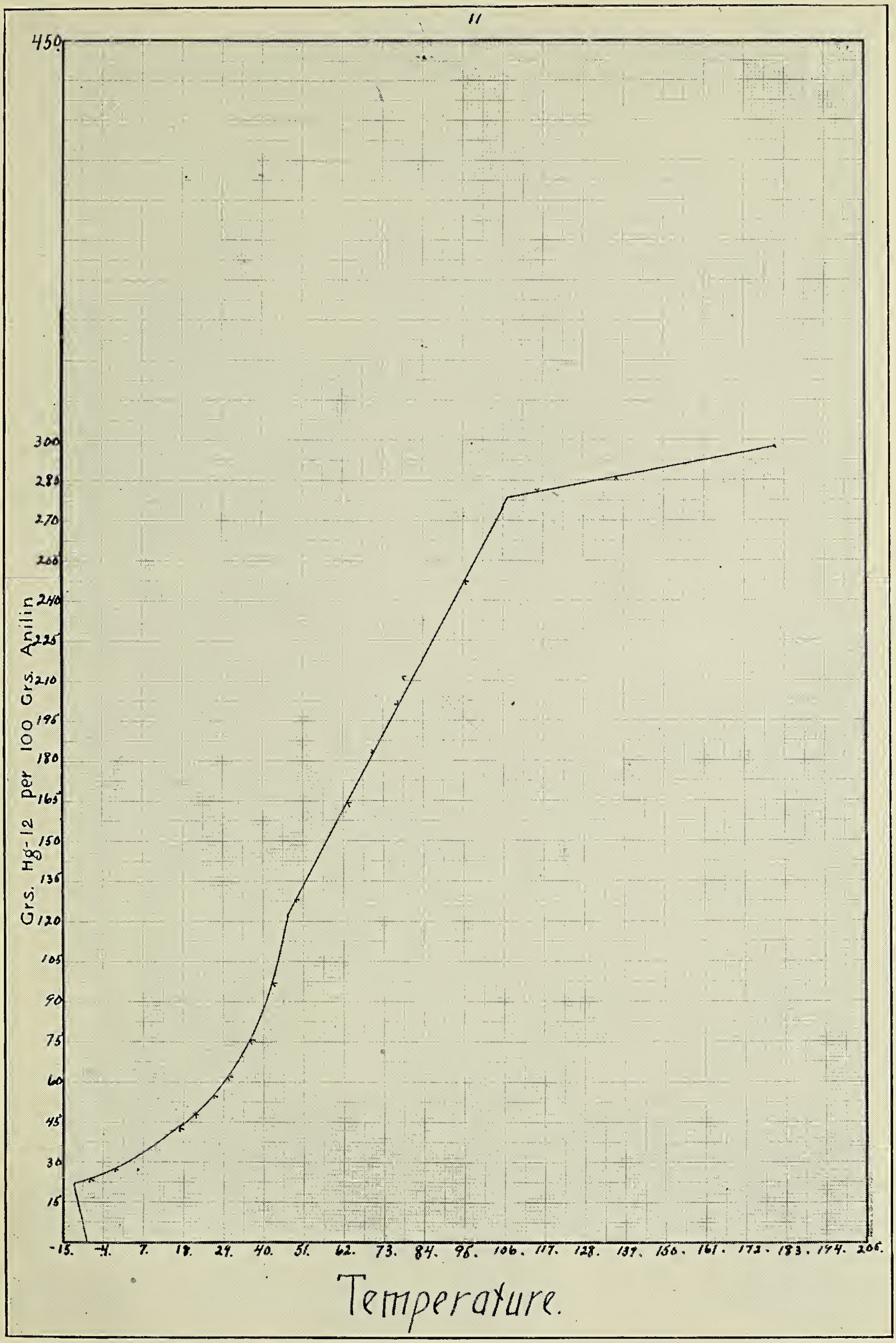

PLATE XIX. Curve showing conditions of equilibrium between mercuric iodide and anilin.

SOME EVIDENCE OF RECENT PROGRESS IN GEOLOGY.

GEORGE F. KAY.

(Abstract.)

In a recent publication by President Van Hise it was stated that the data of geology have become so numerous that they are almost unmanageable. With this view all geologists will agree. Not many decades ago it was possible for a geologist to have a reasonably full and satisfactory knowledge of his own science, and, also, to be fairly familiar with the related sciences. Now it is impossible for any geologist to learn all the important facts about all the branches of his own science. Not only is this true, but no geologist can know all the discovered facts of the world, or even of his own country, concerning that branch of geology in which he may be a specialist. The inability of any person to be thoroughly familiar with the whole field is impressed by the fact that during the last ten years more than 12,000 papers have been published on different phases of American geology alone. However, it is possible and necessary that the geologist be familiar with the leading facts and many of the details of that branch of the science in which he has specialized, and, moreover, that in his science as a whole he be acquainted with the tendencies which indicate the lines along which the greatest progress has been and is being made.

During the last decade great progress has been made in all branches of geology. To illustrate this progress reference is made in this paper to some of the outstanding publications in general geology, economic geology and petrology. No reference is made to the advances in other branches of geology.

GENERAL GEOLOGY.

1. Without doubt one of the greatest influences upon geological thought during the last decade has been the development by Chamberlin and his associates of new and fundamental conceptions of the early stages of the earth's history. These new conceptions have greatly changed our former interpretations of the early atmospheres and hydrospheres of our earth, the oldest rocks, vulcanism, diastrophic movements, climates, glaciation, the early life of the earth, and many other features.

2. The critical study of sediments has been of great assistance in

the interpretation of past climates. It has been recognized that several of the geological formations belong not to marine deposits, as was formerly thought, but to the continental class of deposits.

3. There have been great advances in stratigraphic geology. For example, the researches of Van Hise and Leith and of others have greatly advanced our knowledge of the Pre-cambrian systems of rock. The work of Bailey Willis and others has been of great value in the correlation and unification of the rock systems throughout the world.

4. The study of radio-activity in relation to the interior heat of the earth has become, in recent years, of great interest to the geologist.

5. The development of physics and chemistry has stimulated new modes of attack in experimental geology.

6. As a result of the investigations of the earthquake commission, our knowledge of earthquakes has been greatly extended.

7. Our knowledge of the geology of the western states has been greatly increased as a result of the new duties placed upon the United States Geological Survey in the classification of the public lands.

ECONOMIC GEOLOGY.

1. In recent years it has come to be recognized as never before that chemical work is absolutely essential in connection with the detailed study of ore deposits. Already some excellent researches have been made by Stokes, Sullivan, Wells, and others of the chemical laboratory of the United States Geological Survey, and by Arrhenius, Vogt, Kohler, and others. But the future will see much of this chemical work done on a more systematic basis than has characterized the investigations up to the present time. One of the most interesting illustrations of the great value of experimental chemical work in the correlation of problems connected with ore deposits has been given by W. H. Emmons in a publication entitled, "The Agency of Manganese in the Superficial Alteration and Secondary Enrichment of Ore Deposits in the United States."

2. The chemical study of ore deposits has influenced the interpretations of the genesis of ores. Whereas there were several conflicting but strongly advocated theories regarding the deposition of ores, there now is general agreement. It is now considered by all that some important types of ore deposit are undoubtedly the result of precipitation from meteoric waters, and that many which were formerly thought to belong to this class have been precipitated from magmatic waters. Concerning this latter method of origin, the work of Doctors Day and Shepard of the Geophysical Laboratory in collecting gases unmixed with air from the crater of Kilauea is of fundamental importance. These investigators

have demonstrated the presence in these gases of large amounts of water, thus furnishing direct evidence of a process which many students of ore deposits have for a long time believed to be of fundamental importance, namely, the potency of magmatic waters in contact metamorphism and the formation of mineral veins.

3. Great advancements have been made in the study of ore deposits as a result of microscopic study of rocks and ores. There is now an appreciation of the necessity of microscopic study and the unreliability of observations which are not supported by such testimony. In this connection it is well to refer to the recent application of metallographic methods of study to polished sections of ore. These methods of study are clearing up many points previously uncertain in the history of certain ore deposits and promise to be fully as important in future work on ore deposits as the study of thin sections has become to the petrographer.

4. Lindgren, in a paper on Physical Conditions and Ore Deposition, has made an important contribution to the literature of ore deposits. He shows clearly that there is an intimate relation between the mineral content of an ore deposit and the physical conditions under which the deposition occurred. He has shown that by a study of the mineral associations in an ore deposit it is possible to diagnose whether the deposit was formed under igneous conditions, pegmatitic conditions, contact metamorphic conditions, in the zone of cementation, in the zone of weathering, or under physical conditions which differ from all of these. In his text book on mineral deposits Lindgren has described ore deposits which were formed under each of the conditions mentioned above.

5. In the year 1904 a monumental work was published by Van Hise on the subject of metamorphism. In this he applied the laws of physical chemistry to the outer zones of the earth and showed that the principles of metamorphism have a direct bearing upon ore deposits; in fact, he contended that the deposition of most ores is but a special case of metamorphism which is of exceptional interest to man.

6. During the past few years a distinct advance has been made in the United States in publishing monographs of the important ore deposits of the United States. The geologist makes a thorough study in his particular field and records his results with great detail, thus allowing others to judge whether or not his conclusions are justified. In this connection it is necessary to mention only the excellent monographs issued by the United States Geological Survey on the iron ores of the Lake Superior region, on the copper deposits of Arizona, and on the gold and silver deposits of the West.

PETROLOGY.

1. Notable advances have been made recently in the physical and chemical investigations of rock minerals and rocks. Some of the most important of these are being carried on in the Geophysical Laboratory of the Carnegie Institution of Washington. Of great significance has been the determination of the value of certain minerals, such as quartz, as a geologic thermometer. As has been stated by Iddings, "The synthetical researches of Day and his colleagues, as well as those of Vogt, Doelter, Morozewitz and others, are carrying forward the earlier work of Daubrée, Fouqué and Michel Lévy, and are establishing the laws of formation of the mineral constituents of igneous rocks. Recognition of the character of igneous magmas as solutions has opened the way for the application of modern conceptions of physical chemistry to the elucidation of the phenomena of crystallization and of genetic relationship among igneous rocks."

2. "The Quantitative Classification of Igneous Rocks," by Cross, Iddings, Pirsson and Washington, is a publication which clearly indicates the rapid advance of our conceptions of the classification of igneous rocks. In this classification all igneous rocks are classified primarily on the basis of their chemical composition, and only secondarily according to their mineral constituents, texture, and other characters. In its application detailed chemical analyses of the rocks are required. For the first time in the history of petrology, the fundamental characteristic of the rock, namely, its chemical composition, has been recognized as the basis of classification.

3. The recent publication of text books by Iddings, Daly, Johannsen and others will be of great service to all who are interested in the study of rocks and will stimulate research in petrology.

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EARTH MOVEMENTS AND DRAINAGE LINES IN IOWA.

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It is well known that several systems of drainage lines have been impressed upon the surface of the present state of Iowa, only to be successively wiped out by the hand of time. Not to mention possible earlier ones, a well marked drainage system was cut into the Saint Louis and older strata prior to Des Moines time. Upon the (relative) subsidence of the land during Des Moines time the valleys were filled and drainage lines obliterated to the farthest limits of deposition of Coal Measures rocks. Differences of nearly 400 feet in the altitude of the Saint Louis surface near Des Moines give evidence of the vigor of the erosive forces and the lapse of time during which degradation was active. At least some of the Coal Measures outliers of eastern Iowa may occupy depressions cut during this period, and, as Doctor Calvin[1] pointed out, the land surface of that time probably stood higher than at present, since the base of the Coal Measures sandstones of the Iowa City outlier is sixty feet below present river level. Beyond the eastern limits of the Des Moines strata the drainage systems doubtless continued for a long time, though at times sluggish and ineffective as erosive agents.

The Paleozoic era closed with extensive crustal movements, which initiated the formation of the Appalachian mountains in the east and excluded the sea from the continental interior. The sluggish streams of Carboniferous times must have been invigorated by these movements and new lines incised into the recently elevated Carboniferous rocks. This system of drainage persisted until, and, in eastern Iowa, through Upper Cretaceous times, but whether any of its elements survive to the present time is of necessity uncertain. An age somewhat greater than that of the Saint Louis limestone has been claimed for the prototype of the Mississippi[2] along the Iowa border and buried channels have been noted by numerous writers on Iowa geology.[3] These channels are usually referred to post-Cretaceous uplift and erosion, and, while it is possible that some of them may have been re-incised in Cretaceous and pre-Cretaceous valleys, the fact that pre-Tertiary drainage was toward

[1]Iowa Geol. Surv., Vol. VII, p. 94, 1897.
[2]Fultz, F. M; Iowa Acad. Sci., II, p. 39, 1895.
[3]Gordon, C. H.; Iowa Geol. Surv., III, 237-255, 1895; Bain, H. F.; Iowa Acad. Sci., II, pp. 23-26, 1895. Others might be cited.

the southwest renders it unlikely that any great proportion of this system should be perpetuated in the present southeastwardly trending lines. It is possible that such valleys as the lower part of Oneota or Upper Iowa river valley may represent remnants of this old pre-Tertiary drainage system.

The main purpose of this paper, however, is to attempt an explanation for certain incongruities in the topography and drainage of eastern Iowa. It was pointed out many years ago by McGee[4] and later emphasized by Calvin[5] that the streams of this region do not flow down the slope of the surface, but at practically a right angle. It may also be noted that in general these streams flow parallel to the strike of the underlying rocks and not with or against the dip. There is, however, probably no genetic relationship here. The anomalous courses of the Mississippi tributaries are probably due to the following course of events. During Upper Cretaceous time western, and perhaps a part of eastern, Iowa was under the sea, while the land area of the state was subject to prolonged erosion and so by the close of the period was reduced to base level. The slow-moving rivers wandered aimlessly across their broad, flat-bottomed, shallow valleys, miniature editions of the lower Mississippi of today. But the Mesozoic era was closed, as the Paleozoic had been, by marked crustal and mountain-making movements, which again elevated the upper Mississippi valley beyond the reach of the seas. However, at this time the locus of movement was in the west and the Rocky mountains began their growth, the Great Plains were tilted up and a new system of drainage was initiated. The direction assumed by the members of this system was the resultant of two factors: one, the eastward tilt given the plains between the young Rockies and the axis of the great trough whose eastern rim was, and still is, the Appalachian highlands; the other, the southward slope from the old continental nucleus—the pre-Cambrian shield of Canada. Hence, the Missouri and its tributaries from the west, also the westerly tributaries of the Mississippi, as they worked headward in their development, lengthened out to the northwest. Local factors have varied this scheme, but in general it holds good. The relatively small tributaries of Missouri river in Iowa are probably post-Kansan and owe their somewhat peculiar relations in part to a great southwardly-trending ridge of drift which lies immediately to the west of the present so-called divide and through which some of the larger streams have already carved their valleys. The courses of some, at least, of these streams may also

[4]U. S. Geol. Survey, 11th Ann. Rept., pp. 363-365, 1891.
[5]Iowa Geol. Surv., XIII, pp. 296-299, 1903.

be influenced by the great Sioux island centering about Sioux Falls and Pipestone, which has profoundly affected the history of the immediately surrounding regions.

This growing system of streams, then, to come back to our local province of eastern Iowa, carved out its valleys upon the Cretaceous peneplain until in many cases these had assumed great proportions and had reached late maturity or old age. A Tertiary base-level was being impressed upon the old Cretaceous plain. Whether the Tertiary peneplain extended merely as a narrow strip along the Mississippi, as urged by Hershey,[6] or was co-extensive with the great plain of the entire state, as indicated by Calvin,[7] may be a moot question, though the evidence seems to point to there being but one peneplain in northeastern Iowa. Hershey based his conclusions partially upon the work of McGee, and some rearrangement of McGee's geological section has been found necessary by later workers.

The valleys of the Driftless Area give a clear picture of the development of topographic features unmolested by glacial invasions and therefore show what might have been expected in all of northeastern Iowa had not the advance of the ice sheets terminated the Tertiary cycle. A study of the topographic maps of the Waukon and Decorah quadrangles, for example, will show Oneota or Upper Iowa river flowing in wide meanders across a dissected plain whose summit hills and ridges rise to a fairly common level. These summits represent the Tertiary peneplain and the intrenched meanders of the stream are faithful reproductions of the course of the river when it flowed up near the level of the uplands. It is clear that valley and plain alike must have been very mature by the beginning of the Ozarkian interval, that is, near the close of the Tertiary period.

Now, the Ozarkian was a time of elevation of the continent, of differential movements and warpings of the crust, and one of these warpings affected northeastern Iowa and adjacent portions of the adjoining states. The topographic maps of these states seem to indicate that this deformation assumed the shape of a long ridge trending west of south and culminating in central and southwestern Wisconsin, southeastern Minnesota and northeastern Iowa. Southward beyond Dubuque and westward toward Cedar river it declines rapidly. Unfortunately, the area covered by topographic maps is not sufficiently inclusive to render positive assurance to this supposition. The deformation may have been a dome rather than a ridge. In any case, the streams were obliged to

[6]American Geologist, XX, pp. 253-256, 1897.
[7]Op. Cit., XIII, pp. 298-299.

resume downward cutting in their valleys to prevent being ponded or reversed by the slowly rising land. They succeeded in the effort and now flow in deep canyon valleys whose floors in some cases lie 500, 600 or 700 feet below the hilltops. In fact, the valleys are over 100 feet deeper than this, for they have been filled to that depth with detrital material dropped by the streams, as will be explained later. But the result of the upwarp is that northern Iowa lies as a great trough, with Cedar river in its axis, rather than as a plain sloping uniformly to the Mississippi, as was seemingly the case during Tertiary time. The master streams, being so largely pre-Ozarkian, or reoccupying pre-Ozarkian valleys, have held the main lines of drainage to their old courses and also have been determining factors in establishing the courses of their affluents. These latter are not widely radiate, but are narrowly digitate, or dendritic, due, perhaps, to preglacial topography, coupled with the directions of glacial advance and consequent form of glacial deposition.

The partial filling of Ozarkian-cut valleys was mentioned above. The following cases may be cited. At the mouth of Oneota river wells sunk from an altitude of 650 feet penetrate 130 to 140 feet of alluvial filling before they reach rock. The level of the river here is 620 feet and the actual floor of the valley is 520 feet. Eight miles up Oneota river the floor lies at 560 feet and has been buried 100 feet. At Prairie du Chien the Mississippi bottoms are somewhat more than 600 feet above sea. A deep well sunk for 627 feet pierced 147 feet of valley filling, reaching the rock floor at 480 feet above sea. At Eagle Point, Dubuque, where the flood plain is 600 feet above sea, a well was sunk from this level through 160 feet of alluvium and from the Julien Hotel well, scarcely more than twenty feet higher, there is reported a thickness of 210 feet of loose material. This puts the valley floor at 440 to 410 feet. Most of the deep wells at Clinton strike rock within forty feet of the curb, which latter is about 588 feet above sea level, but one penetrates 205 feet of Quaternary material before bedrock is reached. This seems to indicate a very steep wall here, dropping to 380 feet above sea level. Again, the buried valley of the Mississippi west of Keokuk was cut at least as low as 374 feet above sea level, 103 feet below low water at Keokuk. The accompanying cut shows the relative sizes of the fossil and present channels.

The same situation holds for the tributaries of the Mississippi. For instance, the Wapsipinicon and Cedar-Iowa valleys were originally less than 400 feet above sea level, though nearly 300 feet of glacial and alluvial material has been dumped into them. In Scott county a buried channel, probably of Mississippi river, named by Norton, Cleona channel, has likewise been cut lower than 400 feet above sea, though now entirely obliterated. Low water in the present Mississippi channel at Rock Island, only a few miles to the east, is 542 feet above sea, and the channel is very shallow and rock-cut.

This assemblage of facts points, of course, to the conclusion that at some time in the past, probably during the Ozarkian interval, the lands stood high and that the valleys were being deepened rather rapidly, since the buried channels show very steep walls. Subsequently these valleys were depressed through a sinking of the land surface, or else their outlet was blocked, through a rise of land athwart its lower course or by a change in its course through the agency of an ice barrier. In any case, the result has been the same—the partial filling of the existing valleys with detritus and the entire filling of the abandoned ones.

It seems likely that two of these causes were active. We know that the Mississippi has been obliged to alter its course by invasions of

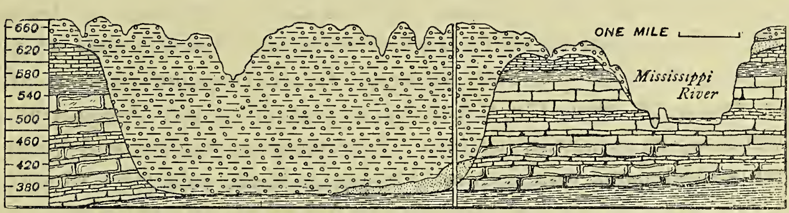

Fig. 6. Section across present and former channels of Mississippi river in Lee County. From Gordon.

glacial ice, and that parts of the course, once abandoned, have never been reoccupied, but that, instead, the river has cut new channels through the hills and is still rock-bound and shallow at these points. This is the cause of the rapids at Rock Island and Keokuk. It will be understood that this change would tend to cause a filling of the channel behind these rock barriers. Whether this cause alone would be sufficient to account for the observed phenomena is perhaps doubtful. But another agency which I believe may be looked upon as one of the causative factors is a depression of the land.

During the final withdrawal of the ice sheet at the close of the Wisconsin age a series of great lakes was formed in front of the ice wall. One of the lakes, Lake Agassiz, occupied the depression now drained by Red and Minnesota rivers, and a group with varying forms and areas filled the basins of the present Great Lakes and spread far beyond their borders. Now, these lakes formed beach ridges, shore lines, wave-cut terraces and other marks, which would naturally be horizontal. But at present these lines depart markedly from horizontality, and, furthermore, the lines which were made at various levels are not parallel one to the other. This means not only that there has been a tilting of the land, but that this tilting was going on while the ice was retreating and the glacial lakes were extant. It is not thought probable that the lessening burden of ice is primarily responsible for this,[8] and the fact that the ocean invaded the St. Lawrence and Hudson valleys at this time is evidence against such a cause. The significant fact is that while the land to the north of the Great Lakes was raised several hundred feet above present lake level the area south of Green bay and Saginaw bay, on Lakes Michigan and Huron, respectively, was being so depressed that certain of the shore lines are estimated to be 100 feet below lake level at Chicago.[9] So the shore lines of Lake Agassiz are 400 feet higher near its northern than at its southern terminus. Whether this change is due entirely to elevation, or to elevation combined with subsidence, cannot, of course, be determined, since there is no such reliable datum here as exists in the Great Lakes. Studies in the correlation of moraines and the deformation of shore lines show that the same class of movements was affecting the two regions,[10] hence the continuation of the tilting westward from the Great Lakes region to the Mississippi may be considered as somewhat certain. Lowering the valleys and hence the gradients of streams would at once result in lower velocities, diminished carrying powers and a gradual building up of the valley bottoms. This building up would continue until the movement ceased and the streams were aggraded to their base level.

Another factor which assisted in filling the valley bottoms was the immense quantities of silt, sand and gravel brought down by the floods from the Wisconsin ice front and carried down the Mississippi valley until decreasing carrying power forced their deposition. The tributary valleys were also aggraded by the backing up of the flood waters with their burden and the release of this burden in the slack waters of the estuaries. Terraces of detritus in the valleys of Mississippi and Oneota and other rivers fifty to sixty feet above present water level still bear witness to the size of the floods and of the loads carried by them and indicate the level at which the mighty stream once flowed. It is to this agent, at least as the artist which put on the last skillful touches, that the great valley owes its rugged headlands and bold, frowning scarps and precipices, while the side valleys still retain the smooth, flowing contours imposed by ages of weathering.

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[8]Taylor, F. B.; An. Rept. Smithsonian Inst. for 1912, pp. 91-327.
[9]Chamberlin and Salisbury; Geology, Vol. III, p. 481, 1906.
[10]Leverett, Frank; Fourteenth Rept. Michigan Academy of Science, 1912, p. 15.

Then, how comes the river to be flowing at its present intermediate level? After the ice melted beyond the margins of the valley, the stream, though much diminished, still was freed from its great burden and was, therefore, able to degrade its channel instead of aggrading it. Further, during the early part of its existence Lake Agassiz was drained into Minnesota and thence into Mississippi river. This volume of water had left its load of detritus in the lake, hence was able to assist in carrying away the material which is found choking the valley of the Mississippi. It is possible, of course, that there has been a slight uplift of the entire valley following the disappearance of the ice, but of this we have no positive knowledge. We do know that there have been postglacial uplifts in eastern and northeastern America.

In this connection there is another fact of some interest. Some years ago, during our work in Winneshiek county, Doctor Calvin called my attention to the fact that the smaller streams of the region were all cutting into their valley filling. The accompanying cut, taken from the report on Winneshiek county,[11] gives a good illustration of the situation. It will be readily seen that, whatever the cause of this re-erosion, it is of recent occurrence and its effects are just now being felt in this region. It may be noted that this photograph here reproduced was taken less than two miles from Oneota river, and, therefore, in a location where any quickening of erosive activity in the master streams would be easily felt in their tributaries.

The most reasonable explanation of this phenomenon seems to be its correlation with the formation of the great terraces along the major drainage courses through the degradation of the detrital accumulations within them, as discussed above. The lowering of the water levels in the larger streams would necessitate a readjustment of gradients throughout their basins and a consequent increase in velocities and erosive powers. It may be remarked parenthetically that this increased activity is not confined to northeastern Iowa, but may be observed in other drainage areas. Gullies twenty feet deep and scarcely as wide at the top are being cut into the loess plains of the western slope of the state. Similar instances are occurring elsewhere. The incursion of human civilization and agriculture has been held responsible for this phenomenon, but whether the coincidence is causal, or merely fortuitous, or both, is, as yet, undetermined. Certain it is that there has been, within recent years, a notable depression of the ground water table, and these various changes may be intimately related one to the other.

[11]Iowa Geol. Surv., XVI, pp. 55, 56, 1906.

Resumé.—The streams of northeastern Iowa are strike streams, rather than dip streams. Their southeasterly direction was determined originally by the eastward tilt of the Great Plains and the southerly slope from the old Canadian land nucleus. Later the slope of the area considered was changed by an upwarp extending across southwestern Wisconsin, southeastern Minnesota and into northeastern Iowa. The streams were quickened, cut deep valleys into this ridge and so have held to their courses instead of being changed to other directions of flow. The land was formerly higher than now, as attested by the partially filled valleys of Mississippi and tributary rivers. This filling was aided by floods from the Wisconsin ice, which dropped great quantities of silt, sand and gravel along the bottom lands. Much of this material has since been cut away, leaving the remnants as terraces along the valley walls.

IOWA GEOLOGICAL SURVEY,
DES MOINES.

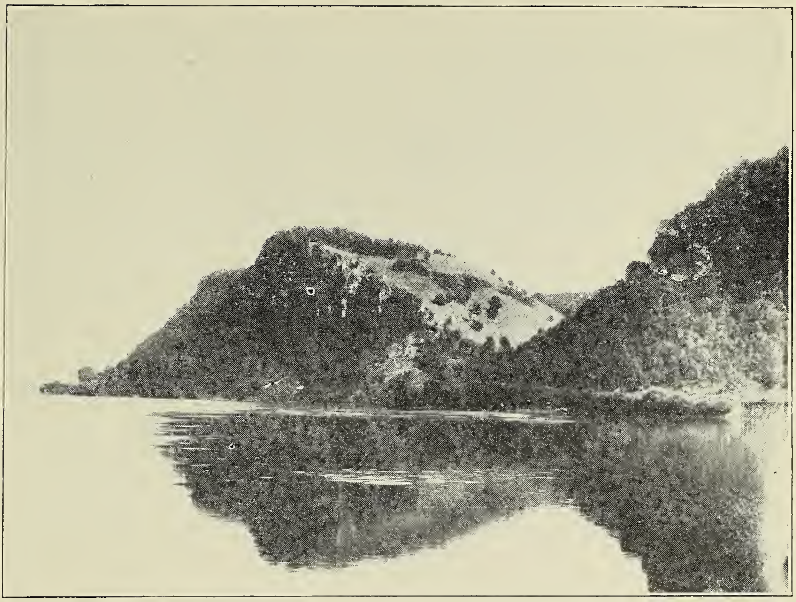

FIG. 1.—Mississippi bluffs below Lansing, Allamakee county, showing vertical walls fronting the river, but mature side and back slopes. From Calvin.

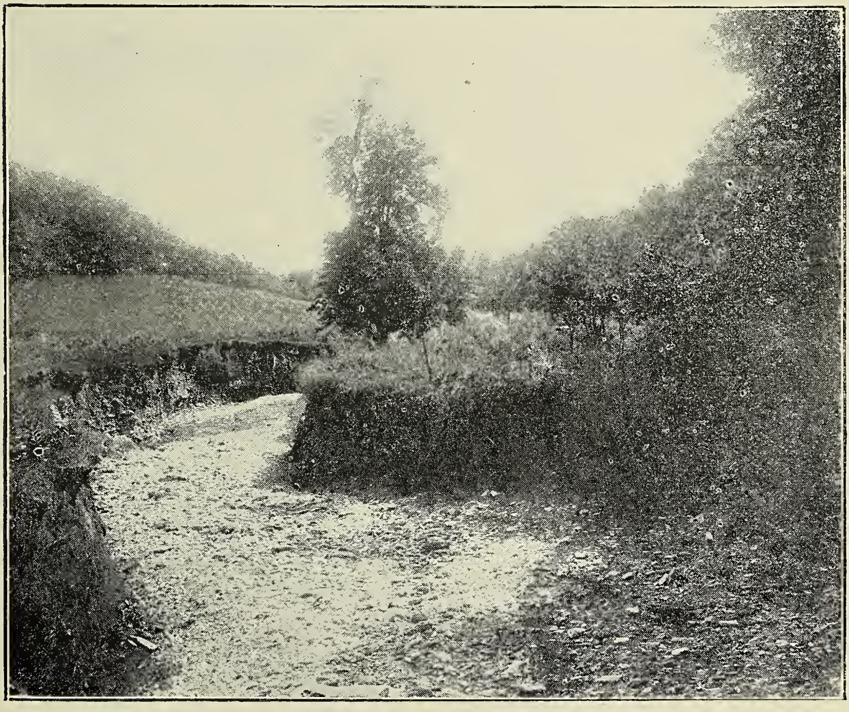

FIG. 2.—Reërosion of an aggraded valley, in the northeast quarter of section 21, Glenwood township, in Winneshiek county. From Calvin.

IOWA'S GREAT PERIOD OF MOUNTAIN MAKING.

BY CHARLES KEYES.

It is a fact almost too well known to state here that the most important single problem in earth-study with which we have to deal in Iowa is that of exact mapping of the different rocky formations. Unlike the cases in the majority of states, the work in this state is vastly simplified by the fact that there has been apparently little orogenic disturbance in the region, and the geological terranes of fundamental consequence mainly belong to a single geologic era. Calling the problem somewhat simple does not by any means signify that the labor of discrimination and tracing of the formation boundaries is easy, or that it is not highly varied.

The basis upon which Iowa geologists have to work is almost entirely Paleozoic in age. This general rock-sequence is very complete—as much so, perhaps, as any other Paleozoic section of our continent.

In Iowa there are two special conditions which rather severely limit close mapping of the Paleozoic formations. These are the presence everywhere over the state of a thick mantle of glacial till, associated with which are heavy deposits of loess, and, in the western half of the state, the occurrence of a great sheet of Cretacic sediments. The difficulties presented by the presence of the glacial deposits are fairly well overcome. In the case of that part of the state covered by the Cretacic formations in addition to a great overburden of drift, little or nothing has heretofore been done to elucidate the present structural attitude and the stratigraphic and taxonomic affinities of the underlying terranes.

There are, moreover, some of the broader relationships of the several formations that have not been taken into account and this fact makes the various associated problems which have come up still harder to solve. These features are more than state-wide in character. In extent they are really provincial rather than local, and certain of them are of continental proportions. It is to some of these aspects that attention is here briefly directed.

By peeling off, as it were, the Cretacic covering in the western one-third of the Iowa area, the entire Mesozoic floor is laid bare, and the Paleozoic formations then constitute the bedrock of the whole state. By what is essentially the same thing, elimination of the glacial and Cretacic coverings is accomplished by plotting the deep-boring records and other data. Part of these are made available through Professor Norton's recent report on the underground water supplies; but a large portion of the data is derived from sources to which he did not have access. All of these data are checked by the results of recent field-work. In addition, examination of the rocks of neighboring states throws much light upon the problems long regarded as too intricate to be solved within state borders alone.

On the general geologic map of Iowa the Paleozoic formations are distributed in relatively narrow belts trending in a northwest direction across the northeastern one-third of the state. Very singularly, it has always seemed, these belts abruptly terminate at the north soon after leaving the state boundary. For many years I have longed to know what becomes of these belts; and to learn the exact reason of this rather peculiar and unlooked for circumstance. During the past summer I found out. While on the geological excursions which followed the sessions of the Twelfth International Geological Congress which convened in Canada I had special opportunities to examine the Paleozoic sections of Manitoba, and under the guidance of those who had long worked in the field. There the same narrow belting of the same formations occurs and, as farther south, the strike is northwest. The Canadian Paleozoic area is separated in central Minnesota from the Iowan Paleozoic field by a broad Pre-Cambric area.

These Pre-Cambric rocks form the core of a rather notable arch, the axis of which runs northeast and southwest. This anticline is one of large proportions and extends from the east shore of Lake Superior to South Dakota, where, as a canoe-shaped form, it plunges beneath the post-Paleozoic deposits of the Great Plains region. The exposure of Sioux quartzite constitutes its western nose.

It is against the south slope of the sharp Siouan anticline that the belted Paleozoic terranes of northeastern Iowa are upturned and cut off. The eastern margin of the vast Cretacic field crosses the same line so that there is apparently no westward extension of the five groups of formations, if it ever existed, at least on the surface of the ground. On the other, or north, side of the anticline the same belts reoccur, as already stated.

Bearing in mind the position of this marked anticline, an arch between the center of which and the limbs there is a stratigraphic interval of more than 5,000 feet, it is obvious that the Paleozoic belts originally did not really terminate against it in southern Minnesota, but rather extended over it and were continuous with the Canadian belts. This being the case, it is equally obvious that the Iowan belts should not only not terminate against the arch in eastern or southeastern Minnesota, but should continue westward along the strike of the arch, but beneath the Cretacic covering. This is found actually to accord with recently observed facts. A cross section (figure 7), drawn to a scale indicates the actual amount of tilting displayed at the present time,

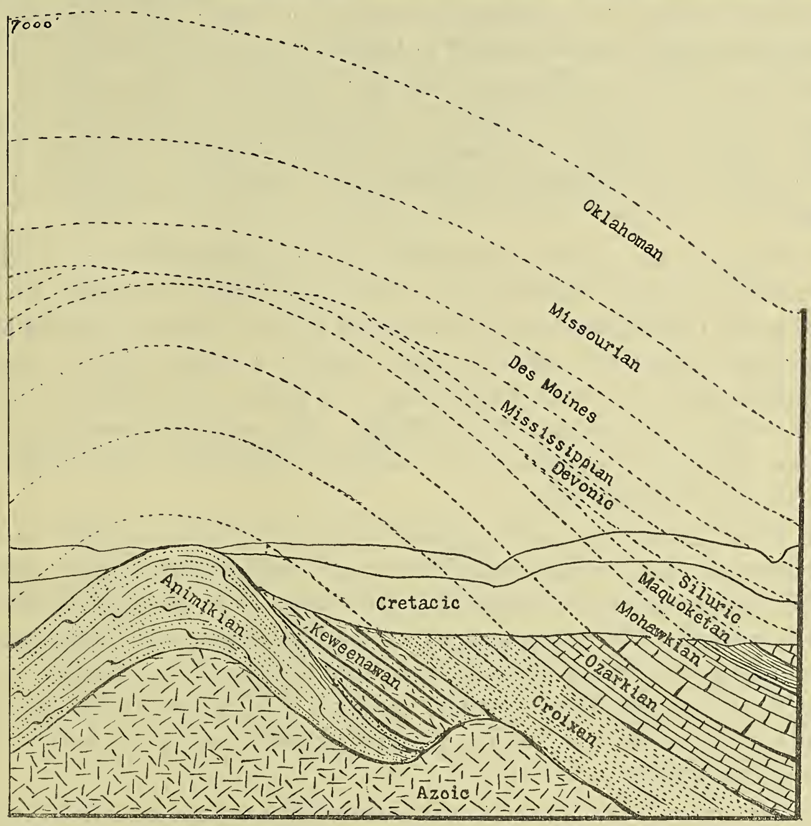

Fig. 7. Section showing strata removed from Siouan anticline.

with the part originally present, but removed during Mid-Cretacic time, represented by dotted lines.

By reconstructing the many well-sections and other deep-boring records, and correlating them in cross section, and then roughly mapping them on the Cretacic floor, it is found that all of the five belts actually turn sharply westward in eastern Minnesota and, crossing again into Iowa, extend southwestward into South Dakota and Nebraska. The Devonic and Ordovicic belts appear to pass under Sioux City. At any rate, they are so steeply upturned in the great truncated arch that their outcrop on the Cretacic floor is relatively narrow. The areal distribution of these various belts is indicated on the accompanying sketch-map of the state (plate XXI). The boundaries of the formations are located about as accurately as are the similar lines in much of the region nearer the Mississippi river.

Several other points incidentally brought out are of great interest. The areal extent of the Missourian series, or Upper Coal Measures, is probably not more than one-half as large as it has been commonly supposed to be. On the Missouri river this formation does not appear to extend north of Harrison county. The limestone outcrops in the Boyer valley, between Logan and Woodbine, seem to belong to no other than the familiar basal member of the Missourian series—the Bethany limestone.

Contrary to all previous conceptions, there appears to be but a small part of the present Cretacic area in Iowa immediately underlain by the Productive Coal Measures, or Des Moines series. The pre-Cretacic outcroppings appear in a narrow band scarcely a dozen miles in width extending southwest from Fort Dodge to a point on the Missouri river about twenty miles above Council Bluffs. The entire northwestern part of the state thus appears to be without Productive Coal Measures beneath the Cretacic beds.

A third instructive point suggested by the present inquiry is its bearing upon the age and deposition of the Fort Dodge gypsum, about which there has always been warm controversy. It is conclusively shown by the evidence here presented that if the Oklahoman and Cimarronian beds (so-called Permo-Carboniferous and Permian) of Kansas ever existed so far into Iowa territory as Fort Dodge they were at least 2000 feet above the floor of the gypsum deposits; and were never continuous with them.

It may not be out of place to say a word here on the age of the great Siouan anticline and the physiographic significance of the Cretacic floor. Since all of the Paleozoic formations take part in the arching, while the Cretacic rocks do not, it is quite evident that the main movement or uprising occurred in Early Mesozoic time. At the beginning of Comanchan deposition (Early Cretacic), when this part of the continent was land area, the country was again completely baseleveled, the Siouan arch as well as the lower lands. Upon this even plain, worn out on the bevelled edges of the ancient strata, which was then gradually carried beneath sea-level sediments were laid down during Mid Cretacic times.

These are the deposits which cover the northwestern portion of our state and out of which peeps the crestal remnant of the old arch, called by us the Sioux Quartzite area.

The Siouan mountains were rapid in formation and rapid in decline. At the time of their highest stage they probably stood 3,000 to 4,000 feet above the surrounding country. They were greatly diversified. In the Black hills, the Ozarks, and the Appalachians of today we find their nearest counterparts.

With the recognition of a great orogenic interval within the limits of our State there is added to the general geologic column a new section of very great importance. In the same region new chapters are inserted at the base of the general rock section. These together with other important modifications and intercalated features recently made known renders at this time a revision of previous diagrams particularly instructive. This chart is given below.

REVISED GENERAL GEOLOGIC SECTION OF IOWA ROCKS.

Eras	Periods	Sub-P.	Series	Terranes	Thickness	Rocks
CENOZOIC		Late	*Recent*	Alluvium	25	Clays, sands
				Wisconsin	30	Till
				Peoria	1	Soils
				Iowa	30	Till
				Sangamon	1	Soil
	QUATERNARIC	Mid	*Pleistocene*	Illinois	100	Till
				Yarmouth	1	Soil
				Kansas	200	Till
				Afton	40	Sands
				Nebraska	30	Till
		Early	*Epicene*	Dubuque	10	Clays (geest)
		Late	*Pliocene*	Interval		Unconformity
				Riverside	50	Sands
	TERTIARIC	Mid	*Miocene*	Dodge	100	Shales
		Early	*Eocene*	Interval		Unconformity
MESOZOIC		Late	*Montanan*	Unrepresented in state.		
				Niobrara	150	Limestones
			Coloradan	Hawarden	125	Shales
				Crill	100	Limestones
	CRETACIC	Mid		Woodbury	150	Shales
				Ponca	25	Sandstones
			Dakotan	Sergeant	75	Shales
				Nishnabotna	200	Sandstones
		Early	*Comanchan*	Interval		Unconformity
	JURASSIC			Interval		
	TRIASSIC			Interval		
PALEOZOIC		Late	*Oklahoman*	Unrepresented in state.		
				Atchison	300	Shales
				Forbes	25	Limestones
				Platte	125	Shales
				Plattsmouth	30	Limestones
			Missourian	Lawrence	100	Shales
				Stanton	20	Limestones
				Parkville	100	Shales
				Thayer	75	Shales
				Bethany	50	Limestones
		Mid		Marais des Cygnes	300	Shales
			Des Moines	Henrietta	100	Limestones
				Cherokee	250	Shales
			Arkansan	Interval		Unconformity
				Pella	30	Shales
	CARBONIC		*Tennessean*	St. Louis	50	Limestones
				Verdi	100	Sandstones
						Unconformity
				Spergen	10	Limestones
				Warsaw	65	Shales
		Early	*Mississippian*	Keokuk	75	Limestones
				Burlington	125	Limestones
				Chouteau	50	Limestones
						Unconformity

REVISED GENERAL GEOLOGIC SECTION OF IOWA ROCKS—Concluded.

Eras	Periods	Sub-p.	Series	Terranes	Thick-ness	Rocks
PALEOZOIC			*Waverlyan*	Hannibal Louisiana Saverton Grassy	75 10 60 50	Shales Limestones Shales Shales
				Chattanooga		Unconformity
	DEVONIC	Late	*Chemungan*	Lime Creek	125	Shales
			Senecan	Lucas Coralville Rapid Solon	25 30 35 25	Limestones Limestones Limestones Limestones
				Tully		Unconformity
		Mid	*Erian*	Fayette Independence Otis Coggan	75 20 10 15	Limestones Shales Limestones Dolomites
		Early	*Oriskanian*	Interval		Unconformity
	SILURIC	Late	*Goweran*	Bertram Anamosa LeClaire	35 60 70	Dolomites Dolomites Dolomites
		Mid	*Niagaran*	Monticello Hartwick Colesburg Sabula	100 80 30 50	Dolomites Dolomites Dolomites Dolomites
		Early	*Alexandrian*	Interval		Unconformity
	ORDOVICIC	Late	*Maquoketan*	Brainard Atkinson Clermont Elgin	125 40 15 75	Shales Limestones Shales Shales
		Mid	*Mohawkian*	Galena Decorah Platteville	225 30 100	Dolomites Shales Limestones
		Early	*Minnesotan*	Glenwood St. Peter	15 100	Shales Sandstones
	CAMBRIC	Late	*Ozarkian*	Shakopee New Richmond Oneota	75 25 150	Dolomites Sandstones Dolomites
		Mid	*Croixan*	Jordan St. Lawrence Dresbach Hinckly	100 50 150 600	Sandstones Dolomites Sandstones Sandstones
		Early	*Georgian*	Interval		Unconformity
PROTEROZOIC	SUPERIORIC	Late	*Keewenawan*	Corson Hull Tipton	 475 425	Diabases Porphyries Sandstones
		Mid		Interval		Unconformity
		Early	*Animikian*	Split-rock Sioux Jasper	75 500 30	Slates Quartzites Conglomerates
	SELKIRKIC			Interval		Unconformity
ARCHEOZOIC				Unrepresented in state.		
AZOIC					500	Gneisses Schists


PRE-CRETACIC
DISTRIBUTION
OF
PALEOZOIC FORMATIONS
IN
IOWA
Proterozoic
Cambric
Ordo.
Devonic
Ordovicic
Camb.
Cambric
Ordovicic
Devonic
Mississippian
Des Moines
Missourian
LYON
OSCEOLA
DICKINSON
EMMET
WINNEBAGO
WORTH
MITCHELL
HOWARD
WINNESHIEK
ALLAMAKEE
SIOUX
O'BRIEN
CLAY
PALO ALTO
KOSSUTH
HANCOCK
CERRO GORDO
FLOYD
CHICKASAW
FAYETTE
CLAYTON
PLYMOUTH
CHEROKEE
BUENAVISTA
POCAHONTAS
HUMBOLDT
WRIGHT
FRANKLIN
BUTLER
BREMER
BLACKHAWK
BUCHANAN
DELEWARE
DUBUQUE
WOODBURY
IDA
SAC
CALHOUN
WEBSTER
HAMILTON
HARDIN
GRUNDY
TAMA
BENTON
LINN
JONES
JACKSON
MONONA
CRAWFORD
CARROLL
GREENE
BOONE
STORY
MARSHALL
CLINTON
CEDAR
HARRISON
SHELBY
AUDUBON
GUTHRIE
DALLAS
POLK
JASPER
POWESHIEK
IOWA
JOHNSON
SCOTT
MUSCATINE
POTTAWATTAMIE
CASS
ADAIR
MADISON
WARREN
MARION
MAHASKA
KEOKUK
WASHINGTON
LOUISA
MILLS
MONTGOMERY
ADAMS
UNION
CLARKE
LUCAS
MONROE
WAPELLO
JEFFERSON
HENRY
DES MOINES
FREMONT
PAGE
TAYLOR
RINGGOLD
DECATUR
WAYNE
APPANOOSE
DAVIS
VAN BUREN
LEE

SERIAL SUBDIVISION OF THE EARLY CARBONIC SUCCESSION IN THE CONTINENTAL INTERIOR.

CHARLES KEYES.

As the taxonomic consideration of the Early Carbonic formations of the American continent has proceeded during the quarter of a century just passed, complication, rather than simplification, has taken place. Systematic arrangement of the terranes has become less rather than more clearly defined. The recent attempt to amplify one of the subordinate divisional titles so as to cover the whole has been attended by rather incongruous consequences. Small real advancement has resulted from mere change in nomenclature. Bureaucratic authority has been unable to take the place of fact, and its dictates have been as unfortunate, as they have been unsatisfactory and unreal.

That present custom is as unsatisfactory as it is inexpressive of actual genetic relationships between the various terranes represented on the American continent is amply indicated by a number of incidents. For example, Chamberlin and Salisbury[1] propose to give the Early Carbonic interval a taxonomic rank righer than it has been the custom to do, and to have it represent a periodical division, thus paralleling it with Carbonic itself, Cambric or Cretacic. Both Schuchert[2] and Ulrich[3], in recent arguments, strongly support either restriction of the term Mississippian, as now widely applied in America, or abandonment of it altogether. They suggest also new subdivision.

Were the Early Carbonic rocks of the continental interior reviewed anew today, without reference to any arrangement or subdivision already proposed, it is quite likely that a tripartite scheme would be, without much discussion, adopted. Upon grounds faunal, genetic, lithologic, stratigraphical, structural, diastrophic and paleogeographical, there is close agreement upon at least two major divisional lines. It so happens that these lines also correspond to the early subdivision deliminations. If, without too much disturbance in nomenclature and conception, these subdivisions can be readily used and the various local sections adapted to them, great and permanent advancement in provincial stratigraphy will have been made. This appears possible.

[1]Text-book of Geology, Vol. II, p. 160, 1906.
[2]Bull. Geol. Soc. America, Vol. XX, p. 548, 1910.
[3]Ibid., Vol. XXII, p. 608, 1911.

The two divisional lines which are most striking in the Early Carbonic sequence of the Mississippi valley are those at the base of the Burlington or Chouteau limestone and at the bottom of the St. Louis limestone. Both of these lines were pointed out by Owen[4] as early as 1852. Upon strictly faunal grounds, they were especially defined by me[5] in 1889. Two years later Williams[6] also recognized them and proposed new titles for the faunas of these subdivisions thus suggested. In 1892 I again[7] distinctly called attention to the same lines and also another of subordinate importance. Lately Schuchert[8] and Ulrich[9] propose still another grouping of the formations but draw the line of separation at or near the base of the St. Louis limestone. In the Iowa section, as lately reviewed,[10] I do not especially emphasize any subserial grouping.

In view of the fact that in late years two new criteria have come to have a dominant influence in stratigraphic classification and the faunal standard is largely displaced, the conception of rational grouping of terranes is somewhat changed. These two factors are diastrophic record and paleogeographical distribution. The two division lines here noted happen to be products of both diastrophic movement and paleogeographical limitation. They mark provincial effects, not continental or universal changes. The sections which they limit therefore have a taxonomic rank that is neither higher nor lower than that of series.

The three series thus demarcated are already designated by special names which, with slight modification in scope, may be appropriately retained.

The nethermost set of terranes corresponds to the section which in Ohio was early defined as the Waverly formation, in Michigan as the Marshall group, in Illinois and Iowa as the Kinderhook beds, and in Missouri latterly as the Chouteau section. Since the main and most widely distributed limestone section constitutes the middle series, the term Mississippian is appropriately restricted to it; and this also is very nearly Winchell's original use of the title. The lately proposed name, Tennessean, for the uppermost series, is useful and valid because the term Ste. Genevieve was already preoccupied for one of the subordinate limestones.

Little need be said here concerning the Waverlyan or the Tennessean series. Regarding the term Mississippian, a word or two may not be

[4]Rept. Geol. Surv. Wisconsin, Iowa, and Minnesota, p. 92, 1852.
[5]Am. Jour. Sci., (3), Vol. XXXVIII, p. 186, 1889.
[6]Bull. U. S. G. S., No. 80, p. 169, 1891.
[7]Bull. Geol. Soc. Vol. III, p. 263, 1892.
[8]Ibid., Vol. XX, p. 548, 1910.
[9]Ibid., Vol. XXII, p. 608, 1912.
[10]Iowa Geol. Surv., Vol. XXII, p. 154, 1913.

out of place. The formations of the Rocky mountains, which are commonly called by this title, probably represent little more than the Burlington and Keokuk limestones of the continental interior. Hence, the use of the term in a somewhat restricted sense is not out of place and will give rise to but small confusion.

As it now appears, the correlation of the Iowa section of Early Carbonic, with other characteristic sections, is given below:

CORRELATION OF EARLY CARBONIC TERRANES.

	Iowa.	Missouri.	Illinois.	Indiana.	Ohio.	Pennsylvania.
Tennessean.	Unconformity	Unconformity	Unconformity			
	Wanting	Chester Sh.	Chester Sh.	Birdville Sh.		
	Wanting	Kaskaskia Li.	Kaskaskia Li.	Tribune Li.		
	Wanting	AuxVases Ss.	Cypress? Ss.			
	Wanting	Ste. Genevieve	Ohera Li. Rosiclare Li. Fredonia Li.	Mitchell Li.	Maxwell Li.	Greenbrier Ss.
	Pella Sh. St. Louis Li. Verdi Ss.	St. Louis Li.	St. Louis Li.			
Mississippian.	Unconformity		Unconformity			
	Spergen Li.	Spergen Li.	Spergen Li.	Spergen Li.		
	Warsaw Sh.	Warsaw Sh.	Warsaw Sh.	Warsaw Sh.		
	Keokuk Li.	Keokuk Li.	Keokuk Li.	Keokuk Li.	Logan Ss.	Pocono Ss.
	Montrose Ch.	Montrose Ch.	Montrose Ch.			
	Burlington Li.	Burlington Li.	Burlington Li.			
	Chouteau Li.	Chouteau Li.	Chouteau Li.			

WAVERLYAN.	Unconformity?	Unconformity?	Unconformity?			
	Hannibal Sh.	Hannibal Sh.	Hannibal Sh.	New Providence	Cuyahoga	Grainger Sh. (Upper part)
	Louisiana Li.	Louisiana Li.	Louisiana Li.	Rockford Li.		
	Saverton Sh.	Saverton Sh.	Chattanooga	New Albany Sh. (Upper part)	Sunbury Sh.	Chattanooga Sh.
					Berea Ss.	
	Grassy Sh.	Grassy Sh.			Bedford Sh.	
					Cleveland	
	Unconformity	Unconformity	Unconformity			

OUR PRE-CAMBRIAN ROCKS.

CHARLES KEYES.

Terranes older than those of Paleozoic age occupy in Iowa a very small area. Attention which has been bestowed upon them is about commensurate with their relative surface extent. Heretofore, little attempt has been made to determine their broader stratigraphic relationships, their real position in the general geological column, their possible subdivision, or their role in the geotectonics of the region. It has seemed all sufficient to merely note their existence in the extreme northwest corner of the state. Yet, these very rocks now appear to have a history longer, more complicated and more vicissitudinous than any other terrane represented within our borders.

We now learn that some of these Pre-Cambric rocks are very much younger than was thought to be the case; and that others are very much older. For the first time we are able to compare them with a standard section of the most ancient sediments known. The most complete and satisfactory scheme of classification is that adapted from Lawson's scale for the Lake Superior district. Our rocks are really a part of these more northern masses, a long tongue of which extends from Lake Superior southwestward into Iowa and South Dakota. This section of Iowa rocks may be expressed as follows:

PRE-CAMBRIC ROCKS ABOUT THE NORTHWEST CORNER OF IOWA.

	Feet.
Unconformity.	
8. Corson diabase	
7. Hull porphyries	500
6. Tipton sandstones	450
Unconformity.	
5. Splitrock[1] slates	75
4. Sioux quartzites	500
3. Jasper conglomerate	30
Unconformity.	
2. Gneisses	1,000+
1. Schists	1,000+

Of these formations Nos. 1 and 2 are assigned to the Azoic; Nos. 3 to 5 to the Animikian series of the Archeozoic; and Nos. 6 to 8 to the Keewenawan series, also of the Archeozoic.

The salient characters of the several formations are briefly enumerated below. The full description and discussion of their broader stratigraphic affinities are necessarily reserved for another occasion.

[1]These are the slates described by S. W. Beyer (Iowa Geol. Surv., Vol. VI, p. 105, 1897).

The gneisses and schists which are reached in several of the deep-borings in northwestern Iowa appear to belong, without much doubt, to the fundamental crystalline complex here designated as Azoic. Their foliated character attests their great antiquity. At Sioux City the drill entered them for a distance of 840 feet.[2] At this point the rock was mainly dark gray in color, and the chief minerals were plagioclase, quartz, and biotite, with some hornblende. In the deep-well at LeMars 500 feet of typical gneiss and schist were penetrated by the drill. Fifty to seventy miles to the northward, in Minnesota, around the headwaters of the Des Moines river, these same rocks crop out and are open to direct inspection.

The Pre-Cambric rocks which outcrop about the extreme northwest corner of the state are commonly covered by the single title of Sioux quartzite. There are, in fact, several distinct members. The formations are identical with those of the Animikian series which is so well developed farther to the northeastward. It seems best to regard the rocks of the Siouan region as belonging here rather than with the original Huronic of Canada to which they are probably not to be traced and with which they bear no direct relations.

A conglomeratic phase of the quartzite appears east of the village of Jasper and south of Pipestone, in Minnesota. This is near the easternmost outcrops of the Sioux formation and it may be a part of a true basal conglomerate. The pebbles are of all sizes up to an inch in diameter. The observed thickness of the Jasper conglomerate is about 20 feet.

The characters of the Sioux quartzite have been repeatedly described in the various volumes of the Iowa Geological Survey. I have already reviewed, in the Proceedings of the Academy[3] opinions as to the age of this terrane; and its various features are elsewhere considered.[4] As lately determined the thickness of this formation is probably not more than 500 feet, instead of thrice this figure as formerly estimated.

Above the quartzite proper, or as the upper part of the section, are red and spotted slates. They are well exposed along the Splitrock creek from Corson northward. Their lamination is not true slaty cleavage but an ordinary stratification effect. At the Palisades, Pipestone, and elsewhere, the lamination is not very apparent. The more massive beds which are sometimes ten feet thick afford the so-called catlinite. The Splitrock slates doubtless have a wide areal extent.

Overlying the Animikian rocks in central Minnesota is a great succession of basic and acidic extrusives and red sandstones. They con-

[2]Iowa Geol. Surv., Vol. XXI, p. 1096, 1912.
[3]Proc. Iowa Acad. Sci., Vol. II, p. 18, 1895.
[4]Iowa Geol. Surv., Vol. I, p. 15, 1893.

stitute the Keewenawan series. An erosional plane of unconformity separates the two series of rocks. The entire sequence is cut by intrusives—diabases, gabbros, and granites. Rocks associated with the Sioux quartzite have identical characters and structural relationships. For all practical purposes they seem to be a part of the typical Keewenawan series.

The red sandstones and slates which often contain enough iron oxide to rank them as low-grade iron ores, have been reached in a number of deep-borings, notably in the well at Tipton. After passing through over 2,000 feet of Paleozoic sediments, 465 feet of the red beds were penetrated. These Tipton sandstones correspond in every way to formations outcropping seventy-five miles to the northward in Minnesota. It is probable that in the Hull well the same beds alternate with the quartz-porphyries. A notable feature of the Keewenawan sandstones is that they are not metamorphosed into quartzites, but are almost indistinguishable from associated sandstones of Cambric age.

The extensive succession of quartz-porphyry sheets disclosed in the deep-well at Hull is of exceptional interest. The drill penetrated over 450 feet of them. Their petrographic characters are fully described by Professor Beyer.[5] These porphyries are not intrusive sills as sometimes considered, but successive lava flows which were poured out upon the surface of the ground during Keewenawan time. The several sheets alternate with sandstones, a fact that points to the lava's solidification under water.

An instructive factor to be taken into account is the circumstance that the lavas appear to occupy an old valley, resting partly upon the ancient gneisses and partly upon the Sioux quartzites. These porphyries are identical with the acidic lavas which once flooded the country to the north far into Canada.

The diabase dike displayed so conspicuously at Corson, South Dakota, is one of many which cut the Pre-Cambric rocks of the Siouan ridge. These dikes vary in width from a fraction of an inch to one or two hundred feet. They traverse the Animikian rocks and therefore are much younger than the latter. In central and north-central Minnesota they do likewise; but in those regions there are no younger rocks covering the Proterozoics.

The geologic age of the diabase dikes, sills and bosses is commonly regarded as Keewenawan, but of this there is no positive evidence. In view of the fact that in the Siouan region there was a notable uplifting in Triassic times it is not beyond possibility that all of the diabases are

[5] Iowa Geol. Surv. Vol. I, p. 163, 1893.

of that age and are to be associated with the forming of the great Siouan Mountain ridge of that time. If it could be found that any of the Paleozoic rocks were fissured by these intrusives the testimony would be conclusive on this point. However, until it is shown by direct observation that the basic dikes actually do cut the overlying Paleozoics the Corson diabases are best regarded as Keewenawan in age.

With the recognition of a diversity of Pre-Cambric rocks about the point where the three states of Iowa, Minnesota and South Dakota meet a wide new field of investigation is opened up in our local geology.

There is another aspect of the Pre-Cambric rocks of Iowa that should not be lost sight of. At this time the special geologic significance of the terranes lies in the circumstance that they have suddenly acquired world-wide interest on account of the fact that they supply critical data for evaluating for the first time the duration of Pre-Cambric periods. They give us a basis of comparison of the mid-continental sections with the Paleozoic successions as we best know them. They enable us to formulate a systematic scheme of Pre-Cambric stratigraphy that is comparable in its variety, its complexity, its detail and extent, with the Post-Cambric standard which has been evolved during the course of the past century.

In this connection, also, the recent determination of the antiquity of the oldest fossil faunas has a direct bearing upon our own rock section. Through a period of more than two generations progress so inappreciable had been made in onerous attempt to carry back farther than Cambric time the geologic record of life on our globe that many students of ancient organisms almost despaired of ever seeing their efforts in this direction rewarded. At no stage, however, during these long years had the problem been regarded entirely without hope of solution. Latterly there had been accumulated a great mass of pertinent facts. So suggestive had been found some of them that an eminent English geologist, fully a decade ago, was led to predict, with no little confidence, the final differentiation of the great Pre-Cambric complex into an orderly succession of fossiliferous formations not very unlike that of the familiar Paleozoics. The results of the past year or two have, without warning, more than fulfilled the most sanguine of these expectations.

The wide interest aroused by these recent discoveries of abundant well-preserved organic remains in rocks of undoubted Pre-Cambric, and hence Pre-Paleozoic, age is secondary only to the enthusiasm produced a few months ago by the actual location of the fossiliferous horizons in the general geological column. As definitely determined these oldest fossil-bearing levels are stratigraphically more than two miles beneath all other known horizons yielding traces of life. These revelations are, of course, as important biologically as geologically. They materially modify all of our previously held views on the subject. They open up a more inviting field of investigation than awaited the paleontologists of the first half of the last century when they started to unravel the life record preceding Cretacic times. They promise even greater triumphs than when the Paleozoics first revealed their secrets to Murchison, Sedgwick and Lonsdale.

In past attempts to discover fossils in strata older than those of Paleozoic age the most serious obstacle always has been the highly altered condition of the ancient rocks whenever they were exposed to view. The well-known geologic law that the older a rock is the more metamorphosed is it likely to be especially applies to the Pre-Cambric formations. It is a criterion of such great weight that it is still a decisive factor in the determination of the relative ages of these old rocks. In the majority of cases known metamorphic processes have gone on so long and so intensely that it is often almost impossible to tell whether a rock-mass was originally igneous or sedimentary in character.

Indeed, as is well known, there is a large school of able investigators and acute thinkers which has reached the conclusion that the crystalline schists are almost wholly of eruptive nature. Among those who have hoped for a different explanation the great endeavor has been to find a locality somewhere in the world where rock-alteration is so slightly developed that the original sedimentary characters, if they ever really existed, are not completely obliterated and where the fossils are still in recognizable shape. A number of just such promising spots in different parts of the world are now known. Upon them much effort is being expended in the attempt to force them to yield up their fossil treasures.

It remained for two widely separated localities in North America, suddenly and almost simultaneously, to disclose the long sought sections. One of these places is in the Lake Superior district, and the other is in the Rocky cordillera of the West. In the first of these localities especially, does it appear that a definite standard of terranal succession of the Pre-Cambric rocks is capable of establishment with a measure of accuracy and detail quite comparable to that of the younger and highly fossiliferous Paleozoic sequence so well known.

Peculiar notions surround the discovery of Pre-Cambric fossils. When it became apparent that there really existed below the lowest Paleozoic horizons—or Olenellus zone—a great sequence of little altered sediments indistinguishable lithologically from the Early Cambric rocks, there at once arose among some of the workers on these ancient clastics an inordinate desire to repeat the brilliant achievements of the great English geologists seventy-five years previous. In the haste to formulate a theoretical deduction the real significance of many obvious facts was overlooked. An unfortunate misconception which resulted for a score of years retarded rather than advanced further progress.

At the very beginning there was, furthermore, a strong desire at once to evaluate the conclusions. It was argued that the length of time during which these Pre-Cambric sediments were formed was many times greater than that which had elapsed since the commencement of the Paleozoic era. Thus entirely without access to a measurable rock-section, without an adequate scheme of formational sequence, and without the aid of fossils there were made estimates of the duration of time required for the accumulation of the Pre-Cambric sedimentaries. These figures have crept into many of the more recent text-books. In a measure the results were unconscientiously forced until the period became excessively long. After making liberal allowances for frequently mistaking slaty cleavage for bedding planes, for personal equation, and for the wrong interpretation of sequence, there was still a very large factor of wholly unreliable data to be taken into account.

In the absence of any known fossils in the Pre-Cambric rocks strong appeal is ordinarily made to the possibilities which modern biologic or embryologic teachings point out. The fact that at the beginning of Paleozoic time, as we now understand conditions, life suddenly and profusely burst forth along all its main zoological groups is taken to indicate, notably by Professor Van Hise, that at this period it was already more than nine-tenths differentiated, the inference being that the oldest Cambric fauna is only a little way back in an immeasurable life-span. So far as this opinion rests upon the diversity of types in Cambric times it has no good basis. As W. K. Brooks so well shows "Evolution of the ancestral stems must have taken place at the surface of the sea, and all the conditions necessary for the rapid production of types were present when the bottom fauna first became established."

It is, then, on the continental shelves and in the epi-continental seas, belts or areas with which paleontologists have mainly to deal, that owing to hardships imposed and to the fierce struggle for existence among the simpler types of life, diversity of form and structure is ever present and exceedingly rapid in development. Especially bearing upon this phase of the problem are the observations of A. Agassiz on the bathymetric distribution of modern echinoids in the Gulf of Mexico. As one passes from the shore into deeper and deeper water the forms take on successively Pliocene, Miocene and Eocene characters until those of the deepest zone persist with well defined Cretacic features.

Notwithstanding the fact that in the oldest Cambric faunas we have essentially the characteristic forms of the primitive life of the sea-bottom, and that we need not expect anything so very different from these bottom-forms in the oldest rocks which may ever become accessible to us, it is instructive to know of what the most ancient fauna recently discovered in Pre-Cambric beds consists, and where it actually belongs in the general geologic time-scale. In these most ancient fossil faunas we may not, therefore, anticipate any very new or very remarkable ancestral or previously unknown stems.

To the bottom of the general geologic column as usually presented in the text-books of the science we may now add the following scheme of fossiliferous formations, remembering that each eral division represents a time-span equal to or even surpassing in duration that covered by the entire Paleozoic succession, and even the entire time interval which has elapsed since the laying down of the earliest Paleozoic sediments.

TENTATIVE TAXONOMY OF PRE-CAMBRIAN ROCKS OF LAKE SUPERIOR.

Eras	Periods.	Sub-periods.	Series.	Rocks.
PALEO	CAMBRIC	Late Mid Early	*Ozarkian* *Croixan* Wanting	Limestones Sandstones Unconformity
PROTEROZOIC	SUPERIORIC	Late Mid Early	*Keewenawan* Interval *Animikian*	Lavas Unconformity Slates
	SELKIRKIC	Late Mid Early	Interval	Sediments 20,000 feet thick in Cordillera
	ANIANIC	Late Mid Early	Interval	Unconformity
ARCHEOZOIC	ALGOMIC	Late Mid Early	Unnamed Interval *Soultan*	Lavas, granites Unconformity Quartzites
	HURONIC	Late Mid Early	Unnamed Interval *Marquettan*	Lavas? Unconformity Limestones, etc.
	LAURENCIC	Late Mid Early	Unnamed Interval *Keewatin*	Lavas, Granites Unconformity Lavas, slates
	VARENNESIC	Late Mid Early	Unnamed Interval *Coutchichingan*	Lavas? Unconformity Slates
AZOIC				Slates Gneisses Schists

The great triumph of Murchison and Sedgwick in the first half of the last century in bringing order out of chaos in the case of the vast Transition mass of rocks and in working out two great systems according to the fossils contained seems destined in the opening decades of the new century to be more than matched by the differentiation of two huge sequences of fossiliferous terranes each of greater stratigraphic and taxonomic importance than that of the entire Paleozoic succession as now known.

DES MOINES.

ON THE OCCURENCE OF PRECIOUS STONES IN THE DRIFT.

GARRETT A. MUILENBURG.

The subject of precious stones in the glacial drift is brought before the public from time to time by the report of gems being found accidentally either in or upon the drift. Most of the gems are diamonds and occasionally are of considerable size and value. No diamonds have been reported from the drift of Iowa. Several of good quality have been reported from Wisconsin while others have been found in Michigan, Ohio and Indiana. Professor Hobbs in his book on, "Earth Features and their Meaning," p. 307, tells, in discussing the diamonds of the drift of one stone in particular which has become famous and has been the subject of a costly law suit. The stone in question was found by a farmer in digging a well. Being ignorant of its value he sold it to a Milwaukee jeweler for the sum of one dollar. The jeweler sold it to the Tiffany's for a considerable sum and when the real value became known the farmer started suit to recover. The Supreme Court of Wisconsin finally decided that the jeweler and not the farmer, was entitled to the price of the stone, since the latter had been ignorant of its value at the time of purchase.

So far as the writer has been able to learn, diamonds have been the only valuable gems found in the drift of North America, until the summer of 1912, when a sapphire was found in the gravel along the shore of Lake Okoboji, Dickinson county, Iowa. In appearance it was very much like a piece of blue bottle glass but its superior hardness and peculiar luster, together with the fact that it was worn smooth and round, attracted the attention of the finder and led him to suspect that it might have some value. Subsequent examinations showed it to be a sapphire of good quality. The stone was cut by Messrs. Jurgens and Anderson of Chicago, and weighed, when cut, one and three-eighths carats. It is of the cornflower blue variety, which is most prized as a gem, and has the remarkable velvety luster which gives to a sapphire its value.

Doubtless there are thousands of precious stones scattered through the drift, but no systematic search for their recovery can be undertaken, because the glaciers in passing over the country, have scattered them everywhere, and it is only the occasional one that is found. When more have been found it may be possible, at some future time, by plotting the localities on a map, and by projecting lines northward in the direction from which the ice advanced, to discover approximately the location of the parent ledges. In all probability there is to the north, in Canada, a diamond-bearing peridotite or other igneous rock which is as yet unknown.

Our sapphire originally may have come from the famous sapphire region around Yogo Gulch, Fergus county, Montana, and may have been washed down by the waters of Misssouri river, picked up by the ice and later deposited in the place where it was found. It is more probable, however, that there is an unknown sapphire field far to the north, from which the Okoboji stone may have been transported.

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PRELIMINARY REPORT ON GEOLOGICAL WORK IN NORTHEASTERN IOWA.

ARTHUR C. TROWBRIDGE.

Field work is now being carried on in northeastern Iowa, by field classes and graduate students in the Department of Geology in the State University of Iowa, under the direction of the writer. The first work was done in the summer of 1913, in the driftless area of Allamakee, Clayton, and Dubuque counties, by a field class. The most detailed work has been done by Mr. A. J. Williams who has written a Master's thesis on a small area around Dubuque. The work will be continued during the coming summer, and will probably be carried on in following summers, until the outstanding problems of the region have been solved. Perhaps it may then be carried into other parts of the driftless area in adjoining states.

While the field work is being done chiefly for purposes of education and technical training for the students, many features previously unknown, or at least unreported, are coming to light, and it is becoming obvious that some facts already known will need elaboration and new interpretation. The work of this first year has served to discover the problems, to solve some of them, and to make a start at the solution of others, rather than to work out the complete history of the region. It is therefore the purpose of this paper to state the outstanding problems, and to lay out the lines along which their solutions appear to lie, rather than to solve them.

The region affords abundant material in stratigraphic, structural, paleontologic, economic, and physiographic geology.

Although Calvin and Bain, and Grant and Burchard have left little to be done in the way of stratigraphic and structural studies, a few new facts are coming to light along even these lines. For instance, a well-developed unconformity between the St. Peter and Prairie du Chien formations has been found in Allamakee and Clayton counties, and there are some evidences of an erosion unconformity between the Maquoketa and Niagaran beds farther south. The New Richmond member of the Prairie du Chien formation seems to be developed only locally, and it now appears unfortunate that the Minnesota classification of that formation has been followed in Iowa. Evidence of pre-Cambrian rocks underlying the oldest Paleozoic rocks of this part of the state, as shown by well records, is piling up. Aside from these few discoveries, little is to be expected in the way of new data on stratigraphic and structural geology.

No great attempt has been made to collect fossils from the rocks of the region, although some collecting has been done. The trilobite zone in the St. Lawrence beds around Lansing seems to have been pretty well worked out, for few fossils can be found there now. Several new species of brachiopods, pelecypods, and gastropods have been taken from the Platteville beds near McGregor, but they have not yet been described. The famous Graf cut in the lower part of the Maquoketa formation has been enlarged and cleared up by railroad work within a year, so that a more complete inspection of these highly fossiliferous beds can be made. The exposure is being reworked for fossils by Professor A. O. Thomas who has a paper describing his results before this meeting of the Academy.

Iron ore at Waukon, lead and zinc around Dubuque, the sand and gravel industry, and agricultural conditions afford the chief problems of economic geology.

A new plant has been built to produce the iron at Waukon, a new map of the deposit has been made, and numerous prospect pits have been sunk, all of which allow for new work on this interesting deposit. Stream-worn pebbles in the deposit and the location of the ore at the surace of an old peneplain, together with a crescent or meander shape revealed by the new map, seem to indicate that the ore was deposited in an oxbow lake or bayou at some time prior to the glacial period. Fossils belonging to the Platteville formation found in the lower part of the deposit lead to the conclusion that replacement and secondary enrichment have taken place also.

The production of lead and zinc is now at a stand-still in Iowa, and it is not possible to get into the mines. But from surface work, it is clear that there is a time relation between the deposition of the ores and the erosional history of the district. It seems that the ores could not have been deposited until after the Maquoketa shale had been removed from above, and that this formation was not penetrated by streams until early in the Pleistocene period. If this is so, the ores are Pleistocene or Recent in age.

Sand and gravel production, as an industry, has almost entirely displaced the business of quarrying for building stone. This is due to the fact that cement, concrete, brick and mortar have taken the place of building stone for purposes of construction. Practically all the quarries are abandoned, but gravel finds a ready sale at $1.00 a cubic yard. The sand and gravel come from fluvio-glacial deposits in the Mississippi valley and some of its larger tributaries, and their extent in the region is limited.

Agricultural conditions have been profoundly influenced, if not controlled, by the work of glaciers, by the erosive work of streams, by alluvial deposition, by deposition of material by wind, by underground conditions affecting ground water, by deforestation, and by other geological and physiographic agents and processes. The exact relations of all these conditions to land values, crop estimates, and rural social conditions are complex, but the work is progressing. It is hoped that in the not far distant future a paper may be prepared on the agricultural geology of the region.

But most of the outstanding problems of the region lie in the realm of physiographic geology. At the time when most of the previous field work was done, physiography was in its primitive stages as a science, and many features which now appear significant to the physiographer were then overlooked. The physiographic history of the region dates back to the end of the Niagaran epoch of the Silurian period. That is, over one-half of the history must be worked out by the application of physiographic principles, if it is to be worked out at all.

There are many physiographic problems in the region which must eventually be solved, but all of them can be grouped into three sets: (1) the problems of the upland plains, (2) the problems of glaciation, (3) the problems of drainage. These problems are here stated briefly in the order named.

Two more or less distinct plains, both well above the present stream beds, are represented by erosion remnants. While both plains have been quite thoroughly dissected by streams, the erosion has not gone so far but that the relief and slope of the plains and their relations to the rock formations and to present drainage can be ascertained. One of these plains, the higher and older one, lies everywhere on the Niagaran and is wanting where that formation has been eroded away or where it dips beneath the general surface. This has previously been considered as a peneplain of Cretaceous age. From the data so far collected, it seems rather to be a structural plain formed on the hard Niagaran dolomite. This conclusion, however, remains to be corroborated, the age of the plain is still problematical whatever its origin, and it must yet be traced into other regions and correlated with similar plains there. The lower and younger plain conforms more or less closely to the Galena formation, although it can be found at different horizons in that formation, and it even cuts across and lies in the lower part of the Maquoketa shale. This plain persists throughout the region and can doubtless be traced across the river into Wisconsin and Illinois and north into Minnesota. This plain seems to be a true peneplain, now uplifted and eroded, and it has such relations with the oldest glacial drift that it is probably late Tertiary or early Pleistocene in age. It is probably to be correlated with the plains in Wisconsin, Minnesota, Illinois, and Arkansas, on which lie the so-called "high level gravels" which are thought to belong to the Lafayette formation. It is with this plain that the iron ore at Waukon and the lead and zinc farther south have such relations that when the history of the plain is fully known the origin of the ores can also be worked out in detail.

Although the region under discussion lies in what has long been known as the "Driftless Area", a considerable amount of drift is found in it. This drift offers many problems most of which have not yet been worked out. Some of the questions to be answered are: How far east did the ice go? How much of the drift is fluvio-glacial, or eolio-glacial, or iceberg floated? How many glacial epochs were there? With what recognized epochs of the glacial period are they to be correlated? What relations do the areas of drift bear to the topography of the region? How much of the present topography was formed prior to the first glacial advance? How much was developed between the retreat of the first and the advance of the second ice sheet? Etc.? Etc.? Most of these questions cannot now be answered definitely, but data are being gathered which will eventually answer them, and some of them are already well in hand. The region seem to have been affected directly by two old ice sheets, probably the Nebraskan and the Kansan, and to have received water-borne gravel and sand and wind-blown loess from the Iowan and the Wisconsin glaciers. The oldest drift is associated in its distribution with the Galena peneplain, and the ages of the drift and of the plain may be considered to be approximately the same. A large part of the present topography seems to have been made during or since the glacial period.

The drainage of the region is and has been controlled by Mississippi river, and a study of the history of this stream and its gorge will yield rich returns. So far as the region has been studied, there is no trace of the existence of Mississippi river prior to the formation of the Galena peneplain and the deposition of the oldest glacial drift. If the river did exist before that time, either its course did not lie within the region under discussion, or its valley was so shallow and narrow as to have left no record. The present gorge seems to have been inaugurated by the uplift of the Galena plain, either just before, during, or immediately after the first glacial epoch. The gorge was cut to a depth of 600 feet or more before the Wisconsin epoch, and was then more than half filled by a Wisconsin valley train. Since then the stream has removed some of this fill and is at grade 325 feet above its pre-Wisconsin bed. This brings up problems of gradient, apparently involving Pleistocene or post-Pleistocene changes of level, which have not yet been completely demonstrated.

No less interesting than the history of the Mississippi is the history of its larger tributaries. The Upper Iowa, Turkey, Yellow, and Little Maquoketa rivers carried off glacial waters during at least one or two of the earlier glacial epochs, and all of them were ponded during the Wisconsin epoch by the building up of the valley of the Mississippi. These events caused numerous changes in drainage, some of which have already been investigated in the field. The most interesting one so far is the case of Couler Valley, near Dubuque, which was cut to a depth of about 400 feet by the Little Maquoketa river between Nebraskan and Kansan times, was abandoned while the Mississippi river cut 325 feet lower, became then a place of deposition for fluvio-glacial drift of Wisconsin age, and was again bereft of its stream by piracy, the Little Maquoketa having been diverted by a tributary of the Mississippi.

It is expected that continued work in the region will change existing ideas of early Paleozoic history in the state somewhat but not much; that it will yield new data and new interpretations concerning the economic products and their methods and dates of origin; that it will change the Pleistocene paleogeographic map of this part of the United States in some minor details; and that by this work much additional knowledge of the history of the Mesozoic and Cenozoic eras will be brought to light. Especially should a progressive study of the region furnish data on Pleistocene history, including the sequence of events, the duration of glacial and interglacial epochs, and so forth. As the work progresses, other papers will be presented to the Academy, by the writer or by his helpers.

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THE FORMATION OF ESKERS.

ARTHUR C. TROWBRIDGE.

Ever since work has been in progress in glaciated regions, long, narrow, winding, steep-sided, conspicuous ridges of gravel and sand have been recognized by geologists. They are best developed and were first recognized as distinct phases of drift in Sweden, where they are called Osar. The term Osar has the priority over other terms, but in this country, probably for phonic reasons, the Irish term Esker has come into use. With apologies to Sweden, Esker will be used in the present paper. Other terms which have been applied to these ridges in various parts of the world are serpent-kames, serpentine kames, horsebacks, whalebacks, hogbacks, ridges, windrows, turnpikes, back furrows, ridge furrows, morriners, and Indian roads.

Because of a similarity in distribution, in materials, and in general appearance, eskers have long been confused with kames. In the opinion of the writer, these points of similarity are more real than imaginary. In order to make this point clear, the origin of kames will be discussed briefly. A kame is a more or less circular hillock or knob of stratified material deposited in a crack or other re-entrant in the edge of an ice sheet, by a stream which flows from beneath the ice into that re-entrant. So long as the stream is beneath the ice, it is under pressure, has a high velocity, and carries a heavy load. At the point of issue the pressure is released, the velocity is checked, and deposition takes place against the walls of the re-entrant. When the edge of the ice has retreated, the material slumps down to its angle of rest on all sides. There has never been, and there is not today, any reasonable doubt of this mode of origin of kames. In some localities groups of kames are found, arranged in irregular fashion, and known as kame-areas.[1] They are considered to represent a much-broken ice edge where streams issue from the ice. Kames are more abundant than eskers.

There has always been speculation as to the origin of eskers and several theories have been advanced to explain them. The writer has had occasion to study several eskers in the field, and that study has led him to doubt the present accepted idea of their origin and to conceive another method by which they might be formed. A recent reading of the literature of the subject has confirmed his doubt of the existing

[1] Trowbridge, A. C., Ill. Geol. Surv., Bull. No. 19, pp. 50-56.

theory and his confidence in the new one. A partial bibliography of the subject of eskers is appended at the end of the paper.

Let us now bring together the characteristics which must be explained by any theory of the origin of eskers. For the sake of definiteness these characteristics are stated in separate paragraphs:

In shape, eskers are ridges, many times longer than wide.

Their dimensions vary greatly: In height, from 3 to 150 or even 200 feet, and in length from a fraction of a mile to 100 miles or more. Single esker ridges are measured through the base in dimensions of a few hundreds of feet rather than in figures of a higher order. Differences in height are generally the measure of differences in thickness.

The side slopes of the ridges range from 25° to 30° from the horizontal, and the slope in each case is the angle of rest for the material of which the esker is composed.

Eskers are found only in areas once covered by glacier ice, generally in ground moraine, which is near terminal moraine, or which has terminal morainic tendencies, less frequently in terminal moraine itself. No eskers occur beyond the maximum extent of the ice in the zone of outwash material.

No esker ridge can be traced for 100 miles, nor for 10 miles, without interruption. They are discontinuous without exception. The individual parts vary in length up to five or ten miles and the intervals between, up to two or three miles, or perhaps more.

The ends of the ridges, whether at the extreme ends or at the ends of the separate parts, are very abrupt, the degree of slope being as great as the side slopes. There is no apparent tendency to tail out and disappear gradually, except in a few cases.

Practically no esker ridges are straight; rather they have winding courses, somewhat similar to the meanders of a stream, although the symmetry of stream meanders is lacking. When eskers are plotted, with straight lines drawn from end to end across discontinuities, rather irregular courses are shown, with turns, bends, and breaks at all angles.

Combinations of several ridges, which have been termed "reticulated ridges,"[2] are common along the courses of eskers. A single main ridge may be joined by tributary ridges, or it may be broken up into distributary ridges, or there may be many ridges of about equal size braided with one another in such a way as to hold depressions or kettles between them. In some cases the total width of the compound esker, including the depressions, is more than three miles.

[2]Stone, G. H., Mono. XXXIV., U. S. Geol. Surv., p. 34.

Eskers have no particular relation to underlying topography. Although most of them lie in and parallel with valleys, many of them wind their way across valleys and divides and over surfaces of considerable relief, and not everywhere by the most direct routes or the lowest grades.

It is notable that eskers are more common in rough regions than in areas where the surface is smooth. For instance, they are most numerous in Sweden and in Maine. Hundreds of them are known in Maine, while in the flatter glaciated region of the Upper Mississippi valley they are so rare as to occasion special comment and detailed description when found.

The material of eskers ranges in texture from sand to bowlders several feet in diameter, the smallest glacial material, rock flour, and the largest, enormous bowlders, being absent. The material is only roughly stratified, though all of it is clearly water-laid. Stratification lines show evidences of disturbance, either by push of some sort or by slumping and settling. Where apparently undisturbed, cross-bedding planes dip parallel with the side slopes or toward the lee end of the esker; seldom, if ever, do they dip toward the stoss end. The pebbles of the gravel show effects of both ice and water wear. Most of them exhibit a partial roundness superimposed upon subangularity. Striated pebbles are rare.

Eskers differ from kames only in ground plan, the former being linear in shape, and the latter, where typically developed, being more or less circular. The material is the same, the slopes are the same, the general distribution is the same. The width of the average esker ridge is equal in amount to the diameter of the average kame. Perhaps the average esker is a little lower than the average kame, though the difference is not marked. Wherever eskers are discontinuous, kames occur commonly in the intervals. Moreover, all gradations can be found between kames and eskers, even in shape, from eskers of average length, through short eskers and slightly elongated kames, to typical kames.

Practically all the above-mentioned characteristics have long been known, but they have been interpreted in different ways by different investigators. Eskers were first thought to have been formed by ocean currents, but this theory was abandoned when it was discovered that they are associated with glacial drift, rather than with marine deposits. It was early agreed that they were deposited by water associated with the great continental ice sheets; that is, that they are fluvio-glacial in origin. This idea has stood, and will stand; the proof is too obvious to need demonstration. When the fluvio-glacial origin had been settled, it was first thought that the ridges were the result of deposition by streams flowing on the surface of the ice and the lowering of this deposit to the surface of the ground as the ice melted beneath it. But when the great Greenland glacier had been investigated and it was found that superglacial streams carried little sediment, and deposited none, and that the surface of the ice was relatively free from debris, this idea was abandoned by most people, and the theory of subglacial stream deposition came to take its place. It is agreed by all modern writers that most eskers, at least, were deposited under the continental ice sheets by streams flowing there in tunnels, the tops and sides of which were of ice, and the bottoms of which were the deposits of the stream itself. It is noteworthy that, although all modern text books state the subglacial origin of eskers, all of them do so with some apparent hesitancy or qualification, and some of them state that this theory might not explain all eskers.

In the opinion of the writer the subglacial theory is incompetent to explain all eskers, or even to explain most of them, especially the longer and more broken ones, although it is admitted at once that some eskers may have had such an origin. The writer has had occasion to teach this theory to a dozen or more university classes, both in the class room and in the field, and he has met with only mediocre success. The students who learn by rote accept the theory, learn it by heart and answer questions concerning it accordingly; almost invariably, students who think, either refuse the theory entirely or bring forward objections to it. The objections to the theory will be taken up point by point.

Subglacial streams must be under enormous pressure. All estimates go to show that the thickness of continental glaciers is to be measured in hundreds of feet, even a fraction of a mile from their edges, and the thickness 100 miles toward the center from the edge must be very great. And there is no escape from the conclusion that this weight must rest on the surface of subglacial streams, for present accepted theories of glacial motion are based on the principle that the ice at the bottom cannot maintain the weight of the ice above and that no competent arch could exist at the bottom. It is hardly conceivable that a body of moving ice, which fits into every irregularity of the surface and moves over hills and across valleys, and fits so tightly under overhanging ledges that it striates the under sides of the ledges, could by any possibility maintain open tunnels in its bottom. It seems doubtful that a stream flowing in a crowding ice tunnel under such great pressure would flow slowly enough to allow the deposition of sand. Neither do swiftly flowing streams have a habit of depositing sand and gravel and cobbles and bowlders all together.

Under this theory is it possible that there would be no differences between the materials of eskers deposited by streams under the ice and those of kames deposited by those same streams where they issue from beneath the ice? It is certain that the velocity is greatly checked at the point of issue and that it must be much greater before the stream issues. Should not the subglacial deposits have a coarser texture and a lower textural range?

It has been a source of wonder to all holders of the subglacial theory that esker ridges could avoid destruction by the ice constantly moving over them. That wonder is well founded. The explanation has been that eskers were made and preserved only in the last stages of an ice sheet and near its border, where the movement was slight and the weight of the ice not too great. But eskers which are 50 or 100 miles long could hardly be supposed to have existed under these conditions, at least toward their stoss ends, provided the whole esker was made at one time, as the theory postulates.

Perhaps the greatest objection to the theory is that it does not adequately explain the discontinuities so common in eskers. It has been suggested that the breaks are due to irregular glacial erosion of an originally continuous ridge. But the ends of the individual parts are clearly depositional rather than erosional; at least they cannot be considered to be erosional if the sides of the ridges are not. Also the breaks are just as common where the ridges were parallel with ice motion and erosion was at a minimum, as where their crooked courses brought them at right angles with ice motion and erosion was at a maximum. It has been further explained[3] that the varying degree of confinement of the stream might account for the discontinuities, definite ridges being made only where the stream was confined to definite channels, and the material being spread in irregular areas where the streams were not so confined. The entire absence of stratified material in the intervals in many places, and the abruptness with which the ridges pick up on either side of a break seem evidence against this explanation. What sort of an opening would there be under the ice to contain a ridge 100 feet high and sloping upstream at an angle of 30°? Also, what would be the source of so great a supply of material all at once from a stream which had been so separated that it could not transport a load? Practically an opposite theory has been advanced by Stone,[4] who explains that the ratio of volume of water and size of tunnel varies in such a way that deposition takes place where the stream is small and the tunnel large and the velocity is therefore low, and that deposition fails

[3]Chamberlin and Salisbury, Geology, Vol. III, p. 373.
[4]Stone, G. H., Jour. Geol., Vol. I, pp. 246-254.

when the ratio is reversed and the velocity is great. This presupposes that the stream goes from a small to a large tunnel *very suddenly,* and that open tunnels can exist 100 miles from the edge of an ice sheet where glacial motion is in progress. It is clear that if subglacial streams deposit eskers they do so where the stream is under hydrostatic pressure, for eskers exist on the stoss sides of steep hills, where there must have been pressure to force the water over the hill.

If eskers are subglacial in their origin, it must be concluded that kames, which occupy the discontinuities of eskers, are also subglacial. This necessity has been realized by some exponents of the subglacial theory,[5] and the conclusion has been accepted, but it is not made clear just how kames can be made beneath the ice. These kames in the intervals of eskers are identical in every particular with the normal type of kames known to be deposited at the ends of glaciers.

The writer believes that most eskers are simply kames drawn out into long lines by the slow retreat of the edge of the ice while kame deposition is in progress. If a kame is being formed at the edge of an ice sheet, and the edge retreats slowly, deposition will continue so long as the re-entrant remains and the stream continues to issue there, and the kame will be drawn out into a long ridge or esker. This theory seems to satisfy the points advanced as objections to the subglacial theory and to afford explanation for all of the observed characteristics of eskers as given above. The theory makes it unnecessary to conceive that swift subglacial streams deposit; it explains the close similarity between eskers and kames; it does away with the dim vision of a thick ice sheet moving over a steep, narrow, crooked ridge of non-resistant material without destroying it; it affords a reasonable explanation for discontinuities; and it allows for the presence of kames in the intervals. The discontinuities would result in this wise. During the recession of the edge of the ice, if the re-entrant ceased to exist, or if the stream ceased to issue there, kame deposition would cease; when a re-entrant and the mouth of a subglacial stream again coincided, deposition would begin again. This would make a break in the esker, whose length would be determined by the rate of recession of the ice and the length of time during which deposition was not in progress. Such changes as these would take place suddenly, and the beginnings and endings of the ridges would be abrupt like the ends and sides of kames. It is clear that kame-making conditions might be established at any time for only a brief period, resulting in typical kames in the intervals between the esker ridges. A slowly retreating ice edge, if conditions for kame deposition persisted, would

[5]Chamberlin and Salisbury, Geology, Vol. III, p. 376.

result in a considerable concentration of material and a high, thick esker ridge; rapid retreat would draw out a lower, thinner one; rapidly changing rates of recession would cause an esker of varying thickness and of considerable surface relief. Perhaps the higher knobs of eskers result from a temporary halt in recession. Crooked re-entrants or shifting stream mouths would result in crooked ridges. Where there was one re-entrant and one stream, there would be one ridge formed; where the ice edge was badly broken up and streams ran through all the cracks, the result would be a kame-area drawn out into an intricate series of ridges, rather than a single ridge. Converging cracks would result in converging ridges, diverging cracks in diverging ridges, and crossing and recrossing cracks in intricate reticulated ridges. Where the ice edge retreated uphill, the ridge would be extended uphill, where the ice receded across valleys and divides, the esker would be made to follow a course across a surface of high relief. The rougher the region, the more likely would cracks be in the edge of the ice, which explains the greater abundance of eskers in rough than in smooth regions.

To the writer this theory of the origin of eskers seems better than the subglacial theory, and he thinks that most eskers have been made in the way described, but he would not carry it so far as to say that *all* eskers are so made. It is entirely possible that streams might deposit for a short distance back from the edge under the ice, and that some short eskers and the parts of longer ones nearest their lee ends were made beneath the ice.

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AN AREA OF WISCONSIN DRIFT FURTHER SOUTH IN POLK COUNTY, IOWA, THAN HITHERTO RECOGNIZED.

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It is commonly understood that the Raccoon river, where it flows through Des Moines, lies just south of the southern limit of the Wisconsin drift sheet[1] in Iowa. North of this river the upland of Wisconsin drift presents the character of a youthful ground moraine, marked by gentle sags and swells, with undrained depressions here and there, fea-

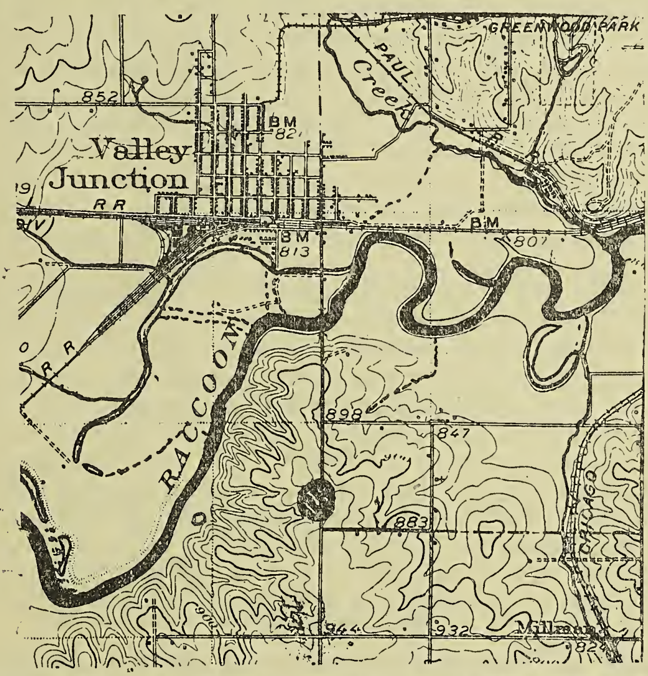

Fig. 8.—Sections 14 and 23 (township 78 north, range 25 west) south of Valley Junction. The area of Wisconsin drift is crosslined. (Topography taken from Des Moines Sheet).

tures that are conspicuous even in so short a distance as that from Des Moines to Ankeny. South of Raccoon river the level of the old Kansan drift plain is still marked by the level of the upland; but the land is well dissected by erosion and the upland in the area of Kansan drift is thoroughly drained by the numerous ramifying ravines. These contrasts are evident, even within the area of a single topographic sheet, that of the Des Moines quadrangle.

[1]H. F. Bain, Geology of Polk county, Iowa Geological Survey, Vol. 7, 1896, page 269. References to other reports are given on page 268; and an excellent description of the physiographic areas on pages 268-273.

In both of the years in which the Des Moines sheet has been included in the list for study at Simpson College the members of the class have called attention to an area mapped as an undrained swale in the upland about a mile and a half south of Valley Junction, in the region ordinarily considered a part of the Kansan drift area. It was to determine whether this representation on the map correctly recorded natural conditions or artificial conditions that a trip was recently made to examine the area.[2]

The swale itself is 250 feet north and south and nearly as wide east and west, shallow, with highway built through the eastern portion of it. Though it lies in the narrow portion of the upland, it is clearly a natural, undrained marsh, as typical of youthful Wisconsin topography as any swale elsewhere in the county.

Nothing but surface muck and soil are visible in the immediate vicinity of the swale, no bowlder clay being there evident. To the south ravines from both east and west extend up into the upland and thoroughly drain it. A few rods to the west and northwest the ravines are cut deep into Kansan drift with its characteristic bowlders and cobbles of greenstone, quartzite (mostly white), and of dark and light colored granite with surface weathered. These cobbles and bowlders are especially numerous in the deeper portions of the second ravine to the northwest, which heads near the swale. The evidence of Kansan drift extends from about eight feet below the level of the swale to the edge of the low ground along the river, below which, of course, nothing is exposed. To the east the erosional topography is of a similar character, but bowlders are not so conspicuous. A quarter of a mile to the north of the swale the drift by the roadside contains small pebbles of dark and light chert at about the upper level of the Kansan drift found in ravines near by to the west. Still further north along the brow of the hill eight feet of loess over three feet (exposed) of stratified sand are cut through in grading the road down to the bridge. The upper portion is typical loess in structure (slightly laminated), yellowish gray in color, almost non-fossiliferous. Fortunately, one perfect shell was found (a large Succinea), one portion of another shell of the same kind, and a few small fragments. The loess extends up into the soil, with no drift between. The base of the stratified sand is not exposed at present, but Kansan drift is found near by to the west.

Even though no Wisconsin bowlder-bearing clay is evident around the swale, this little area on the upland is unmistakably a portion of the Wisconsin topography separated from that north of Valley Junction by the valley of Raccoon river, and deserving to be so recognized in maps of the drift sheets. The present extent of this small area is not over about an eighth of a mile in all directions from the swale. It apparently extends a little further to the east than in the other directions.

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[2]The writer was accompanied by Mr. Theodore Saur and Mr. Lee Butler, students, who assisted in the examination of the region.

PLEISTOCENE EXPOSURES IN CEDAR RAPIDS AND VICINITY.

W. D. SHIPTON.

Lying as it does near the border of the Iowan drift sheet, in hilly country deeply eroded by Cedar river, it might be expected that the city of Cedar Rapids would contain interesting exposures of Pleistocene deposits. Since any geological description of the region was published, the stripping of quarries, cutting of streets, etc., has led to the creation of many new exposures. Some of these will prove more or less temporary in their nature, and it is in the belief that no time should be lost in making permanent records of them, that the descriptions herein contained are here presented. Acknowledgments are due Doctor Gow for his many valuable suggestions and corrections in the writing of the paper.

The North Western quarries are situated directly south of Cedar Rapids just east of the Chicago and North Western railway line. To the west of the tracks there is a slope of a few rods to Cedar river. The quarries consist of a row of deeply eroded hills, which vary greatly in height. The rock was formerly used for building purposes, but at present it is used entirely for railway ballast, it being crushed at the quarries. The following geological strata are found here:

7. Alluvium
6. Loess
5. Buchanan gravels
4. Kansan drift sheet
3. Fayette breccia
2. Kenwood shales
1. Wapsipinicon limestone—Otis beds

The Wapsipinicon exposure consists of the Otis beds. It is very compact, especially near the base; but graduates upward into thin layers of shale. The rock ranges from a light drab to a brown or reddish color. It may assume a light grey color upon weathering. It is very crystalline in character. Much calcite is found in the massive form and occasional pockets are found which consist of whitish, translucent, hexagonal crystals. Seams of calcite are numerous. Lying unconformably upon the Otis are the Kenwood shales. These have been discussed by geologists as the Independence shales, but, although they have the same geological position, they are different in character. Also the Independence shales fauna is not to be found here. There is a sharp line of separation between the Otis and the Kenwood. Near the north end of the quarry are several hills which consist almost entirely of Fayette breccia. This breccia, according to Norton, consists of fragments of Davenport limestone embedded in Cedar Valley. It is a conglomerate mass of limestone pebbles, nodules and fragments cemented firmly together. As the matrix is composed of Cedar Valley limestone, the breccia is fossiliferous.

The Kansan drift sheet begins the Pleistocene part of the exposure. Many interesting and peculiar formations are found here. The Kansan is a very coarse granular clay. Upon being exposed to the weather it assumes a dark yellow color. This is an old Kansan gully.

Immediately above the Kansan comes a band of Buchanan gravels, ranging in thickness from six inches to two feet. The gravel is very coarse and consists of the usual material. The stratification is very distinct and has a typical red coloration. The strata follow the contour of the hill. This is possible, as the stripping cuts at right angles to the old Kansan gully.

The loess is very fine-grained and is of a soft silky material. It is ashen in color. Near the top of the exposure, the loess assumes a heavier color owing to the vegetation and ground water, which have that effect upon it. The texture becomes very nearly that of the Kansan drift, although it is not so coarse. In the western part of the state the weathered Kansan drift has been mistaken for loess, as reported by Gow, and the texture of the weathered loess is certainly much like that of the Kansan. The loess of this exposure varies in thickness from several feet to about twenty feet. It is thicker at the top of the hill than in the valley regions. The reason for this is that when it was deposited it was deposited equally in the valley and on the hill, but the power of erosion is greater in the valley and thus the loess has been eroded faster, leaving a greater amount upon the hill. The concretions of lime carbonate, which are known as loess-kindchen, and which assume many peculiar shapes, are common in this particular formation. Ferruginous casts, which are known as pipe-stems, and are formed about rootlets, are also quite common. The stratification is distinct if carefully looked for. The lines are red and represent different stages in the development of the hill. Each streak probably originated as a band of vegetation which was later covered. The strata are thicker towards the summit of the hill and they follow the contour. Here is a good illustration of the æolian hypothesis. The material was furnished by the old river bars and was blown to its present position. The same is probably true of most of the loess banks of the Mississippi Valley. Upon the top of the loess is a band of recent alluvium, which ranges from one to three feet in thickness. This covers only the gully and hillside, but not the summit of the hills.

Just across Cedar river and a little to the north of the North Western quarries are the Snouffer quarries. They consist of the same Otis beds, and also of the massive calcite, as well as the pockets of hexagonal crystals.

North of the Snouffer quarries is an old brick-yard. At this place we have an excellent exposure of about twenty feet of pure, fine-grained, yellow loess.

At Vernon Heights was an old quarry which had a vertical exposure of about fifteen feet of fossiliferous Fayette breccia. This quarry has lately been destroyed by filling and is now completely hidden from view. Scattered outliers of Fayette breccia are found along the Cedar Rapids and Marion railway.

Another excellent exposure of yellow loess is to be found in one of the cuts of the Mount Vernon Interurban, one mile east of Cedar Rapids. It is about twenty feet in thickness and is decidedly yellow in character.

On 13th street, between F and E avenues, we have an interesting exposure of Pleistocene sands. The sands are about fifteen feet above river level, and about one block from Cedar lake, which is an old ox-bow. The sands are distinctly stratified and represent the old sand bar of the river, the strata being horizontal. In point of age, of course, these sands are very recent.

At the end of 12th street, going north, is a very fine exposure of loess. The bank is about seventy-five feet in height and eight hundred feet in length. The particular thing of interest is that it is nearly all gray loess. In some places yellow loess enters in. But where we find the gray loess alone it is very pure. The color, however, is not constant. Loess-kindchen are very common, some of which attain a very large size. They are the largest that have been found by the writer in Linn county. Vegetable matter is found nearly forty feet below the top of the bank. This would indicate that at one time that was the surface of the exposure. Throughout the loess is stained with iron in large quantities. Here is a good example of how a loess bank will retain its vertical slope under the direct action of weathering. This exposure is only four years old, the rest of the hill having been removed for ballast by the Rock Island railway. There has been very little weathering and the exposure stands as originally made.

On the west side of Cedar Rapids, at the Chandler Hill, is a peculiar formation. At the foot of the hill, or the present ground level, we have the upper surface of the Kansan drift capped by a thin stratum of Buchanan gravels. Just above this is a thin strip of unstratified Iowan sands, probably about four feet in thickness. This is distinctly Iowan, because of the large unrotten bowlders. About one block to the south of this exposure is a clay bank forty feet in height and consisting altogether of typical Kansan drift. The upper level of this is, therefore, forty feet above the Buchanan at the base of the hill. Again to the southwest we have a thick strip of Buchanan gravels, which is just opposite the Chandler home and is thirty-five feet above the Kansan exposure just mentioned. The intermediate ground has been built over and cannot be successfully studied. The situation at first glance would indicate that the Chandler gravels are post-Iowan. But after carefully studying them, the conclusion must be drawn that they are Buchanan. The bowlders are rotten, so rotten that a spade will go right through them; they are all well rounded, and a very large amount of iron is in the exposure. The gravels are, therefore, too old to be post-Iowan. They must, then, be Buchanan. Now the question comes, how is it possible that less than three blocks away we find the same Buchanan gravels seventy-five or eighty feet lower, all connecting evidence being destroyed? This surely cannot be the work of erosion. The conclusion is simply this: As the Iowan glacier advanced, it crumpled the Buchanan gravels up ahead of it. The gravels were probably frozen and were, therefore, crumpled up to their present position. A similar case of this kind, but on a much smaller scale, has been described by Leighten at the Iowa river crossing of the Interurban railway running between Cedar Rapids and Iowa City.

At the top of B avenue hill, east of the river and about the same level as the Chandler exposure just mentioned, but about two miles distant, we have a twelve-foot cut. The lower part consists of stratified and partially cemented sands about three feet thick. Above come seven or eight feet of granular joint clay, which does not contain any pebbles or gravels whatever. There is no trace of stratification, either aqueous or æolian. It has been deeply invaded by roots of grasses and trees, and is to be interpreted as loess whose consistency has been altered by weathering. The underlying sand is probably immediately postglacial in origin, so that the crest of the hill may be taken as forming a portion of the old post-Iowan outwash plain, and is interpreted as being of Peorian age.

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A NEW SECTION OF THE RAILWAY CUT NEAR GRAF, IOWA.

A. O. THOMAS.

The Maquoketa shale is the upper division of the Ordovician of the upper Mississippi Valley. It lies conformably on the subjacent Galena dolomite and is apparently unconformable with the overlying massive dolomitic beds of the Niagaran. In thickness, the formation varies from 160 to 200 feet or more. In common with the other Paleozoic beds of Iowa, it dips gently to the southwest and outcrops in a belt eight to ten miles wide in the northeastern part of the state; this belt is typically developed in Dubuque county and extends to the northwest into adjacent counties and to the southeast into Jackson county and across Mississippi river into Illinois.

Because of the general unindurated condition of the formation it disintegrates so rapidly that natural exposures are discontinuous and few, and its presence as the country rock can best be detected from the physiographic expression that it presents in the form of long gentle slopes and rounded hills. The best artificial exposure of the Maquoketa is seen in a railway cut one-half mile southwest of Graf. The cut is located in the southwest quarter of section 29, township 89 north, range 1 east. A prominent hill or mound, capped by a remnant of the Niagaran is located about one-fourth mile to the northwest of the exposure. The top of the hill is a little more than 200 feet higher than the roadbed of the railway for which the cutting was made. (For map, see the Peosta Quadrangle, United States Geological Survey.)

The first cut in the foot of this hill was made by the Chicago, St. Paul & Kansas City Railway (now the Chicago Great Western) in 1886. Some time later the exposure was visited by Joseph F. James, of the United States Geological Survey, and the results of his studies were published in the American Geologist, Vol. V, pp. 335-356. James, however, did not limit his work to this artificial section but studied the shales with the view of correlating them with the Cincinnati group of southwestern Ohio. For this reason his studies included all the available Maquoketa exposures in the immediate locality and several of the fossils listed by him, page 353, do not occur in the artificial section.

Calvin and Bain give a very careful and detailed section of the cut in the geology of Dubuque county, Iowa Geological Survey, Vol. X, pp. 435-436. Ten or twelve years of exposure to the weather, however, had so obscured the bedding of the upper part of the cut that little more than two-thirds of the section recorded by James was available for their study.

In 1911, the Chicago Great Western Railway Company had the hill cut back thirty-five feet, exposing a face approximately 900 feet long and thirty feet high. The base of this fresh section is not more than fifteen to twenty-five feet above the top of the Galena as may be determined by hand leveling from the contact in the stream bed a short distance to the northeast. Beds Nos. 1 and 2 given below correspond approximately to the upper seven feet of bed No. 5 of the section given by Grant and Burchard on page seven, Lancaster-Mineral Point Folio, United States Geological Survey.

The thicknesses of some of the members described vary somewhat from point to point but the following section taken at about 300 feet from the east end may be regarded as typical:

	Feet.	Inches.
30. Clay shale; plastic, pebbleless, bluish gray, breaks with starchy fracture. Contains occasional flint chips and nodules. Grades upward into soil	3	
29. Hard, yellowish, subcrystalline, slightly calcareous bed. It caps the highest parts of the indurated rock over most of the exposure. Contains broken tubes of Coleolus and fragments of other fossils......................	1	
28. A lean fissile shale; seemingly barren........		3
27. Shale, dark gray to brown, nonlaminated, more or less nodular. Fossils fragmentary.......	2	7
26. Shale, brown to black, fissile, slaty when dry; seemingly barren	1	
25. Shale, brown to gray, nonlaminated, quite fossiliferous in its lower part but barren at its top. Fossils small		9
24. Shale, dark brown, laminated, occasional thin lenses and bands in lower part crowded with the tubes of Coleolus. The Hormotoma occurring at this level is invariably very small		8
23. Shale, gritty, reddish brown, mostly disintegrated to a sort of clay parting. The clay is filled with an abundance of very small fossils and fragments of larger ones		2
22. Shale, fissile, brown to black; tends to split into thin, lenticular, sharp-edged pieces. Fossils few, confined to lower part	1	
21. Shale, gritty, nonlaminated, light brown, slightly calcareous, filled with fossils; the Coleolus tubes are especially abundant and, many of them being hollow, give the rock a porous appearance (16)*..................	1	5

		Feet.	Inches.
20.	Shale, fissile, forms a parting; seemingly barren		2
19.	Shale, drab, very fissile when fresh but weathers into shapeless chips and nodules. Impressions of *Spatiopora iowensis* and of the Orthoceras shells which they enclosed are common. (15)	1	2
18.	Shale, brown to gray, nonlaminated, slightly calcareous. *Orthoceras sociale* abounds, the individual shells being often telescoped into each other. This is Calvin and Bain's fifth Orthoceras bed. (14)		11
17.	Shale, remarkably fissile, slaty when dry, dark gray. A conspicuous horizon containing abundant impressions of the bladelike Bryozoan, *Spatiopora iowensis*. (13)		6
16.	Shale, similar to No. 18 but more crystalline. Abounds in well preserved shells of *Orthoceras sociale*, while occasional fragments occur of a large Orthoceratite, elliptical in cross section, and certainly two or three feet long when whole. Calvin and Bain's fourth Orthoceras bed. (12)		7
15.	Shale, brittle, nonlaminated, gray. Fossils few and very small. (11)......................		3
14.	Shale, hard, gritty, similar to Nos. 18 and 16. Upper part more crystalline than the lower. *Orthoceras sociale* abundant but frequently dissolved away leaving hollow molds partly lined with crystals of calcite and pyrite and encrustations of limonite. This is Calvin and Bain's third Orthoceras bed. (10)		7
13.	Shale, dark, occasionally fissile, often a mere parting. Contains a few fragmentary fossils. (9)		1-3
12.	Shale, brown to gray, nonlaminated, weathers very readily. *Orthoceras sociale* common and most of the individuals compressed as in No. 19, but the Spatiopora absent		5
11.	Shale, similar to No. 12 and has a band in which *Orthoceras sociale* occurs in profusion. This and No. 12 correspond to Calvin and Bain's second Orthoceras bed.		6
10.	Shale, variable in coarseness and hardness, dark gray to black when moist, bluish and brown when dry, imperfectly laminated, earthy. A very fossiliferous zone characterized by the great abundance of *Coleolus iowensis*, *Diplograptus peosta* and many small gasteropods. (7)		6

*Numbers in parentheses refer to practically equivalent members in the Calvin-Bain section, Iowa Geol. Surv., Vol. X., pp. 435-436.

	Feet.	Inches.
9. Shale, compact, dark gray, slightly calcareous, shows banding but is nonfissile; fossils small and broken. (6)		6-7
8. Shale, brown to drab, thinly laminated. Fossils few. (5)		8
7. Shale, gray to black, earthy; the upper two or three inches crowded with comminuted shells. Fossils numerous in parts of this member.	1	2
6. Shale, reddish, soft, in places reduced to a clay parting; seemingly barren		1
5. Shale, dark gray, brittle, nonlaminated; *Hyolithes parviusculus*, *Coleolus iowensis*, and other small fossils stand out in relief on the surface of this member as it is weathered. Nos. 5, 6 and 7 are equivalent to (4).		7
4. Shale, dark, slaty, breaks into angular pieces and fragments; comparatively hard when dry. There is a conspicuous Coleolus band near the middle of the member. Two or more species of Lingula and *Diplograptus peosta* are the most abundant fossils..................	3	7
3. Shale, brownish gray, poorly laminated, compact. No fossils observed.		3
2. Shale, similar to No. 4 but bluer and more fissile. Locally the member contains dark, fissile bands which carry abundant specimens of *Leptobolus occidentalis* and a minute ostracode	5	
1. Shale, brown or black, nonlaminated, contains a few large Lingulas. Covered in large part by talus	2	

The accompanying chart shows the distribution and relative abundance of the fossils in the different members of the section. Among the features brought out in the chart may be mentioned, first, the persistence and abundance of *Coleolus iowensis,* which is found in seventeen of the twenty-four fossiliferous members. Second, *Orthoceras sociale* and other Cephalopods are limited to members seven to twenty-one inclusive; these members are but nine and one-half feet in thickness, which is considerably less than one-third of the entire section. Third, twenty of the thirty forms of life listed are present in number ten.

Further work in the cut will no doubt yield other fossils and the vertical range of some of those tabulated will probably be extended.

DISTRIBUTION OF THE FOSSILS IN THE GRAF SECTION.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Dictyonella (?) sp.	--	--	--	--	--	--	--	--	--	rr	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Hindia parva	--	--	--	--	--	--	--	--	--	rc	--	--	--	--	--	--	--	--	--	--	--	--	--	--	r	--	--	--	--	--
Diplograptus peosta	--	c*	--	cc	--	--	--	--	--	cc	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Diplograptus pristis	--	--	--	--	--	--	--	--	--	rc	--	--	--	--	--	--	--	--	--	--	--	rc	--	--	--	--	--	--	--	--
Streptelasma (?) sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	rr	--	--	--	--	--	--	--	--	--
Cladopora sp.	--	rr	--	--	--	--	--	--	--	--	--	--	--	--	--	--	r	--	--	--	--	--	--	--	--	--	--	--	--	--
Crinoidea; stem segments	--	--	--	--	--	--	rr	--	--	r	r	r	--	--	--	--	--	r	--	--	--	--	rc	r	rc	--	--	--	rc	--
Spatiopora iowensis	--	--	--	--	--	--	--	--	rc	r	--	--	--	--	--	--	cc	r	c	--	--	--	--	--	--	--	--	--	--	--
Lingula whitfieldi	--	rc	--	r	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lingula sp. (large)	c	rc	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	rr	--	r	--
Lingula sp. (small)	--	rc	--	rc	--	--	--	--	r	r	--	--	--	--	--	--	--	--	--	--	r	--	--	--	r	--	rc	--	--	--
Leptobolus occidentalis	--	cc	--	--	--	--	--	c	--	--	--	--	--	--	r	--	--	--	--	--	--	r	--	rr	--	--	--	--	--	--
Orthis testudinaria	--	--	--	--	--	--	r	--	--	rr	r	--	--	--	--	--	--	--	--	--	rr	--	--	--	--	--	--	--	--	--
Orthis (?) sp.	--	--	--	--	--	--	rr	--	--	--	rr	--	--	--	--	--	--	--	rr	--	--	--	--	rc	--	--	--	--	--	--
Ctenodonta fecunda	--	--	--	--	--	--	--	--	--	rc	r	--	--	--	--	--	--	--	--	--	--	--	r	--	--	--	--	--	rc	--
Ctenodonta obliqua	--	--	--	r	--	--	rr	--	--	rc	r	--	--	--	--	--	--	--	--	--	rr	--	r	--	--	--	--	--	--	--
Clidophorus neglectus	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	rc	--
Hormotoma gracilis	--	--	--	rc	c	--	r	r	c	rc	rc	rc	--	--	--	--	--	c	--	--	--	--	r	r	--	--	rc	--	--	--
Pleurotomaria semele (?)	--	--	--	--	--	--	--	--	--	r	rr	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Liospira micula	--	--	--	--	--	--	r	--	--	rc	r	--	--	--	--	--	--	r	--	--	--	--	r	--	r	--	--	--	--	--
Conularia trentonensis	--	--	--	--	--	--	--	--	--	r	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Conularia sp.	--	--	--	--	--	--	--	--	--	r	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	r	--	--	--
Coleolus iowensis	--	--	--	cc	cc	--	rc	rc	c	cc	c	rr	r	--	r	--	--	c	--	--	cc	--	c	c	c	--	rc	--	rc	--
Hyolithes parviusculus	--	--	--	rc	rc	--	--	--	r	rc	rc	--	--	--	r	--	--	--	--	--	rc	--	--	--	--	--	--	--	--	--
Orthoceras sociale	--	--	--	--	--	--	r	r	r	r	cc	c	--	cc	--	cc	--	cc	c	--	r	--	--	--	--	--	--	--	--	--
Orthoceras sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	r	--	--	--	--	--	--	--	--	--	--	--	--
Cameroceras (?) sp.	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	c	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cyrtoceras whitneyi	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	rr	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Calymene mamillatus	--	--	--	--	--	--	--	--	--	rc	rc	--	--	rr	--	--	--	--	--	--	r	--	--	--	--	--	--	--	--	--
Ostracoda (undetermined)	--	cc	--	c	--	--	--	--	--	rc	--	--	--	--	rc	--	--	--	--	--	--	--	c	--	--	--	--	--	--	--

*rr, very rare; r, rare; rc, moderately common; c, common; cc, very common.

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INDIAN POTTERY OF THE ONEOTA OR UPPER IOWA RIVER VALLEY IN NORTHEASTERN IOWA.

ELLISON ORR.

The Oneota, or Upper Iowa, a small river about eighty miles in length, flows through Winneshiek and Allamakee counties in Iowa, close to their northern border, which is also the line between this state and Minnesota. It flows through a beautiful, winding valley, which has a width of half a mile, and is bounded by precipitous bluffs. The glacial terraces which extend up this valley for forty miles to Decorah have afforded very abundant evidences of a former considerable Indian population. Earth embankments, mounds, and camp sites have yielded up a treasure of implements, weapons and ornaments. Notable among these are the large number of small earthen vessels found in burial places and the fewer larger ones which seem to have been buried by themselves.

All along the valleys of the Oneota river and its tributaries, Bear and Waterloo creeks, in Allamakee county, as far up as the benches occur, abundant fragments of pottery may be found. These are pieces of the necks, sides, and the bottoms of pots, kettles or jars, with an occasional handle, usually with a bit of the body and neck attached. Except in or about the circular earthworks, these pieces of earthenware are seldom or never found on the bluff tops or anywhere on the general upland fields. In all the years that I have been collecting I have never found a single piece of pottery anywhere except in the narrow valleys of the Mississippi, the Turkey, the Oneota or its larger tributaries, where they are particularly abundant about the camp sites, and not rare anywhere on the flood plains and benches. Much pottery had been buried, and when the land began to be cultivated it was broken and turned up by the plow.

It was a common custom to bury pots of small size with the dead. They were presumably filled with food for the spirit of the deceased, to sustain it on its way to the happy hunting grounds. Others, larger ones, were buried by themselves, for what reason we are unable to determine. As some, apparently whole, have been struck by the plow,

Note—In the following paper the local name "Bench," is used to designate remnants of the glacial river valley terraces occurring along the Oneota, and all earthenware vessels are called "pots" regardless of the use to which they were put.

where they were buried under fire or hearth stones indicating teepee sites, it may have been customary to place them there, such burial having some religious or other significance.

Very rarely a whole pot has been turned out by the plow, or, much oftener, washed out of one of the numerous ditches that flood water began to cut into the benches and hillsides after cultivation began. Many stories are told by people living in these valleys of finding whole pottery thus washed out, that, after lying about for a while, was broken.

About the year 1890 some persons discovered that some of the graves of the benches, and in the sandy places on the sides and tops of the bluffs, when made, had been covered, or partly covered, with a few flat rocks. As not many were used, and as they had become more or less sunken in the earth and covered by soil or leaf mold, and brush and trees had grown upon and around them, they had not attracted attention before. It now became quite easy for the initiated to discover all these rock-covered graves. It only required patient search, and in the course of a dozen years, all, or at least nearly all, such rock-covered burial places had been found and opened. In many of these pots were found, sometimes whole, but oftener more or less broken—sometimes beyond repair. This pottery so found has been scattered far and wide among collectors.

One digger found seven unbroken vessels on a sandy point of a bench on the west side of the Dorchester road, about eighty rods north of the school house at the forks of the road on section 35 of Waterloo township. Others had been taken out of the same place before. But none of the graves of this small cemetery were rocked over. It had been accidentally discovered by the finding of a pot in a ditch which had cut through one side of the bench. The whole point was then systematically dug over and the skeletons with their pottery and other relics found.

Another burial place on a similar point, on Bear creek, near the northwest corner of section 3, township 99 north, range 6 west, now a part of Mr. Dennis Malone's farm yard, was discovered in the same way by the creek washing out skeletons and pottery. An old man living with Malone claimed that one eighteen inches in diameter was washed out and that he broke it with a rock because it was "Heathen pottery."

Nearly all earthen pottery found at any time along the Oneota, so far as we know, has been of one general pattern—a rounded "pot" bottom, running upward into regularly rounded sides reaching the vertical at about one-half the total height of the vessel, at which point they turn sharply inwards, approaching the horizontal, and then upward, terminating in a neck having a height of from one-fifth to one-third of the entire height of the vessel. The opening, or orifice, of the neck has a diameter of approximately two-thirds of the greatest diameter at the swell. Where the pot is oval shaped the opening is also often oval, and both long and short diameters have the same relative proportion of two-thirds of the long and short greatest diameters.

The greater part of the small pottery is round, with a round orifice, but some of it is very symmetrically oval. Most of the round pots have two handles, on opposite sides from each other, placed much the same as those on a modern common jug, the top of the handle being flush with the top of the neck, and the lower part attached to the upper part of the swell. Some have four handles, placed at one quarter of the circumference apart.

On oval pots the handles are placed at right angles to the shortest diameter, but on many of these, instead of handles, the neck is pierced with holes for a cord or thong. On all small handled pots the hole between the handle and the body of the pot is seldom large enough for the insertion of even one finger, and a cord must have been run through it with which to carry the vessel.

Handles were made of a separate piece and put on after the other part was finished. They are often strengthened and ornamented by a rib on the outside, and sometimes are ornamented by markings similar to those on the body.

The neck and body, from the middle of the swell up, are quite often ornamented with both long and short lines, usually straight, but sometimes curved, indented with the point of a flint or a bone or wood instrument in the soft material before burning, and with rows of indented dots made in the same way. Lines resembling those which could be made by pressing a tightly twisted double string into the soft clay are also found on some. But even where the most elaborate work has been done in ornamentation, anything approaching a symmetrical and regular pattern is not often seen. The top of the neck was sometimes ornamented by pinching around it with the thumb and finger, or by making indentations on the top with the finger, entirely around, forming a sort of scallop. Plate XXIII is from a photograph of pieces showing bits of the more elaborate markings and tracings.

The center of gravity is such that the vessel, though having a rounded bottom, retains an upright position, and if laid on its side will at once resume the vertical.

Among the fragments of pottery picked up on the fields of the Oneota bottoms and benches, and along the ditches washed in the latter, are many pieces of from one-fourth to three-eighths of an inch in thickness, the curvature of which would indicate vessels having a diameter of from one to two feet. While the ornamental markings on the smaller pots are usually quite regular, and sometimes approach elaborateness, and the work was quite well done, these larger ones had little or no ornamentation, and what they did have was crude and irregular.

Handles large enough to thrust from one to three fingers through them are not uncommon among these larger pieces, while the handles of the smaller pots were just large enough to thrust a good sized cord through them.

Pots of the size that these larger fragments indicate are never found in the graves, and it would seem that this larger pottery was probably used for cooking, or for holding water or storing corn or wild rice, or for some of the other various uses to which such jars could be put by families permanently encamped. Abundant fragments of pottery indicate the sites of settlements or encampments of long standing, as this earthenware was of so fragile a nature that great care must have been necessary in handling it, and it is doubtful if it was possible to move it for any distance by the usual methods of Indian transportation.

Occasionally vague reports of the striking of one of these large vessels by the plow, or of the finding of one broken in a ditch, are brought in by some farmer. One was reported to have been struck and broken by the plow in making a dug-way road on the north side of the bench between Bear creek and the Oneota, almost directly south of the bridge across the former, on the northeast quarter of section 2, township 99 north, range 6 west, in Hanover township. Another was reported to have been washed out of a ditch on the Tartt farm on section 36, township 100 and same range, in Waterloo township, and found by Mr. Tartt, but afterwards broken by some horses before being moved to a place of safety. Another was said to have been struck by a road grader and smashed to pieces, near the northeast corner of section 4, township 99 north, range 5 west, in Union City township.

In July, 1907, Harry Orr found one of these large pots in situ in the side of a large ditch in the O'Regan farm, near the center of section 6, township 99, range 5, in Union City township. A cow, in stepping too near the side of the ditch, had broken off a piece of it and exposed the pot to view. Unfortunately most of one side of the bowl was broken off and lost, having been washed away with the earth and sand. The pot lay exactly up side down in the sand, with which it was filled, and the bottom was one foot below the surface. The field had been cultivated at one time, and for about one foot below the surface was a black sandy loam. No bones, flints, shells, burnt rocks or other relics were found with or near the bowl, and the sand with which it was filled was the same as that which surrounded it.

On attempting to remove the wet sand with which it was filled and surrounded, the vessel broke into fragments, the bottom crumbling into small pieces. The writer was present and assisted in removing it but was unable to determine whether or not it was whole when buried. If it was, it must have been packed full of sand before being placed in the ground.

The pot was of the oval type with two handles at right angles to its shorter diameter. These handles were large enough to thrust the fore-finger through them and were ornamented with a central vertical rib. The neck was one and one-fourth inches in height, flaring out quite strongly, and without ornamentation, the lip pinched out and without finger scallops or other ornamentation. The bowl below the neck swelled out strongly and symmetrically and was without ornamentation except some irregular markings from the neck downwards to the swell. The bottom was rounded potlike as usual.

The pieces were glued together and the result showed, that had we been able to save it whole, we would have had a handsome, symmetrical vessel. Plate XXV is from a photograph of it when restored. From the swell of the bowl up it had been stained black on the outside.

DIMENSIONS OF THE VESSEL.

	INCHES
From lip to lip, longest diameter	10¾
From lip to lip, shortest diameter	8¾
Longest diameter at swell of bowl	14½
Shortest diameter at swell of bowl	11½
Depth	9

The O'Regan bench lies along the bluff on the north side of the river, which here runs east and west. It is irregularly rectangular in outline and has an area of about sixty acres. East of it the river turns and runs north, coming in quite close to the bluff, which also turns north. A narrow bench lies along this north and south bluff, having a width at the top of from one hundred to three hundred feet. This north and south bench is composed of light loess clay, easily dug. Scattered through it are fragments of rock, some of which are very large.

On June 14, 1908, Harry Orr found a second large pot in the side of a small ditch which had been washed in the steep slope of this bench about half way to the top. The pot was of the same shape and ornamentation as the one found the year before in the ditch on the O'Regan bench, but was larger, having the following dimensions:

	INCHES
Longest diameter at swell of bowl	16
Shortest diameter at swell of bowl	14
Depth	10½

The circumference of the lip of the orifice is an almost exact circle, having a diameter of eleven inches.

When found the pot lay on its side about one foot below the surface, with the top down hill, was complete, and was filled solidly with clay. The weight of the earth, aided probably by the creeping or sliding down hill of the clay when wet, had distorted it and broken it into many fragments, and may also have been the cause of its lying on its side. On the inside of the bottom was a thin coating of soot or some burned substance. There was also a fragment of a smaller pot. Plate XXVI is from a photograph of this pot when restored.

The right hand figure on Plate XXVII is from a photograph of pot No. 1 of our collection of pottery from the Oneota valley. The greatest diameter is 5 in., the height is 3⅞ in., and the opening at the top 3¼ in. It is a very symmetrical two-handled vessel, but with little ornamentation, having only a few incised lines running from the neck downwards to a little below the swell of the body. In firing it did not turn red but a dark ash color changing to a reddish or pinkish cream on the outside. The whole of the outside of the body and neck, and the inside of the neck, had once been stained black, but much of this had come off.

This pot was taken by Mr. W. F. Dresser, in 1893, from a grave in a sandy spot about half way up the sloping eastern extremity of the high and narrow "Hog Back" or divide between Bear creek and the Oneota, and on the southeast quarter of the northeast quarter of section 2, township 99, range 6. Other graves, rock covered, were also found at the same place.

Above and below this sandy spot the surface is very rocky. At the foot of the slope is a rectangular piece of bench about twenty rods each way, the flat top of which is about seventy feet above the flood plain, and which is said to be thickly dotted with graves, but as they were not rocked over they cannot now be found.

The east end of this bench is a sand "slide", along the bottom of which runs the Waukon-Dorchester road. The bridge across the Oneota, a few rods to the southeast, is known as the New Galena bridge. Sand is being hauled away from the bottom of this slide causing the top to break off from time to time. In the fall of 1910 a piece broke away exposing a part of a skeleton, with which were found, when it was wholly excavated, two silver band bracelets having the word "Montreal" stamped on them.

The left hand figure shown on Plate XXVIII is from a photograph of pot No. 6, of our collection. It is somewhat unsymmetrical, one side of the rim of the neck being an inch higher than the opposite side. Its greatest diameter is 5¼ inches, the height in the center is 3¼ inches, and the opening at the top, 3⅛ inches. It is a four-handled, red burned, unstained pot with something attempted in the way of an incised ornamental pattern, as shown on photograph and figure. This pot was found by Mr. Tartt, about 1900, in a grave on the small bench on the east side of Waterloo creek opposite his residence. A number of other pots were dug up on the same bench by him.

Pot No. 7, shown on Plate XXVII, was dug up close to No. 6, and also by Mr. Tartt. The bench cemetery from which these two were taken is on the northwest quarter of the northwest quarter of section 36, township 100, range 6.

In this pot both body and orifice are oval, and there are no handles. Instead it has holes three-sixteenths inch in diameter punched through the neck, at the ends of the oval orifice, where there are triangular upward projections of the same, somewhat like ears. The top of the swell is ornamented with a few straight incised lines, and the edge of the orifice is indented with shallow notches all around. The long diameter at the swell is 6 inches, the short is 5¼ inches, and the height in the center is 4 inches, the ends of the oval having the holes for suspension cords, rising a half inch higher. The mouth or orifice has a long diameter of 4⅝ inches, and a short one of 4 inches.

This pot shows very distinct marks, both inside and out, of having been rubbed down or smoothed with a piece of dressed skin. As in No. 6, the outside of the body and neck, and the inside of the neck, have been stained black. It is a question hard to determine, whether this black color is a stain, or whether it is the remnants of a coating of soot acquired while in use and still adhering.

Pot No. 2 is higher in proportion to its diameter, and has a larger orifice, than any yet described. It is of the round type, having the following dimensions:

	INCHES
Diameter of swell at five-eighths of height	7¼
Height	5½

The mouth is slightly oval, the longest diameter being 5½ inches, the shortest, 5 inches. It burned to a light ash color in firing, and the outside is blackened in patches. Plate XXIX is from a photograph of this pot. There are two handles, and the ornamentation consists of straight vertical marks on the upper part of the body, and an indented lip.

The pot was found by Mr. W. F. Dresser in the most southerly of a group of rocked-over graves, located on the southern point of the bench under the nose of the southern vertical escarpment of the Elephant, (a hill of circumundation for cut of which see page 46, vol. IV, Annual Report of Iowa Geological Survey), and located on the southeast quarter of the southwest quarter of section 32, township 99, range 5. In the grave was also a flint knife.

In the next grave, also excavated by Dresser, was a four-handled pot containing a clam shell spoon. Two more of this group were excavated by Mr. Bulman and each contained a pot. The remaining one was later excavated by Doctor Ratcliff and in it he found the Dragon or Lizard pipe of dioryte of which Plate XXII is a photograph.

Pot No. 4 seems to be something of an anomaly. It is rudely hemispherical in shape, and without handles or ornamentation. Two holes one-fourth inch in diameter are punched on opposite sides half an inch below the rim. The rim is approximately round, having a diameter of six and one-fourth inches. The depth is four inches. Plate XXX is from a photograph of this kettle. The original was found by W. W. Carpenter, in 1897, in one of a group of rocked-over graves on the top of a low rocky point just north of the Dennis Malone residence. It was in one of these graves that, in 1896, I found a steel table knife almost entirely rusted away.

Very rarely is a pot found having a hemispherical form. On this type the top of the opening is the greatest diameter of the vessel. There are no handles, no lines, dots or other attempts at beautifying this class of ware. Holes are made on opposite sides for thongs.

Tiny pots of no particular shape and with no ornamentation or handles are sometimes found with the skeletons of children. See Plate XXVIII.

On the whole it may be said that the aboriginal dwellers of the Oneota Valley had a sufficient knowledge of ceramics to make pottery that was symmetrically formed and well constructed; that it was easily broken, being usually less than one-fourth of an inch in thickness, and consequently great care was required in handling it, so that it probably was seldom moved from one camp ground to another; and that the ornamentation was simple and crude, and beyond a few incised lines and dots but little was attempted. Nothing approaching the intricate designs of the southern and southwestern pottery is found. In short, these prehistoric potters, while they were able to produce very shapely ware, were unable to add to its beauty by elaborate, intricate and symmetrical designs.

For comparison, a photograph of a pot or jar dug up near Dubuque by Mr. Herrman, in the territory of the Sacs and Foxes, or prior to their occupancy, of the Illini, is shown on Plate XXIV. This shows much greater skill in this line.

The pottery of the Oneota was made of clay, mixed up with pulverized clam shells, and did not always burn red in the firing, but more commonly a slate black or ashy color. Pieces often exhibit a more or less laminated structure.

WAUKON.

[illegible] suf
[illegible]call

PLATE XXII.—Dragon pipe.

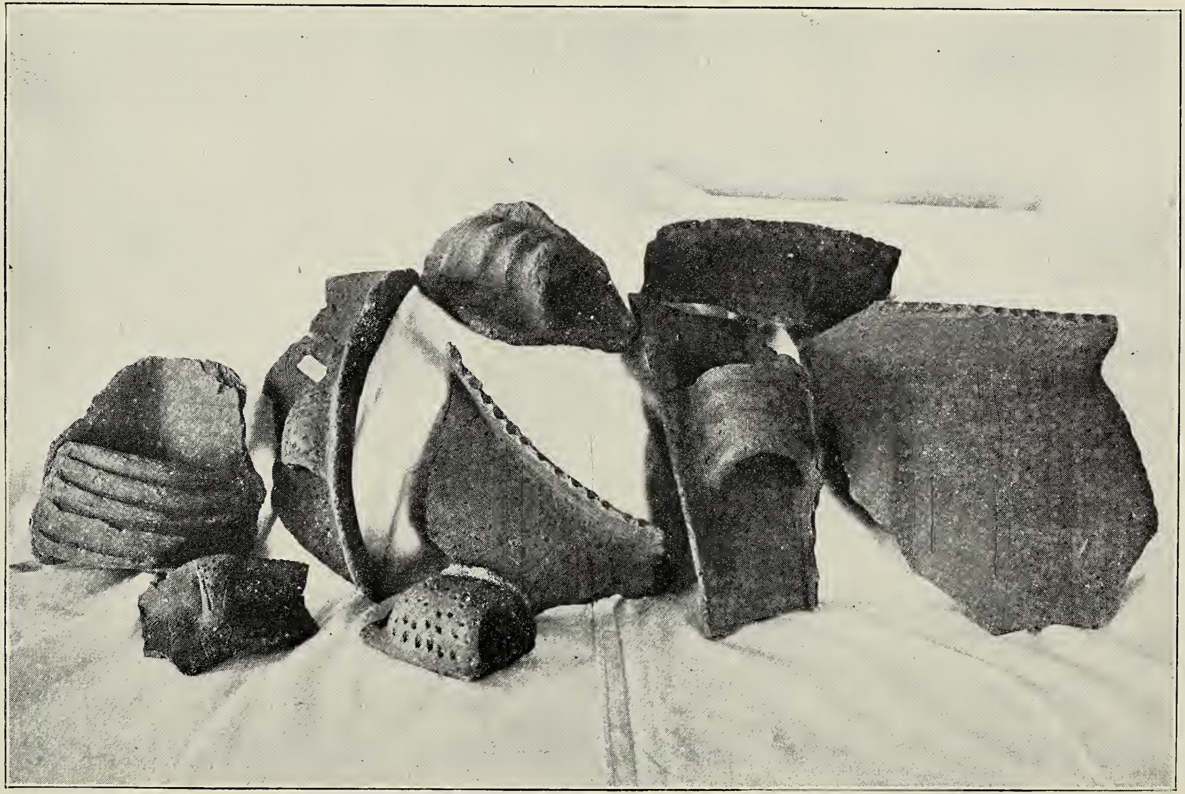

Plate XXIII.—Pieces showing ornamentation.

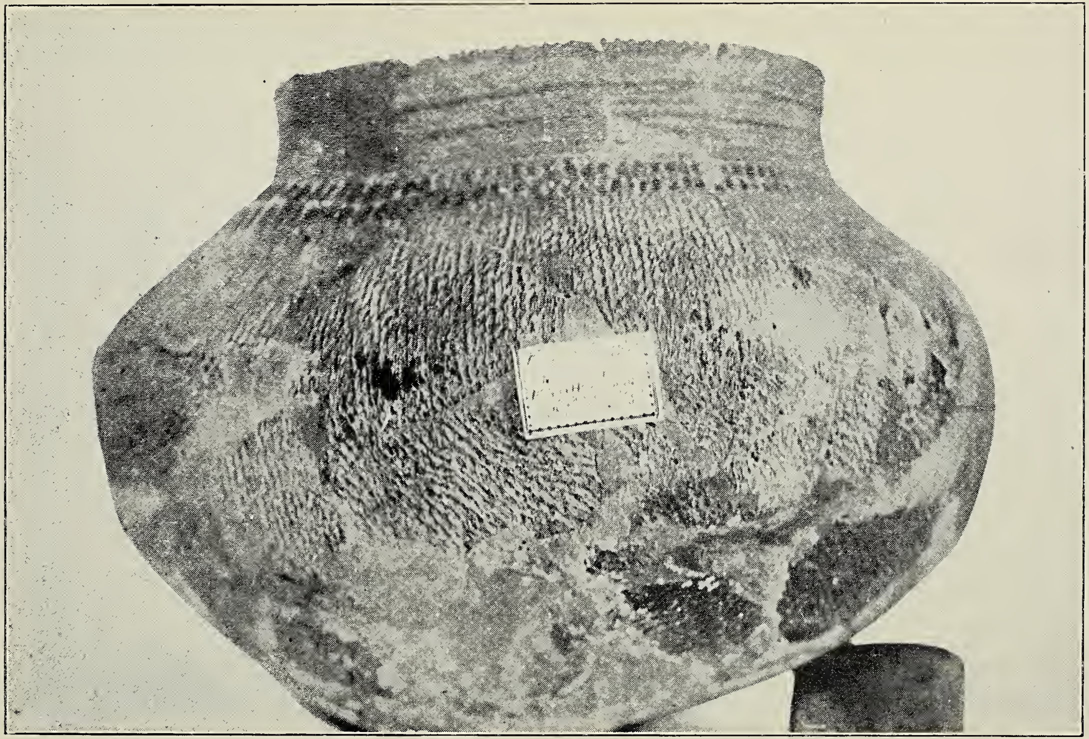

PLATE XXIV.—Herrman pot, from Dubuque.

PLATE XXV.—First large pot found.

Plate XXVI.—Second large pot found.

PLATE XXVII.—Pots number 1 and number 7.

Plate XXVIII.—Pot number 6.

PLATE XXIX.—Pot number 2.

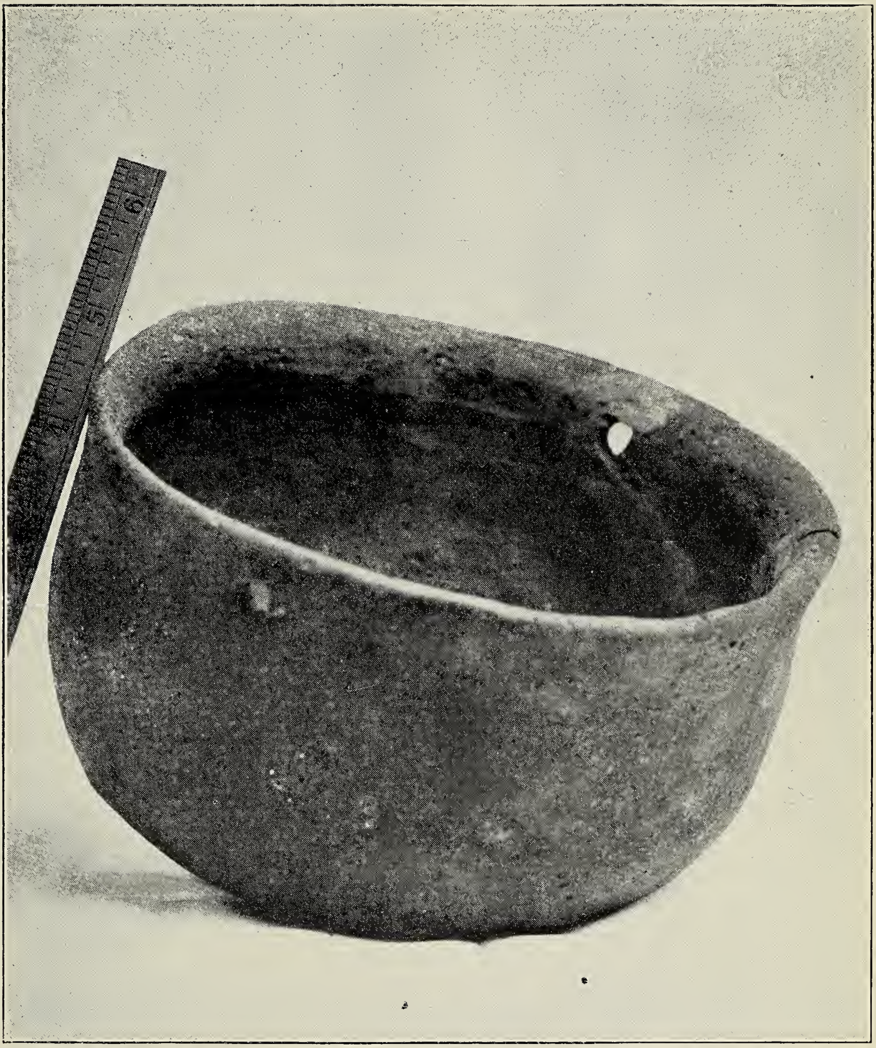

Plate XXX.—Pot number 4.

ILLUMINATING POWER OF KEROSENES USED IN IOWA.

WILLIAM KUNERTH.

HISTORICAL.

The kerosene oil industry in the United States dates back to about the year 1850, although evidences are found in the oil producing regions of Pennsylvania which indicate that the existence of the oil was known long before that date.

According to Brannt,[1] the first barrel of oil was delivered to Messrs. Stout and Hand of Brooklyn in December, 1857, at seventy cents per gallon, and hence this firm may be considered as having sold the first illuminating oil in the United States. Soon the price rose to $2.00 per gallon.

At that time the flame diminished rapidly in height, and went out on its own account in a short time, even when the basin was still half full of oil. The color of the oil soon changed to a dirty dark brown so that people did not wish to keep it in glass vessels. Then too, an offensive odor filled the house where the oil was burned. The facilities for mining the oil and for refining it were much more crude and unsatisfactory than at present. Notwithstanding these difficulties and drawbacks, people were anxious to buy this new oil and scientists were invited to inspect it and take samples home for chemical analysis.

As improvements were made in the production of the oil the industry grew apace until in 1877 (only twenty years after selling the first barrel) approximately 13½ million barrels were sold. It was coming into prominence as an illuminant, and was rapidly replacing tallow candles, fagots, torches, and the use of vegetable and animal oils for that purpose.

The use of kerosene soon made night reading a general practice. Every body could now read, and every body did read. Dr. David T. Day states that the progress of the countries of the civilized world today is in nearly every case directly proportional to their consumption of kerosene.

In 1911 the total production was 345,512,185 barrels.[2] Of this the United States produced practically two-thirds. That the amount of

[1]Petroleum and its Products, and Natural Gas, p. 9.
[2]The Production of Petroleum in 1911, by D. T. Day. Washington 1912, p. 7.

petroleum produced should be increasing between five and ten per cent annually may at first seem surprising. But the extended introduction of electric and gas illuminants in cities and towns, and the partial substitution of acetylene lighting for kerosene oil lamps in the country is more than offset by the increased number of lights required, and the numerous other uses to which oil has been put recently.

THE KEROSENE OIL LAMP AS AN ILLUMINANT.

It would appear desirable to find the best kerosene oil for illuminating purposes, and the conditions under which it should be used, as it seems destined to be the chief artificial illuminant in many places for some time to come, and to retain in a large measure the prominent position it has held. In agricultural districts and for all isolated dwellings it is practically the only illuminant used. Nor need it be replaced; for, as regards cost of installation or general adaptability it is at once the most economical system of illumination available. It is self-contained and portable, besides being a very reliable source of light as attested by its use in railroad signals. Nor is the party using it effected by anything that corresponds to irregularities that occur in the working of the power or gas plant. There are few, if any, artificial illuminants which yield a light so free from detriment to the eyesight as does the oil lamp, because it contains an abundance of yellowish rays from the middle of the spectrum.

The low intrinsic brilliancy of the kerosene oil flame is in its favor. By intrinsic brilliancy is meant the candle power per unit area. This varies with the height of the flame, and was found to be about six candle power per square inch when the flame was at its optimum adjustment. When the flame is lower the intrinsic brilliancy is higher and vice versa. Moreover, it varies with the density of the oil used, being about 4.8 candle power per square inch for a light oil, and about 7.2 candle power per square inch for heavy oil. For the candle the intrinsic brilliancy is approximately three candle power per square inch.

Almost all the modern electric illuminants have a very high intrinsic brilliancy (about 1,000 candle power per square inch for the tungsten filament), and hence shades, globes and reflectors are made necessary. But by this means the total flux of light can never be increased, only decreased; and the installation is less efficient because of it.

Being essentially a small illuminant, the kerosene oil lamp is placed close to the object viewed. If the reader finds that he is inconvenienced by glare due to the specular reflection from the paper, he can shift his position, or that of the lamp slightly and thereby avoid the difficulty.

If he finds that the illumination is too low or too intense, a slight change in the distance from the lamp to the paper he is reading will make considerable difference in the illumination on the paper. This is not the case when the source of light is far from the surface which is to be illuminated, as is usual with electric lamps.

OBJECT OF EXPERIMENTS.

This series of experiments was conducted with a view toward determining the quality of kerosene oils used in this state, and to ascertain the relations existing between the illuminating power of a kerosene oil and some of its physical properties. For a fuller treatment of this subject, consult the bulletin of the Engineering Experiment Station of the Iowa State College under the same heading (No. 37).

When the relations existing between the illuminating power and the physical characteristics of an oil are known, the usefulness of the oil as an illuminant can be specified without actually testing it by burning some in a lamp. The latter is a long and tedious process, and has to be done with great care to get significant results. This may account for the fact that physical methods of investigating this problem have been tried very little. These experiments demonstrate the use of practical photometry, for in no other way can the exact flux of light from a flame be ascertained at all definitely. They also present conditions that must obtain to secure the best results from kerosene oil when used as an illuminant.

APPARATUS.

A two-meter photometer bar, a Lummer-Brodhun screen of the contrast type, a standard voltmeter, a small kerosene lamp with a No. 2 falt-wick burner, a laboratory balance, storage cells, and primary and secondary incandescent carbon lamps were the most important pieces of apparatus used in determining the illuminating power. The wicks used were all of the same make, and seven-eighths of an inch wide. The weights were standardized before the test was begun and were used throughout as were also all other pieces of apparatus. The oil chamber of the lamp used was of metal and had a volume of approximately one pint. The same quantity of oil (about one-half pint) was used in each test in order that the temperature effect produced upon the oil in the basin might be as nearly the same as possible. For the flash and burn points the apparatus used was that of Dr. A. H. Elliott. It is the one our State Oil Inspectors use, being recommended by the State Board of Health.

ILLUMINATING POWER—HOW DETERMINED.

As here used the term Illuminating Power means the number of candle-power-hours-per-gallon of oil. The candle power was measured in one direction only, and that was perpendicular to the plane of the flat flame. The candle power hours are obtained by multiplying the average candle power by the time required to consume one gallon. Thus, when the illuminating power is given as 1,100, it means that the flux of light obtained is equivalent to that of a lamp burning at one candle power for 1,100 hours. A new wick was used for every sample of oil tested. The lamp was placed in one pan of a balance at the end of the photometer bar with the flame always at the same point and perpendicular to the bar. A setting of the photometer screen was made every twenty seconds, and the results averaged. It was necessary to take readings thus frequently, for the candle power was continually changing. Forty-five readings were taken with the flame at any one adjustment. The amount of oil burned and the time during which it was burned, were determined by a balance and a stop watch respectively. Several determinations were made with the flame at different heights and a curve plotted with the candle power as abscissae and illuminating power as ordinates. As stated by Stewart[3] the illuminating power was found to approach a maximum as the flame is increased in height and decreases at about the same rate as the height of the flame is still more increased. The best height of the flame differed for different oils and also depended upon atmospheric conditions. It was therefore constant for no two consecutive trials. By several preliminary tests the height of the flame at which to burn the lamp to be somewhere near the optimum adjustment could be ascertained approximately. It therefore became unnecessary to test the flame either when very low or very high. When the flame burned at its maximum illuminating power approximately an ounce of oil was consumed per hour. At the optimum adjustment the average candle power for the samples tested was 9.3.

One cannot tell by the height of the flame whether he is burning a lamp at conditions of maximum illuminating power or not. That must be determined by experiment. It is partly for the same reason that people employing kerosene as an illuminant do not know whether they are using a good oil or not. They know neither the flux of light obtained nor the amount of oil burned.

Because of the dependence of the illuminating power on atmospheric conditions, it was found necessary to test a sample known as the standard sample every day when unknown specimens were tested, and then the results were reduced to correspond to those of the standard sample.

[3]Physical Rev. Vol. 31, p. 514.

TABLE I.

Number	Cost	Brand	Illuminating power	Cost per 100 C. P. hours in cents	Flash point	Burn point	Density in grams—cc.	Viscosity	Index of refraction	Surface tension	Quantity obtained	Source
1	20	White Swan	1072	1.85	113	156	0.791	141	1.443	3.18	0.86	East
2	13	Perfection	1126	1.15	127	145	0.816	170	1.451	3.22	0.78	West
3	15	Headlight	1126	1.33	120	152	0.821	189	1.460	3.20	0.81	
4	12	Perfection	1105	1.09	137	164	0.819	182	1.456	3.21	0.83	West
5	15	Palacine	1063	1.41	119	142	0.803	145	1.450	3.18	0.78	East
6	20	Olane	1054	1.89	104	133	0.803	140	1.458	3.10	0.94	East
7	12	Puro	1129	1.06	116	146	0.821	195	1.466	3.26	0.85	West
8	10	Perfection	1139	0.88	121	142	0.818	182	1.464	3.21	0.86	West
9	18	Palacine (Red)	922	1.96	116	145	0.791	168	1.448	3.14	0.88	East
10	20	Palacine	902	2.22	115	137	0.792	167	1.447	3.09	0.71	East
11	18	Rosine	1002	1.79	102	136	0.793	160	1.446	3.08	0.88	East
12	13	Northern Light?	1108	1.18	116	142	0.816	172	1.456	3.22	0.85	West
13	15	Northern Light	1115	1.35	113	148	0.816	170	1.459	3.23	0.82	West
14	15	Perfection	1139	1.32	116	157	0.814	168	1.454	3.20	0.80	West
15	12	Northern Light?	1120	1.08	117	152	0.816	172	1.458	3.21	0.72	West
16	15	Family Safety	1120	1.33	117	140	0.818	201	1.462	3.20	0.82	East
17	15	Best	1068	1.41	117	148	0.819	191	1.460	3.23	0.85	
18	15	Best	1124	1.33	120	152	0.817	183	1.455	3.20	0.88	
19	15		1078	1.39	116	150	0.817	193	1.451	3.23	0.94	
20	15	White Swan	1101	1.37	106	140	0.817	194	1.459	3.22	0.94	West
21	13	Gem	1121	1.16	109	156	0.822	213	1.460	3.26	0.93	
22	18	Palacine (Red)	1000	1.79	112	148	0.797	170	1.443	3.14	0.96	East
23	15	Gem?	1098	1.37	114	151	0.823	216	1.460	3.21	0.95	West
24	20	Superb?	1043	1.92	106	141	0.797	156	1.443	3.11	0.86	West
25	13	Gem	1111	1.16	112	150	0.823	219	1.462	3.23	0.93	West
26	15	Gem	1062	1.41	105	143	0.816	196	1.457	3.21	0.90	West
27	15	Gem?	1133	1.32	109	153	0.816	197	1.459	3.22	0.92	West
28	13	Perfection	1109	1.18	109	150	0.817	195	1.460	3.21	0.90	West
29	15		1112	1.35	120	156	0.817	193	1.459	3.25	0.95	
30	20	Penn Coal	1112	1.79	122	153	0.816	192	1.462	3.25	0.91	East

TABLE I—CONTINUED.

Number	Cost	Brand	Illuminating power	Cost per 100 C. P. hours in cents	Flash point	Burn point	Density in grams—cc.	Viscosity	Index of refraction	Surface tension	Quantity obtained	Source
31	15	Perfection?	1105	1.35	115	153	0.819	198	1.467	3.22	0.90	West
32	12	Daisy White	1082	1.11	110	155	0.815	187	1.453	3.21	0.91	West
33	15	Radio?	955	1.56	110	142	0.796	169	1.450	3.16	0.93	West
34	18	Ruby (Red)	885	2.04	109	146	0.791	174	1.443	3.11	0.87	East
35	18	Penn Special?	967	1.85	102	140	0.796	152	1.447	3.11	0.89	East
36	15	Eclipse	1090	1.37	116	155	0.808	166	1.451	3.19	0.92	West
37	15	Daisy White	1124	1.33	116	156	0.817	179	1.451	3.23	0.97	West
38	15	Home Oil	1077	1.39	110	146	0.816	183	1.456	3.22	0.95	
39	12	Home Oil?	1089	1.10	111	154	0.816	182	1.457	3.22	0.91	
40	12	------	1102	1.09	111	150	0.814	189	1.457	3.21	0.91	
41	15	------	1032	1.45	103	147	0.796	153	1.452	3.09	0.90	
42	15	Posco Special?	1016	1.47	102	135	0.797	153	1.449	3.09	0.87	East
43	18	------	936	1.92	102	135	0.798	189	1.445	3.14	0.87	
44	15	------	1121	1.33	116	152	0.812	198	1.451	3.22	0.94	
45	15	Water White	1129	1.33	112	150	0.819	211	1.458	3.23	0.94	West
46	10	Water White	1108	0.90	114	145	0.819	200	1.457	3.22	0.93	West
47	10	------	1128	0.88	117	156	0.821	204	1.462	3.24	0.94	
48	10	------	1129	0.88	118	153	0.820	204	1.461	3.25	0.93	
49	13	Gem?	1116	1.16	106	142	0.822	204	1.460	3.24	0.87	West
50	20	Life Guard (Red)	1046	1.92	111	138	0.797	164	1.447	3.13	0.93	
51	20	Penacene (Red)	944	2.13	106	140	0.792	183	1.445	3.11	0.94	
52	-----	White Swan	959	------	112	138	0.789	145	1.443	3.07	------	East
53	-----	Water White	982	------	112	131	0.796	171	1.447	3.12	------	East
54	-----	Prime White	1056	------	115	136	0.808	210	1.457	3.18	------	East
55	-----	(Standard Sample) Perfection	1114	------	122	148	0.819	183	1.462	3.19	------	West
56	20	Palacine	978	2.04	117	150	0.793	------	1.443	3.12	------	East
57	18	Palacine (Red)	930	1.92	110	148	0.788	------	1.442	3.11	------	East
58	10	Perfection	1065	0.93	124	158	0.818	------	1.457	3.22	------	East
59	18	Ruby (Red)	940	1.92	112	140	0.792	------	1.451	3.10	------	West
61	-----	------	973	------	122	167	0.818	------	1.456	3.23	------	East
60	-----	Perfection	1139	------	110	141	0.792	------	1.447	3.12	------	West

RELATION OF COST TO ILLUMINATING POWER.

As a rule the greater flux of light is obtained from a gallon of the cheaper oil, in fact it might be stated that the lower the cost the higher the illuminating power. The cost of 1,000 candle-power-hours of each oil is seen to vary over a wide range as shown in table II.

TABLE II.

Cost per Gallon	Average Illuminating Power	Number of Samples	Average Cost of 1000 C. P. Hours
10 cents	1114	5	8.9 cents
12 cents	1105	6	10.9 cents
13 cents	1115	6	11.7 cents
15 cents	1090	22	13.8 cents
18 cents	948	8	19.2 cents
20 cents	1019	8	19.7 cents

When considering only the seven samples of red oil tested, it was found that the average cost is 18.57 cents per gallon, their average illuminating power is 952 candle-power-hours-per-gallon, and the cost of 1,000 candle-power-hours is 19.6 cents, thus showing that it is less economical to purchase red oil. The common belief that the more expensive oils are the better is here clearly shown to be false. As a rule, they are obtained from eastern oil fields, but give less light than the oils from the west whether considering the total flux of light from a gallon or that obtained for unit cost. Even at the same price per gallon, the oils now sold for the least cost would be the better bargain.

DENSITY AND ITS RELATION TO ILLUMINATING POWER.

The density of the oils was obtained by the use of a specific gravity bottle in the ordinary way, and could be determined with great accuracy. Corrections were made for temperature as usually, the coefficient of expansion being assumed constant for the different samples. The results showed a fairly definite relation between density and illuminating power. The average density of the oils whose illuminating power is less than 1,100 candle-power-hours-per-gallon is 0.801 grams per cubic centimeter, while the average density of the oils whose illuminating power is more than 1,100 candle-power-hours-per-gallon is 0.818 grams per cubic centimeter, thus showing that the illuminating power increases with the increase in density.

FLASH POINT, AND ITS RELATION TO ILLUMINATING POWER.

The flash point as defined by the law of the state is the lowest temperature at which sufficient vapor is given off to produce a perceptible flash when a small flame is passed over the surface of the oil. The law requires that the flash point should be above 100 degrees F. The lowest flash point found in all the samples tested was 102 degrees F. The flashing test is a very important test as it is the inflammable vapor evolved that causes accidents. In recent years the great demand for gasoline has caused refiners to distil off more of the lighter ingredients and hence leave the average kerosene oil denser, and less volatile than formerly.

From certain experiments it appears that the temperature of the oil in burning lamps often rises above 100 degrees F. The temperature fixed by the law of the state at or below which an oil shall not flash, is therefore not too high.

The oils having a high illuminating power were found also to have a high flash point and vice versa. The average flash point of the oils having an illuminating power of less than 1,100 candle-power-hours-per-gallon is 110, while that of the oils having an illuminating power above 1,100 candle-power-hours-per-gallon is 116.

BURN POINT AND ITS RELATION TO ILLUMINATING POWER.

The lowest point at which an oil will ignite and burn is to be taken as the burning point. The results of this test showed that an oil having a high flashing test also has a high burning test, whereas the reverse is not true. In the flash test only the vapor over the oil burns or explodes, the oil itself is not affected; in the burn test the oil continues to burn on the surface. The two points can therefore never agree, and in these tests there was found a difference ranging from 18 degrees to 47 degrees F.

While the relation between the illuminating power and the burn point is not as well marked as between the illuminating power and the flash point, the figures seem to indicate clearly that an oil with high burn point can be expected to have a high illuminating power and vice versa.

VISCOSITY AND ITS RELATION TO ILLUMINATING POWER.

The relative viscosities were determined by means of a long capillary tube. In general it may be stated that the oils with high illuminating power are comparatively viscous. A range of over fifty per cent was found in viscosity.

SURFACE TENSION AND ITS RELATION TO ILLUMINATING POWER.

The surface tension of these kerosenes was determined by the drop method. Three hundred drops of each sample were weighed, and these weights taken as proportional to the surface tensions. Corrections were made for temperature as usually. A high surface tension is in general accompanied by a high illuminating power of a kerosene.

FOGGING OF CHIMNEY.

This series of tests afforded an excellent opportunity to determine which oils fog the chimney most and which least. This was done by first having the standard sample of oil fog a chimney and then comparing with it another chimney fogged by another sample. It can be said that the heavier oils fog the chimney more than the lighter oils do. This necessarily does much to counteract the low illuminating power of the lighter oils as in the case of these latter the labor or expense of cleaning the chimney is lessened. It should, however, be noted that the oils which fog the chimney most, thereby reduce their apparent candle power, and hence their illuminating power is even better than recorded on account of the absorption of light by the fogged chimney. In other words, the flame that fogs the chimney most is at a disadvantage when the burning quality or the illuminating power is determined.

ILLUMINATING POWER AND CHARRING OF WICKS.

Another part of this work consisted in determining the length of wick charred after a lamp had burned for a definite period. With the wick newly trimmed, the lamp was burned for twenty hours, and it was observed that in general the oils that gave the lowest illuminating power had charred the wicks most. This would seem natural, as charring of the wick is probably due to foreign matter in the oil. In these tests the flames were started at practically the same candle-power, with the same amount of oil in the basin, and using the same chimney and burner.

OPTICAL PROPERTIES.

Red Oil.—Among the samples collected were seven that had been colored red, probably either with alkanet root or with red aniline. It will readily be noticed by reference to the table that the illuminating power is less for these oils than for the others. It will also be noticed that the density of these oils is low, and that, as previously stated, one might expect a low illuminating power. Accordingly, one of the heavy oils was colored with alkanet root in the laboratory and tested. It was found that even with a slight coloring its illuminating power was decreased by almost two per cent. While the amount of coloring matter introduced is very small, it nevertheless seems sufficient to increase the clogging of the wick appreciably.

Index of Refraction.—The index of refraction was determined by the prism method. The data indicate that high illuminating power and high index of refraction go together, and that knowing the latter the former could in general be foretold.

Effect of Light on Illuminating Power.—A glass bottle filled with kerosene and securely corked was placed outdoors where it was exposed to daylight and sunlight for six weeks. At the end of that time the oil was tested again. It was found to have suffered a decrease of fifteen per cent in its illuminating power. According to Brannt[4] ozone is formed when oil is exposed to light. This is probably responsible for the reduction in the illuminating power. It therefore seems advisable not to keep kerosene oil where it is exposed to light.

SCOPE AND RELIABILITY OF TEST.

Of the sixty-one samples tried in all, a few were duplicates in brand and several in price. Almost all of the samples tested were gotten in close succession in order to be able to compare the prices at which they were retailed, owing to the unsteadiness in the market. The oils were gathered in gallon lots in person. In general it was the purpose to get as great a variety of samples used in this state as it was possible to get. It was considered advisable to test a great many samples, and to gather them from many different localities in order to make a fair and comprehensive test of the oils used. Accordingly oils were gotten from thirteen different cities and from forty-five different merchants in this state.

Five samples were purposely duplicated, i. e., a gallon of the same brand was bought from the same dealer. This was done six months after the first samples were gotten in order to determine whether any brand of oil could be relied upon as giving the same result even if it came from another tank, and had probably been refined at another time.

No. 56 is a duplicate of No. 10.
No. 57 is a duplicate of No. 9.
No. 58 is a duplicate of No. 8.
No. 59 is a duplicate of No. 34.
No. 60 is a duplicate of No. 55.

[4]Petroleum and its Products, and Natural Gas, p. 46.

These special samples were duplicated because they were in general most readily accessible, and, because among them were found some of the poorest and some of the best oils in the whole series. It will be noticed that these duplicates check the originals with reasonable closeness. The brand name was gotten from the dealer whenever possible, or from the distributing house whence the dealer bought his oil. It is to be regretted that for a few of them,—among these some of the best,—it was impossible to obtain the brand name.

COLOR OF KEROSENE FLAME.

Perhaps every one has noticed that in general the light from a tungsten lamp is more nearly white than is that from a kerosene oil lamp. That there is a difference in the color of the flame produced by different samples of kerosene oil, may not be so generally known. It was noticed during the progress of these experiments that the flames from the lighter oils were more nearly white than those from the denser oils. The color also varies considerably with the height of the flame, being more nearly white when the flame is low. This seems due to the fact that when the flame is turned higher the carbon particles get red hot, no longer white hot.

RELATIVE COST OF TUNGSTEN AND KEROSENE ILLUMINATION.

Inasmuch as the tungsten lamp is the chief illuminant where it is available at present, it seemed desirable to make a comparison between the cost for a certain flux of light from a tungsten lamp, and for that from a kerosene lamp. The cost of kerosene illumination from the average of the samples tested is found to be 19 cents per 1,000 mean-spherical-candle-power-hours. By mean-spherical-candle-power is meant the average candle power of a source taken over the surface of a sphere having its center at the source of light.

At an efficiency of 1.25 watts per mean-horizontal-candle-power for tungsten lamps and at a cost of 11.7 cents per kilowatt hour (the cost of electric energy at Ames), the price of tungsten illumination is also 19 cents per 1,000 mean-spherical-candle-power-hours.

Ordinarily then, the cost of illumination is practically the same whether tungsten lamps are used or kerosene oil lamps are used, it being understood that this is for the same flux of light. However, with kerosene illumination rooms are very seldom lighted up to the same degree of brightness as they are with modern electric lamps. Nor does this calculation take into consideration the numerous factors that must be reckoned with when the total cost of an illuminant is determined.

BURNING QUALITY.

By "burning quality" is meant the ability of a flame to remain a constant height. The retrogression of the flame has been ascribed to various factors. One of these is the clogging of the wick by the residue in the oil; one is the temperature at the wick producing charring; another is the lowering of the oil in the holder. It used to be thought that oil became denser as some of it was burned, and that this caused a retrogression in the candle power. This, however, has been shown by several experimenters[5] not to be the case.

In this series of experiments the candle power was determined hourly for eight hours immediately preceding the end of a twenty-hour interval at the beginning of which the first reading was taken. In approximately half of the cases the candle power at the end of twenty hours was higher than when the first reading was taken, which was about twenty minutes after lighting the lamp. This shows that tests that run for less than twenty hours show little if anything concerning the "burning quality." The flame fluctuates constantly, and at the end of one hour may be quite different from what it was when the first reading was taken, but it usually comes back more or less closely to its normal candle power. In a few cases a lamp was burned for considerably longer than twenty hours (as many as thirty-nine hours in one case), and even then the flame was higher in some cases at the end of the series of observations than near the beginning.

It seems then, that the oils used in this state have practically the same burning quality when tested under the same conditions, and they are of sufficiently high grade that no depreciation in flame height or candle power would be noticed during the time that an ordinary lamp takes to burn dry, even when tested by accurate photometrical means.

ILLUMINATING POWER AND DRAFT.

The experiments here recorded were performed when the ventilating fans were shut off so as to produce a minimum amount of flickering of the flame. The standard sample was tested immediately before or very soon after any sample was tested, and hence no error was introduced on account of the air becoming vitiated or changed in any other way.

For the sake of determining the effect of the draft on the illuminating power a small office fan was set in operation a few feet from the lamp so as to produce an appreciable draft, and the illuminating power was determined. It was found that with the flame at the same height the

[5]Brannt, "Petroleum and its Products, and Natural Gas," p. 58.

illuminating power was about seven per cent less when the fan was running than when it was not running. There was a decrease in the candle power, and a much greater decrease in the illuminating power when the fan was running.

EFFECT OF AIR ON THE ILLUMINATING POWER OF AN OIL.

It was thought desirable to determine the effect on the illuminating power of kerosene oil when air is stirred into it. Accordingly a sample of an oil was placed in an open bottle and left in a dark room. Air was stirred into it several times a day for six weeks. On testing, its illuminating power was found to have decreased by seven per cent.

QUANTITY OF OIL OBTAINED.

Inasmuch as a great number of samples were collected, the quantity of oil received on an average when a gallon was paid for was significant. Table I shows that in no case was more than 97 per cent of a gallon obtained. This could not be due to the deficiency in the size of the can for it was determined by actual measurement that out of fifty-one cans, only three were found slightly wanting in volume, and these three contained on an average as much oil as the others.

SUMMARY.

The results of this series of experiments can be summarized as follows:

1. By the application of ordinary photometric methods great differences in the illuminating power of different samples of kerosene oils have been shown.
2. Oils from the east have a lower density and are sold at a higher price than those from the west.
3. Those oils which have a high illuminating power were found also to be high in density, index of refraction, viscosity, surface tension, flash point, and burn point. The length of wick charred was shorter, and the fogging of the chimney was more marked than for the oils having low illuminating power.
4. The oils which were retailed at lower cost gave more light.
5. By putting coloring matter into an oil the illuminating power is decreased.
6. By exposing oil to light, the illuminating power is decreased.
7. Draft reduces the illuminating power.
8. The denser the oil the greater is the intrinsic brilliancy of the flame.

9. Air in oil seems to decrease the illuminating power.

10. For a given flux of light the cost of illumination by kerosene oil lamps is about the same as that by tungsten lamps.

11. The oils used in this state have practically the same burning quality.

12. Kerosene oil lamps are not very desirable as standards of comparison.

13. The quantity of oil received for a gallon is often very deficient.

14. The lighter the oil the more nearly white is the flame.

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THE VARIATION OF SOUND INTENSITY WITH DISTANCE FROM THE SOURCE; AN INTERESTING CASE OF DEVIATION FROM THE INVERSE SQUARE LAW.

HAROLD STILES AND G. W. STEWART.

The phenomena of sound present many interesting features and diffraction is not the least. The writers have been able, by an extension of Rayleigh's theory, to determine the effect in the neighborhood of a rigid sphere produced by a source of sound located on that sphere. One of the results of this theoretical investigation is the establishment of the variation of the intensity of sound with the distance from the center of the sphere. The computations necessary for approximate numerical results are tediously long, and those given herewith are merely those that were readily available in other investigations of the writers.

The results are shown in Tables I and II. r is the distance from the center of the sphere, and the angle given is that between the two lines, one drawn through the source of sound and the center of the sphere, and the other from the center to the point for which computation is desired. The variable shown is the number which must be multiplied into the inverse square of the distance from the center to give the correct relation between the various intensities.

TABLE I.

Wave Length, Approximately Middle C. Circumference of Sphere, 60 cm.

r	0°	30°	60°	90°	120°	150°	180°
19.1 cm.	6.28	3.54	1.28	.652	.655	.756	.777
477.0 cm.	1.04	1.03	1.02	1.00	.978	.968	.957
1910.0 cm.	1.00	1.00	1.00	1.00	1.00	1.00	1.00

TABLE II.

Wave Length, Approximately an Octave Above Middle C. Circumference of Sphere, 60 cm.

r	0°	30°	60°	90°	120°	150°	180°
19.1 cm.	4.24	2.58	1.14	.622	.396	.329	.270
28.6 cm.	2.26	1.81	1.18	.728	.564	.446	.420
76.4 cm.	1.75	1.53	1.15	.862	.661	.544	.520
477.0 cm.	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Aside from the theoretical interest in the results obtained, there is a practical significance to be found in the subject of architectural acoustics, where the variation of the sound from the speaker is desired. Of course in this case there are assumed to be no reflecting surfaces excepting the rigid sphere.

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NOTES ON THE CONSTRUCTION OF SELENIUM BRIDGES.

E. O. DIETERICH.

The value or effectiveness of a selenium bridge depends upon several factors; namely:

1. The resistance of the bridge.
2. Its permanence, or stability.
3. Its sensitiveness, i. e., the ratio of the resistance of the bridge in the dark to that in the light.
4. The shape of the wave-length-sensibility curve.

This paper summarizes the results of an investigation of the conditions governing the production of selenium bridges of certain types.

In this investigation bridges of the Bidwell type were constructed; that is, two parallel wires were wound spirally around an insulating form, and the spaces between the wires were filled with selenium. In applying the selenium to the form the following method was adopted. The form was first heated to a temperature slightly above that of the melting point of selenium, 217°C., and then the selenium, in stick form, was rubbed over the heated surface. In this way, a thin, uniform layer of selenium was obtained which crystallized immediately, on cooling, to the gray metallic variety, which is conducting and light-sensitive. However, in these experiments, the resistance was, in general, very high, and the sensitiveness low. The samples were, therefore, subjected to an annealing process; i. e., they were kept in an electric oven at a high temperature for some hours. After annealing each sample was immediately transferred to a glass tube which had been carefully dried and which was then securely sealed to prevent the access of moisture and vapors. With these precautions all of the samples were found to be permanent, with respect to light sensitiveness, at least throughout the duration of this investigation, and very steady.

To analyze the bridges the same method of procedure was followed as that described by Doctors Brown and Sieg[1], and the same apparatus was used. The analysis revealed several new types of wave-length-sensibility curves. It was found that some bridges, instead of showing a maximum sensitiveness to red light, were most sensitive to blue light. In general, two types of curves resulted; those that showed a maximum at wave lengths shorter than 640$\mu\mu$, and those that had a maximum at wave lengths greater than $640\mu\mu$. Those which showed a maximum above $640\mu\mu$ had a pronounced minimum at $640\mu\mu$, a broad maximum at the shorter wave lengths, and a sharp maximum at either $700\mu\mu$, or $720\mu\mu$. Maxima were found at the following wave lengths in various samples: $440\mu\mu$, $500\mu\mu$, $550\mu\mu$, $700\mu\mu$, $720\mu\mu$, and $800\mu\mu$. The location of the maximum was found to be dependent upon the method of annealing; those samples annealed at temperatures above 190°C. had a maximum in the blue, while those annealed at temperatures below 190°C. showed a maximum in the red.

The resistance of the bridges, also, was found to vary with the procedure adopted in annealing, in a manner previously described by Ries[2], who, however, gave this phase of the subject but a very brief consideration. With very few exceptions, the samples annealed at a temperature near the melting point of selenium had a low resistance. Some of those that were annealed at 180°C. or 190°C. were given a short preliminary heating at 210-215°C. It was found that those so treated also had a low resistance, while others made at the same time but not given this preliminary heat treatment had a resistance much higher, in some cases, ten to fifteen times as great.

With regard to the conditions governing the sensitiveness of the bridges much cannot be said at this time, except that the sensitiveness also seems to be dependent solely upon the method of annealing. Two samples, much more sensitive than the rest resulted, and, as far as is known to the author, the only difference in making was in the temperature control during the annealing process. These samples, however, did not retain their high sensitiveness, nor has it been possible to duplicate them.

A more complete discussion of the results of this investigation is in preparation, and is soon to be published in the Physical Review.

The writer wishes to acknowledge his indebtedness to Doctor Brown and to Doctor Sieg for the use of their apparatus and for their many helpful suggestions.

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THE ADAPTATION OF SELENIUM TO MEASUREMENTS OF ENERGY TOO SMALL TO BE MEASURED BY OTHER DEVICES.

L. P. SIEG AND F. C. BROWN.

As a brief introduction to the subject matter of this paper, a review of the various devices used in energy measurements will not be amiss. The devices are not numerous, and they are familiar to every one at all conversant with the methods of physics. They are the thermometer, the differential thermometer, the thermopile, the bolometer, the radiomicrometer, and the radiometer. Several other devices have at different times been suggested and used, but the above represent the most important ones.

In regard to the relative merits of the various devices above, it is hard to be certain. Coblentz of the Bureau of Standards, who has devoted careful study to these devices, has come to the conclusion that they can all be made about equally sensitive, and that each has its peculiar merits. The nature of the problem is the important thing in deciding which device to use. However, in comparing the sensitiveness of the various types of instruments that have been used in different pieces of work, one finds a great deal of confusion, and there is a crying need for a more exact standardization of these instruments than has hitherto been extensively used. A few considerations will make this statement clear. One commonly hears, for example, of a radiation receiving device so sensitive that it will detect the presence of a candle at a distance of nearly two miles. That statement is decidedly indefinite, and yet we see similar statements in many of our texts. Here are some of the questions that one should feel like asking after reading such a statement. What sort of candle is used? A paraffin candle gives a greater amount of energy than a tallow candle in, roughly, the ratio of 14 to 9, in accordance with a test made by us quite recently. How large a receiving surface is used, and what is the material of that surface? Are there any auxiliary devices to enable one to collect more radiation than usually would fall upon the receiver? How sensitive a galvanometer is used (providing that the device requires a galvanometer)? How far from the galvanometer is the receiving scale for the spot of light? How much absorption has been allowed for, both in the intervening air, and in the protecting devices of the instrument? It is through failure to answer specifically such questions as these that one is practically unable to make any comparisons as to sensibility among the various radiation receiving devices that have been used in actual researches. We suggest that anyone working with such an instrument should specify the following things: the area of the receiving surface, and whether it can be considered as practically a black body; the figure of merit of the galvanometer used (if one is used); the scale distance; the resistance of the galvanometer and thermopile (or other device); and lastly, the number of watts falling per square mm. upon the surface, that are necessary to give one mm. deflection of the combination of instruments. The Bureau of Standards is putting out standard lamps which when supplied with certain definite currents are calibrated so as to give definite numbers of watts per $mm.^2$ at a given distance. This is surely superior to the candle. If such information as this is given, it is evident that comparisons among such devices can very readily be made.

To illustrate the above let us cite the example of a linear thermopile with which we have been working. This instrument is of the Rubens type, made by Coblentz of the Bureau of Standards. It is of his special series-parallel design, and the wires are of bismuth and an alloy of bismuth and tin. This instrument has a blackened receiving surface of 22.5 $mm.^2$, and a resistance of 2.25 ohms. This thermopile when used with a galvanometer having a figure of merit with the scale at 125 cm. of 5×10^{-10} amperes per mm. and a resistance of 1.35 ohms. gave one mm. deflection when a total energy of 4.1×10^{-8} watts fell upon the receiving plates. This was an energy of 1.8×10^{-9} watts/$mm.^2$ on the receiving surface. It may be added that with this same combination of instruments, a paraffin candle at a distance of 200 cm. gave 140 divisions on the scale. Assuming no absorption, and assuming further the inverse square law, this candle would give one division at a distance of about 78 feet. This at first thought does not compare favorably with Boys'[1] distance of sensibility of about two miles (In fact his work indicates 1.3 miles). However, examination of his work shows that he used a sixteen inch mirror with which to concentrate his beam of light from the candle. If the same device were applied to our apparatus, the candle (assuming no atmospheric absorption) could be placed at a distance of about one and one-fourth miles. So our instrument compares very favorably with Boys' apparatus.

Nichols[2] claims that the radiometer used by him in his work on stellar radiation was approximately twelve times as sensitive as Boys' radio-

[1]Proc. Roy. Soc., **47**, 480, 1890.
[2]Astro. Phys. Jour., **13**, 101, 1901.

micrometer. This would enable him, using the same sixteen inch mirror, to have his candle, assuming no absorption, at a distance of 4.5 miles.

This introductory section has been for the double purpose of calling attention to the need for more exactness in describing the action of such heat-receiving instruments, and to give an idea of the relative sensibility of our thermopile, for in advocating the use of the selenium cell for energy measurements, we want to make it certain that the cell

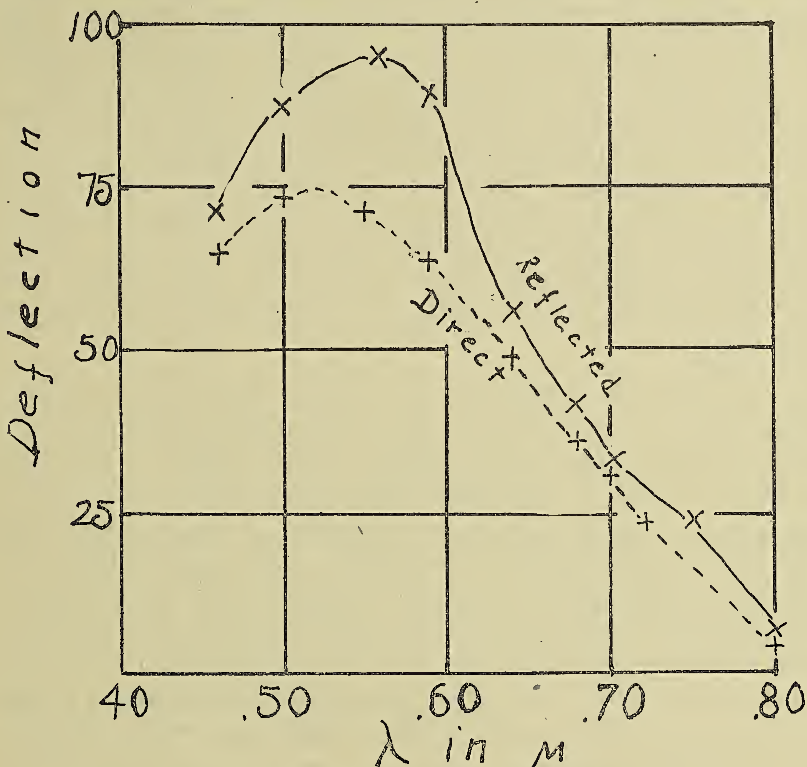

Fig. 9. Sensibility of the selenium cell.

is for its purposes more sensitive than any other receiving device. Our selenium cells have been compared directly with the above thermopile.

At the outset it must be admitted that the selenium cell is not usable for total radiation measurements, for it is not sensitive to any extent beyond the red end of the spectrum. Either curve of Fig. 9 will make the range of sensibility evident. It extends a little into the ultra violet (although our curves do not extend that far) and ends rather abruptly in the deep red, at about wave length 0.80μ. However, there are many experiments where it is satisfactory, and sufficient to measure from a source the energy that is contained in the range of the visible spectrum. For example, one of the most difficult pieces of research has been the attempt to detect heat radiation from the stars. Success has been attained, by use of the ordinary devices, only with the brightest of the fixed stars, but the selenium cell makes it a comparatively simple matter to detect the light energy, and further, if the cell is calibrated, its distribution among the various wave lengths, not only for these bright stars, but also for much fainter ones. Stebbins'[3] work with variable stars, for example, is a sample of the sensibility of the selenium cell for this sort of research. The work of Stebbins, however, was undertaken merely to determine the amount of light coming from the stars, with no special thought of the use of the cell for the determination of the energy of radiation. Before one can think of using the cell for such purposes, he must be certain of at least two things; first, whether the selenium is selectively sensitive to the various wave lengths in the visible spectrum, and second, whether the selenium acts in any way as a black body.

The first point mentioned above is indicated in the curve of Fig. 9, marked, *direct*. It will be seen that this particular selenium cell is selective in its response to the different wave lengths in the visible spectrum. It must be noted that care was exerted to see that the energy was the same for all these wave lengths, as was determined with the use of the above described thermopile. Unfortunately there is no unique type of sensibility curve for selenium, as we have shown in former papers,[4] so that any given cell must be calibrated before it can be used in energy determinations, wherever variation of wave length enters into the problem. The next important point to decide is whether the cell acts to a sufficient extent like a black body. This was determined in the following simple manner: A selenium cell was placed in the path of the light coming from a monochromatic illuminator. The light falling upon this cell was reflected to the same cell that was used in obtaining the curve marked *direct* in the above discussion. The energy was adjusted until about the same deflection was obtained for a given wave length in the two cases, and then the spectrum was traversed. The resultant sensibility curve is marked *reflected* in Fig. 9. It will be noted that the shape of the two curves is very similar, showing that when equal energy falls upon the selenium surface, practically

[3]J. Stebbins, Ast. Phys. Jour. **27**, 188, 1908.
[4]Phys. Rev. N. S. **2**, 487, 1913.

equal amounts of the various colors are reflected. Secondly, and just as important, calculation of the amount of the energy reflected showed clearly that not more than two per cent of the incident energy was reflected, the remainder being absorbed into the cell. This is the more surprising in view of the fact that the surface of the selenium is far from black in appearance, and though it is dull in luster, it is rather light gray in color. So, then, we have conclusively proved that the selenium cell, while limited to the visible spectrum, is nevertheless, in this region virtually a black body, and although it is not equally sensitive to light of different wave lengths, such a cell can readily be calibrated, so that it can be made a most useful agent for this type of work.

Little has been said here concerning the sensibility of the cell in comparison with the thermopile, but on that point there is in our minds no question at all. Almost any one of our cells, in connection with just a moderate E. M. F., and a galvanometer much less sensitive than the one we use with our thermopile, will give a deflection from 10 to 100 times that of the thermopile with equal incident energy. And it must be remembered that the thermopile that we are at present using is probably not much less sensitive than the most sensitive heat receiving devices that have hitherto been used. It may be added lastly, that the variation of sensibility of the selenium cell among the wave lengths in the visible spectrum is not always so pronounced as is represented in the cell used in obtaining the curves for Fig. 9. In fact, we have tested some cells that have shown nearly a horizontal line, or equal sensitiveness throughout the spectrum, and we do not believe we are unduly optimistic when we express the expectation of eventually learning how to produce at will a type of cell that will show this uniform behavior.

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SEX-LINKED FACTORS IN THE INHERITANCE OF RUDIMENTARY MAMMAE IN SWINE.

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Characters fall into four classes when related to sex. The first type is represented by horns in cattle, and red, black and white coats in swine, their appearance being entirely independent of sex. At the opposite extreme are those characters that are confined to one sex only, as the male plumage of the Brown Leghorn or pheasant. Similarly, although exhibiting different behavior somatically, are characters like mammae or tusks that exist in a rudimentary condition, or at least a relatively undeveloped condition, in one sex. Characters of this sort are intimately related to the sex glands and removal of the gland in the young animal will usually cause such characters to remain in the juvenile stage.

The third category approaches this type of inheritance in the sense of being affected somatically by sex, and is represented by the transmission of horns in sheep, as reported by Professor T. B. Wood, and of rudimentaries in swine, as reported by the writer (1912-13). The essential feature of this type of heredity is that the character is dominant in one sex and recessive in the other. When Wood crossed the hornless Suffolk sheep with the Dorset Horn, he obtained horned males and polled females in the first generation. When he inbred these individuals, he found a ratio of three horned to one polled in the males and one horned to three polled in the females. Apparently there was something about femaleness that prevented the horn from developing in this sex except when it was in the duplex or pure condition.

The fourth type of inheritance in relation to sex is where the character is linked or coupled with the sex-determining factor. There are two kinds, one where the female carries two sex factors (XX) and the male carries one (XO), and the other where the female carries one and the male none. Since swine apparently fall under the first type only, attention will be directed toward it alone. In the light of present knowledge there is no difference, apparently, in the general mechanism of inheritance between the two types, except as to a reversal of the sexes in relation to the sex-linked character; hence Morgan's paper on Drosophila with reference to the transmission of red and white eyes will illustrate the point. The difference between the red eye and the white is that the red eye carries a color-base that the white eye lacks. Referring to this as C, when a red-eyed male (XC-O) is mated to a white-eyed female (Xc-Xc)[1] all the male progeny are white-eyed (Xc-O) and all the female progeny are red-eyed (XC-Xc). When these are inbred half of each sex in the resultant generation are red-eyed (XC-Xc and XC-O), and half are white-eyed (Xc-Xc and Xc-O). The reciprocal cross of white-eyed male (Xc-O) to red-eyed female (XC-XC) gives all red-eyed progeny (XC-O and XC-Xc). When these red-eyed individuals are inbred all of the females and half of the males are red-eyed (XC-XC, XC-Xc and XC-O), and the remaining males are white-eyed (Xc-O). These results are accounted for very nicely if we assume that the color base is linked to the sex-determining factor in inheritance.

When the writer first reported on the rudimentary mammae of swine (1912), he felt that they belonged to the third category. In glancing over the work, Dr. Cole, of the University of Wisconsin, suggested that there were probably no homozygous males. Search to date has confirmed his suggestion and forced a modification of interpretation. The rudimentary mammae discussed are located to the rear of the inguinal pair, and are on the lower part of the scrotum of the male and the inner part of the rear thighs of the female. So far as the writer has observed in upwards of 2,000 cases, they are never functional.

When boars possessing rudimentaries are mated to sows possessing them, the following results were observed:

I.

	Males with rudimentaries	Males without	Females with	Females without
Observed	60	0	26	32
Expected[2]	59	0	29.5	29.5

When boars having the rudimentaries were mated to sows lacking them, these results obtained:

II.

	Males with rudimentaries	Males without	Females with	Females without
Observed	205	169	72	293
Expected	208.57	131.34	71.19	327.90

[1]Lower case letters represent the absence of factors, thus C means that the color base is present and consequently red eyes; c refers to the absence of the color base and consequently white eyes.

[2]These expectations are based on theory discussed later in the article. They are inserted here for comparison.

The excess of males lacking the rudimentaries and the deficiency of females without them is large enough to be significant, but in the face of the agreement with expectation elsewhere, it is difficult to interpret this without further material.

Boars lacking the rudimentaries sired pigs from sows possessing them as follows:

III.

	Males with rudimentaries	Males without	Females with	Females without
Observed	25	0	0	13
Expected	25	0	0	25

The deficiency of females is due only to chance modification of the proportion of births between the sexes.

Where both sexes lacked the rudimentaries, the progeny were grouped as indicated.

IV.

	Males with rudimentaries	Males without	Females with	Females without
Observed	19	48	0	48
Expected	16.34	50.66	0	67

Again the deficiency of females is due to a modification of the birth ratio and not to hereditary effect of the characters.

The inheritance is apparently a combination of the sex-linked and sex-limited types discussed as the fourth and third categories. It appears sex-linked in so far as the transmission of the genetic factor for rudimentaries is concerned, and is sex-limited in so far as there is apparent repression somatically of the rudimentaries of the female sex when they are in a simplex condition. This would make two classes of females in tables II and IV, those heterozygous for the rudimentaries and those lacking them hereditarily. In figuring the expectation the relative frequency of each class has been allowed for. Letting X represent the sex-determining factor and R the factor for rudimentaries, the following types of each sex exist:

Boars.	Sows.
XRO	XRXR
XrO	XRXr
	XrXr

Only the first type under each sex would have rudimentaries somatically. Males lacking the rudimentaries when bred to the two classes of females lacking them, show the following:

	Males with rudimentaries	Males without	Females with	Females without
XrO–XRXr	19	16	0	17
XrO–XrXr	0	32	0	31

Barring variations in the birth ratio (a deficiency of females) in the third type of mating, the expectation is realized within practical limits. On the whole, the figures come close enough to expectation to support the assumptions that the female carries two sex factors to the male's one, that the hereditary factor for the rudimentaries is linked to the sex factor, and that the rudimentaries must be present in a duplex condition in the female to develop somatically.

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DEPARTMENT OF ANIMAL HUSBANDRY,
KANSAS STATE AGRICULTURAL COLLEGE,
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THE EFFECT OF CALCIUM AND PROTEIN FED PREGNANT SWINE UPON THE SIZE, VIGOR, BONE, COAT AND CONDITION OF THE OFFSPRING.[1]

JOHN M. EVVARD,[2] ARTHUR W. DOX,[3] S. C. GUERNSEY.[3]

To determine the effect of adding calcium and protein to a corn ration fed the pregnant gilt upon the relative size and vigor of the offspring, a series of experiments has been conducted at this station. The results obtained during the year 1912-13 will be discussed briefly in the following pages.

The gilts under observation were divided into three lots of ten each. Lot I received whole corn grain (shelled) only, 1279.13 grams (reduced to 14 per cent moisture basis) per head daily; Lot II whole corn grain (shelled) the same amount as Lot I, plus calcium allowed in the form of chloride and carbonate (equivalent to approximately two and one-half grams of calcium daily) ; and Lot III corn grain (shelled) the same in amount as Lot I, plus protein fed as black albumen to the extent of 136.08 grams of the blood product per head daily. This black albumen analyzed 88.24[4] per cent protein and contained very little of the mineral elements, being especially low in calcium. All gilts received equal

[1]Written April 1, 1914, Preliminary Report.
[2]Animal Husbandry Section.
[3]Chemical Section.
[4]The black albumen and corn as analyzed contained in a hundred grams:

	Albumen	Corn
Protein	88.24	9.81
Ether extract	1.30	2.64
Ash (Total)	3.26	1.42
Nitrogen free extract	none	74.83
Crude fibre	none	2.38
Moisture	7.20	8.92
Calcium	.03	.01
Phosphorus	.19	.61

We used the black albumen because it was the best and purest form of commercial protein on the market. We preferred the blood derivative to the wheat gluten because of the much greater likelihood of its containing the complete series of amino acids.

The blood albumen runs higher than corn only in protein and ash. Fortunately the ash constituents of the corn exceed in potassium, magnesium, and phosphorus. The blood ash excels in sodium, chlorine, calcium and sulphur but the possible influence of the first two, sodium and chlorine, is negligible because we purposely fed a sufficiency of sodium chloride, the same to all lots. The calcium difference is so small as to be almost negligible. The results presented, wherein Lots I and II are contrasted, show plainly that calcium has some influence, and we must make some allowance for the extremely small but nevertheless constant difference. As regards the sulphur difference we attribute to it considerable possible influence,—but inasmuch as sulphur is to the protein much as "the tail is to the entire hide" we must charge the effects produced to the protein of the blood albumen. Summarizing, therefore, we find that the results secured by supplementing corn with black albumen are theoretically due almost entirely to its protein content.

quantity of sodium chloride daily, namely 7.26 grams per head. The daily gains for the three groups were as follows: Lot I, 107.95; Lot II, 154.68; Lot III, 237.23 grams.

The number of pigs farrowed per sow from these three lots was, respectively: Lot I, average 7.88; Lot II, 7.30; and Lot III, 8.22. Here we notice, as in our previous experiments, that the protein added to the corn ration during the breeding season influences favorably the number of young.

The weight of the total litters, as well as that of the individual pigs, shows clearly the influence of calcium and protein respectively upon the developing fetus. The table presented gives the number in litter, litter weight, and average weight per pig. The basis is grams.

WEIGHT OF OFFSPRING.

Lot No.	No. in litter	Litter weight —grams	Average per pig—grams[5]
I	7.88	6454.62	821.00
II	7.30	6695.02	916.26
III	8.22	7838.08	952.54

The litter of the lightest weight comes from the group receiving "corn alone," whereas the heaviest is to be found where corn was supplemented with protein, as in Lot III. Here we note a litter difference of 1383.46 grams in favor of the protein supplemented corn ration. The protein increased the weight of litter practically 29 per cent. The effect of the complex protein in black albumen is much more marked than that of the simple calcium fed as chloride and carbonate. The important deductions are such as to emphasize the importance of both of these constituents, namely calcium and protein, in feeding corn to bred swine; the addition of either one of these resulting in heavier litters and larger average pigs.

The vigor of the offspring was markedly affected by the ration. We have the following distribution of the pigs in the three lots according to their relative strength:

[5]On basis of all pigs farrowed.

VIGOR OF OFFSPRING.

(On basis of 100 pigs farrowed.)

Lot No.	Very strong	Strong	Medium	Weak	Very weak	Dead
I	9.52	34.92	17.46	12.71	20.63	4.76
II	23.29	24.66	24.66	2.74	8.22	16.44
III	39.19	32.43	17.57	5.41	1.35	4.05

Most assuredly, the addition of protein affected profoundly the vigor and stamina of the offspring. (See chart for distribution.) The addition of calcium was not without its effects. The protein, however, seems to be the more important constituent in balancing up the corn when compared to calcium.

The size of bone was likewise affected. When calcium and protein were added to the ration the bones were larger. This was determined by measuring the front and hind shins. The measurements are presented in centimeters:

SIZE OF BONE, CIRCUMFERENCE.

Lot No.	Front shin	Hind shin
I	4.60	4.36
II	4.88	4.67
III	4.81	4.56

Peculiarly enough, where calcium was added to corn the size of bone was somewhat greater[6] than where the protein was added. Now this may be due in part to the fact that the Lot III farrowed a greater average number of pigs per litter, which would have a tendency, other things being equal, to decrease their relative size.

One is not surprised particularly to find that both calcium and protein had considerable effect upon the size, vigor, and bone of the offspring,

[6]Cf. Hart, Steenbock, and Fuller, Research Bulletin 30, Wisconsin Experiment Station. "High calcium rations, as compared with low calcium rations, had no effect whatever during a single gestation period on the size or calcium content of the skeleton of the fetus. The skeleton is not increased in any dimension by a wide variation in the amount of calcium fed the mother." According to these investigations the ration considered as a "low calcium" one is a much higher carrier of calcium than the basal ration of corn used in the Iowa experiments.

but the fact that the coat is likewise markedly affected is somewhat surprising. To determine the influence of the addition of the constituents above mentioned upon the quantity of coat produced in the offspring, observation being made at farrowing time, the relative coat covering upon all of the new-born pigs was carefully recorded. The table on "Coat Quantity of Offspring" gives the number of pigs of every hundred born showing the Very Heavy, Heavy, Medium, Light, Very Light and Absent coats. A chart showing the coat quantity distribution is also given.

COAT QUANTITY OF OFFSPRING.

(On basis of 100 pigs farrowed.)

Lot No.	Very heavy	Heavy	Medium	Light	Very light	Absent
I	3.23	29.03	41.94	24.19	1.61	none
II	8.33	34.72	40.28	9.72	6.94	none
III	21.62	40.54	42.43	5.41	none	none

The calcium addition was somewhat effectual in that the coats produced from this lot were a bit heavier. The difference between Lots I and II is, however, very slight. Marked effects are shown from the protein addition where the number having very heavy coats was increased from 3.23 to 21.62, or practically seven times as many, possessing the Very Heaviest, Densest coats where protein is allowed, as compared to where it was not. Dropping down to the next coat quantity, namely, Heavy, we find 29.03 in the check lot, as compared to 40.54 where the protein was added, or more than 40 per cent difference. The Very Light coated pigs are conspicuous in Lot III for their absence, thus further demonstrating the effects of protein additions in increasing the amount of hair covering.

That the coat of swine should vary according to the feed given is common experience. Just one month after these young gilts were placed on the experimental rations a marked contrast in the quantity and color of the coats was evident. The coats of hair in the order of their length and density are from Lots III, II, I, with II and I fairly close and III easily first. In color we have the same order, III, II, I, with III much the darkest. It is significant that the coat quantity and color should be affected by the ration—it is still more suggestive that the coats of the new-born should correspond somewhat with those of the dams from which they are farrowed.

What is the explanation of this difference? We know that keratin, a simple protein of albuminoid nature, is the chief constituent of hair. We find keratin in the epidermis, wool, nails, hoofs, horns, feathers, and so on. Keratin is peculiar in that it has a high sulphur content, the sulphur being present largely in the form of the complex amino acid cystine.

The keratin of human hair runs as high in cystine as 13 to 14½ per cent[7]. No other protein runs so high in cystine as the keratin of human hair. Swine hair, or bristles, contain about 7.2 per cent cystine. Most assuredly hair cannot be built unless the constituents of cystine are present in the feed, hence it is reasonable to suppose that if said sulphur compound, namely, the amino acid cystine, is absent from the feed, the development of hair may be retarded. In corn we find approximately .171[8] parts of sulphur in 100 parts of dry matter, whereas in black albumen we have .820[8] parts, or almost five times as much. Furthermore, it has been shown that of the sulphur present in zein, the amino acid that comprises 58 per cent of the proteins of corn, only 35 per cent[7] is present as cystine. On the other hand, a large proportion of the sulphur found in black albumen is supposedly present as cystine, hence it is not unreasonable to assume that the main reason why the addition of black albumen is efficient is because it furnishes the cystine, the basal constituent of hair growth.

The coat color of the offspring differs depending upon the dietetic treatment accorded the pregnant dam. The relative effects of the supplements upon the color is shown quite clearly in the following table showing the number of pigs out of a hundred farrowed classified as Very Dark, Dark, Medium, Very Light, and Absent coat colors:

COAT COLOR OF OFFSPRING.

(On basis of 100 pigs farrowed.)

Lot No.	Very dark	Dark	Medium	Light	Very light	Absent
I	1.61	19.35	30.65	37.10	11.29	none
II	2.78	29.17	38.89	12.50	16.67	none
III	14.86	44.59	32.43	8.11	none	none

Again we see the effects of the added black albumen in that it increases the general coat color of the offspring. The chart showing color

[7]Buchtala; Z. Physiol. Chem. Volume 52, page 474, 1907.
[8]Forbes; Bulletin No. 255, page 225, January, 1913, Ohio Experiment Station.

distribution plainly demonstrates the differences. The hogs which we used were Duroc Jerseys, having red coats. The coats designated as "Very Light" refer to those of little color, as compared to the "Very Dark" coats, which were of a bright cherry red. The calcium did not seem to affect the coat very much, although it shows a minor influence. The black albumen, with its high protein, and possibly its specific cystine content, seems to be the causative agent in the production of highly colored coats. It is to be understood that the coat color markings are affected by the amount of coat present, depending upon whether the hairs are densely studded on the surface of the body, as well as the length of the hair, and furthermore on the inherent color of the hair itself. As far as superficial observation goes, without entering into the details of microscopic technical examinations, we would give it as our judgment that the coats were not only denser and longer, but that the hairs themselves seemed to show a greater amount of pigment when corn was supplemented with the black albumen protein, as compared to corn fed alone.

The condition or degree of fatness of the new-born pigs is somewhat dependent upon the feed allowed the dam during the period of gestation. To demonstrate the effect of specific supplements to corn upon the relative condition of the offspring we append herewith table showing the degree of fatness of the various new-born pigs farrowed in the three lots:

CONDITION OF OFFSPRING.

(On basis of 100 pigs farrowed.)

Lot No.	Prime	Choice	Good	Medium	Fair	Common	Inferior
I	none	3.25	29.03	48.39	9.68	9.68	none
II	1.39	19.44	33.33	29.17	13.89	2.78	none
III	none	16.22	29.73	27.03	20.27	6.76	none

The condition or fatness of the new-born pigs was determined by sight and touch observations. Each pig was handled so that a fairly accurate estimate could be made of the fatty covering, special emphasis being placed upon the superficial layers over the ribs and back. Both the calcium and protein supplements to corn resulted in fatter offspring. The protein in this case had less effect than the calcium. Our estimates of the condition of the dams producing these pigs, placing the lots in order of fattest first, are thus: III, II, I, whereas the condition of the pigs farrowed by said dams, placing the fattest first, is II, III, I. In other words, the condition of the resulting offspring does not compare as closely with that of the mother as does the coat character. There are obvious fundamental reasons for this.

To recapitulate so as to put the foregoing vigor, coat, and condition story on a comparative and more easily interpretable basis there are summarized the relative effects of the specific feed constituents in a grouped combination table chart.

The perpendicular columns denote the average on the assumption of the highest marking being perfect, or 100. The average is computed by placing a value on the various markings given the individual pigs—thus for vigor the Very Strong pig is credited with 100, Strong 80, Medium 60, Weak 40, Very Weak 20, and Dead 0. The Dead, with 0, and the Very Strong, with the 100 credit, makes the range from Absent vigor, the lowest, to Very Strong vigor, the highest marking. The total vigor credits are added and the average taken with results in Lots I, II and III, respectively of 57.14, 60.55 and 78.11. These values may be regarded as percentages of the maximum vigor marking, and so on. The same general scheme was followed out in determining the average "Coat Quantity," "Coat Color," and "Condition." The gradations considered are identical with those on the tables and charts previously presented.

Withal, this method gives us a tangible, definite, interpretable average valuation quite in accord with the facts.

Uniformly the supplemental calcium and protein, respectively, produced improvement in specific characters of the offspring. Manifestly the influence of the complex nitrogenous organic constituents in protein is more marked than that of the more simple inorganic calcium (chloride and carbonate).

The relative influence of calcium and protein is more clearly appreciated on examination of the following table:

COMPARATIVE INFLUENCES OF CALCIUM AND PROTEIN FED THE PREGNANT DAM ON DEVELOPING FETUS.

Character of Offspring	Percentage Increase Over Corn Alone Attributable to	
	Calcium	Protein
Vigor	5.97	35.00
Coat quantity	6.38	24.42
Coat color	9.89	38.04
Condition	16.46	7.17

Perhaps the direct comparison of protein to calcium effectiveness would make the relation of these two constituents clearer.

The increase of the Protein-Corn-Lot III over the Calcium-Corn-Lot II shows for:

Vigor	29.00 per cent
Coat Quantity	16.96 per cent
Coat Color	26.74 per cent
Condition	—7.90 per cent

The protein is more effective than the calcium in the promotion of vigor, production of coat quantity and color, but less so in augmenting the condition.

Evidently the protein is the more efficacious when it comes to the production of those qualities which make for stamina and hardiness. The vigor and coat quantity are relatively more important in lessening the mortality of the suckling pigs than is the degree of fatness. If the new-born be strong, healthy, and well-coated, even though he come into existence under adverse conditions, he is much better adapted to live in the environment he finds than if he lacks vigor and coat but possesses a high degree of fatness. The strong, warmly coated pig will soon fatten on his mother's milk, hence the condition comes quickly. Not so, however, with the strength and coat; lost vitality and scant hair covering are replaced with comparative slowness.

It is vital to early development that the new-born pigs be vigorous, otherwise they will be compelled to suckle the teats discarded by the more active individuals in the litter. "That pig which suckles the hind teat" is at a disadvantage, but this is the consequence, usually, of being farrowed as the weakly member of the litter.

The protein in corn has been demonstrated to be deficient to a considerable extent in some of the essential amino acids. This is especially true of the zein, which comprises practically 58 per cent of the corn proteins, since zein does not contain in its amino acid makeup tryptophane, lysine, and glycine. Fortunately for corn, the glutelin, which furnishes most of the remaining protein, is quite complete in its amino acid constitution. However, the marked preponderance of zein in corn lessens greatly the general efficiency of the protein in toto. The tryptophane[9] is probably the limiting amino acid, hence it is reasonable to assume that the addition to the corn ration of a protein rich in tryptophane would show marked results. We are led to believe from

[9]Osborne, "The Nutritive Value of the Proteins of Maize," Science, N. S., Vol. XXXVII, No. 944, pages 185-191, January 31, 1913.

the work already done on the amino acid content of blood and its derivatives that the blood albumen used as the source of protein in our work carries the deficient tryptophane. Perhaps the possible deficiency of cystine in corn, as heretofore noted, may be a factor, the absence of which contributes to the general deficiency of the corn proteins. The balancing, therefore, of the protein present in corn by making it more complete, as well as an increase in the entire amount fed, should be a double reason for the greater efficiency observed.

We have some difficulty in the administration of our calcium. We first started out with calcium chloride, but found that where it accompanied protein, given in the form of black albumen, difficulty was experienced in that the mixture seemed to have antagonistic relations. We have supposed that this may possibly be due to acidosis caused by the liberation of the chlorine portion of the calcium chloride molecule, thus freeing hydrochloric acid. Along with a high protein ration the demand for calcium would necessarily be greater than where no extra protein was fed, hence we should expect a greater demand for calcium under these conditions, with a correspondingly greater liberation of chlorine, which would induce acidosis. This acidosis would, theoretically, be largely done away with by the feeding of a pure calcium limestone, such as calcium carbonate. We found when calcium chloride was replaced with calcium carbonate, feeding same between meals, that the ill effects heretofore noted were largely eliminated. Observation and trial showed, however, that calcium carbonate should not be mixed with the feeds as allowed, but that it should be fed, preferably, between meals. We are further investigating this problem in order to demonstrate the best way to feed the calcium.

It is reasonable to suppose that calcium will give results when added to the corn ration, as corn is especially lacking in this important mineral element, which comprises 40 per cent of the dry ash of bone. Calcium furnishes 70 per cent of the basal elements of bone, of the remainder, 29½ per cent being supplied by phosphorus and ½ per cent by magnesium. In the normal human body there is just about two-thirds as much calcium as nitrogen, that fundamental element of protein concerning which we hear so much and upon which a maximum of emphasis is invariably placed by feeding experts and dieticians. It is not to be gainsaid that the lack of protein is the more conspicuous deficiency in ordinary grain diets, but nevertheless the calcium deserves among the mineral nutrients considerably more attention than is now accorded.

Much of a conflicting nature has been said by obstetricians, dieticians, and the laity concerning the effect of different food constituents upon the development of the embryo and fetus.

The experience at the Iowa Station, involving over 2,000 new-born pigs, shows beyond all reasonable doubt that the addition of meat to the ordinary cereal diet of pregnant swine has very marked influence upon the size and vigor of the new-born.

All work heretofore done at the Iowa Station has plainly indicated that the addition of mineral elements as well as protein to the ration had its marked effects upon the development of the young in utero. We are led to believe that any feed, including water, added to or subtracted from the ration of pregnant swine which will tend to promote or discourage growth, thrift, and vigor of the dam will, within reasonable limits, have its effect upon the developing fetus.

SUMMARY.

1. Corn maize is markedly deficient in calcium and quite low in protein, the major part of which lacks certain important amino acids.

2. The addition of calcium (allowed as chloride and carbonate) to a fixed basal ration of corn and sodium chloride with pregnant gilts resulted in new-born pigs having greater size, more vigor, bigger bone, increased coat quantity, better coat color, and higher condition.

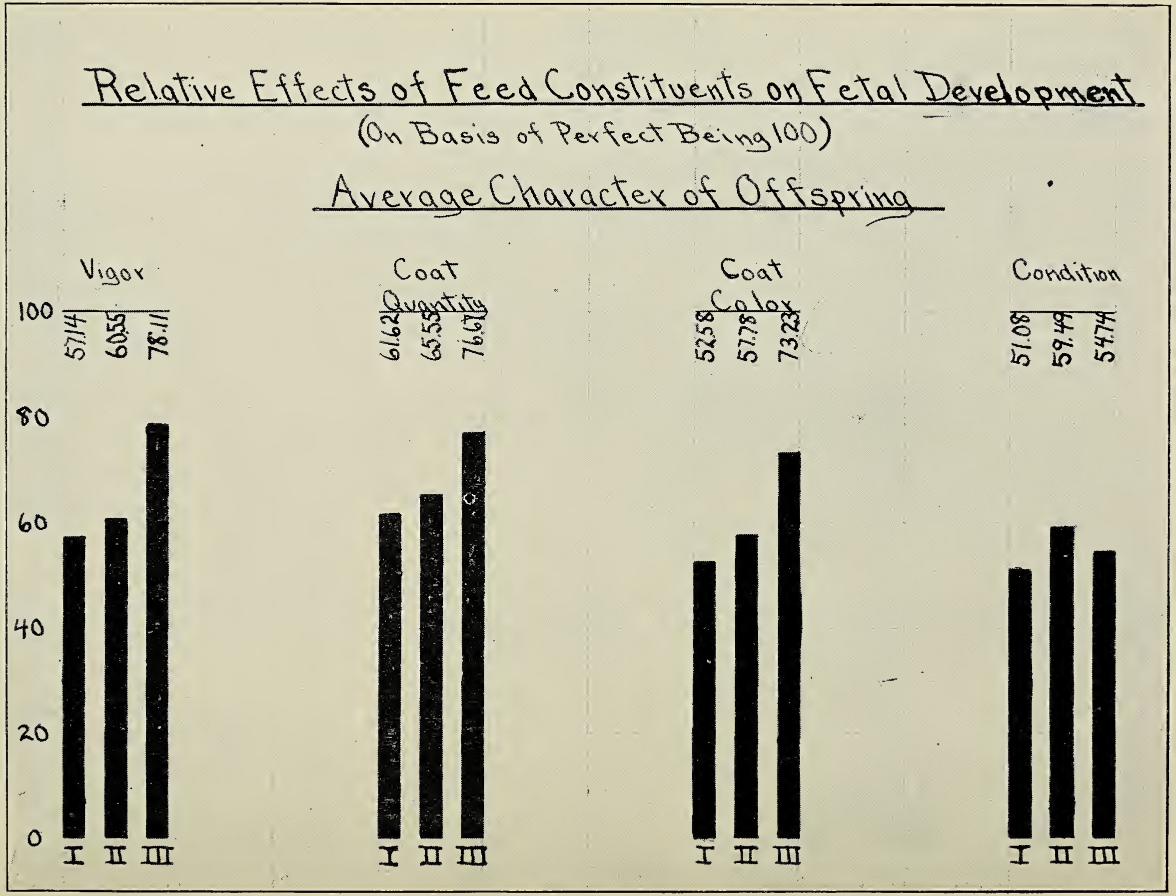
3. The addition of a high protein feed (black blood albumen) resulted in the new-born pigs having greater size, more vigor, bigger bone, increased coat quantity, better coat color and higher condition.

4. The influence of the complex organic protein is more marked generally than that of the more simple inorganic calcium.

5. The use of chloride as the source of calcium was not as satisfactory as the carbonate in a high protein ration presumably because of the undesirable liberation of chlorine causing a possible condition of acidosis.

6. The ration fed the pregnant mother affects in a marked degree the general development of the fetus.

Animal Husbandry and Chemical Sections,
Iowa Experiment Station, Ames.



Relative Effects of Feed Constituents on Fetal Development
(On Basis of Perfect Being 100)
Average Character of Offspring
Vigor
Coat Quantity
Coat Color
Condition
100
80
60
40
20
0
57.14
60.55
78.11
61.62
65.55
76.67
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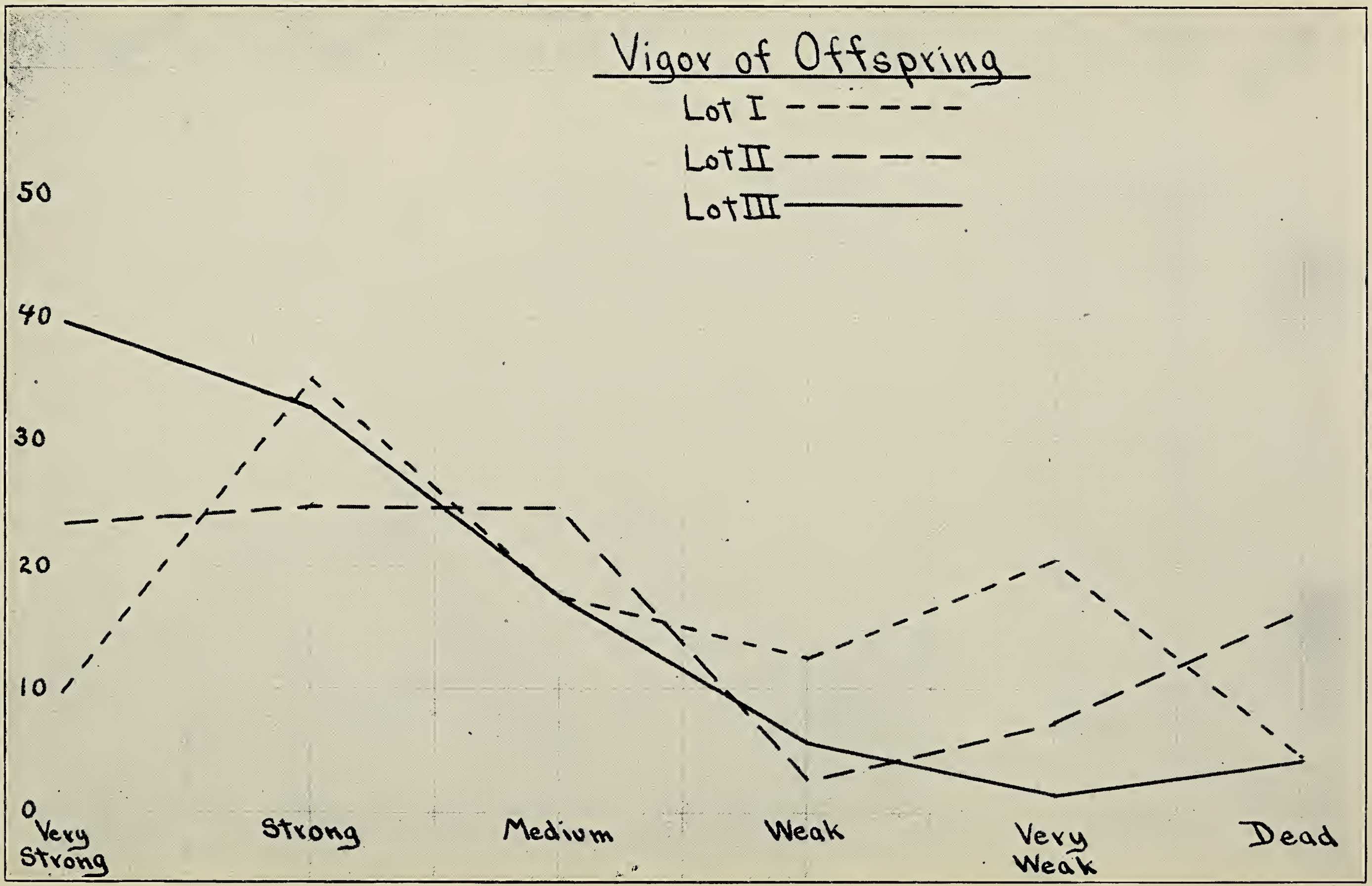
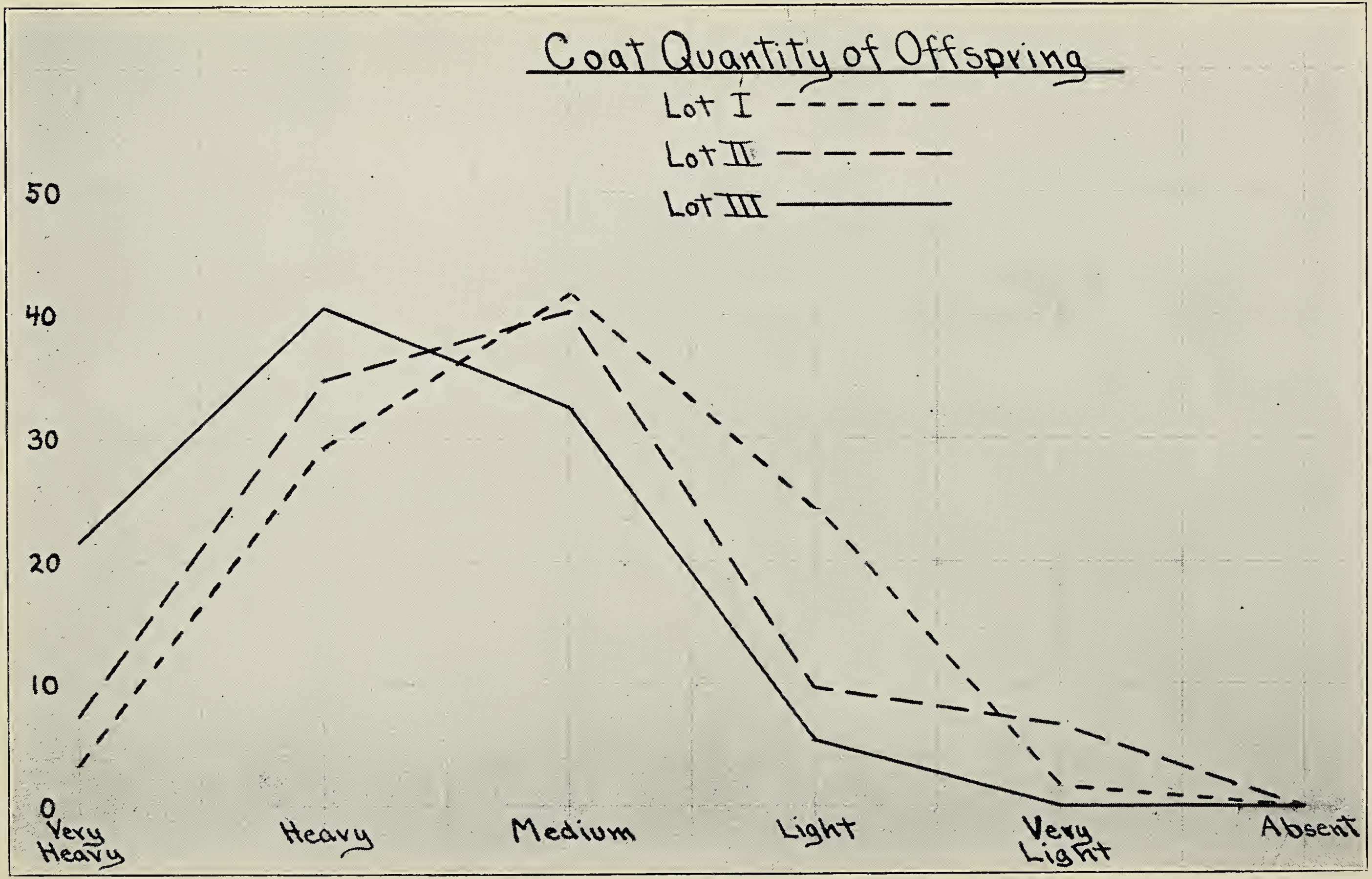
57.78
73.23
51.08
59.49
54.74
I
II
III


Vigor of Offspring
Lot I
Lot II
Lot III
50
40
30
20
10
0
Very Strong
Strong
Medium
Weak
Very Weak
Dead



Coat Quantity of Offspring
Lot I
Lot II
Lot III
50
40
30
20
10
0
Very Heavy
Heavy
Medium
Light
Very Light
Absent

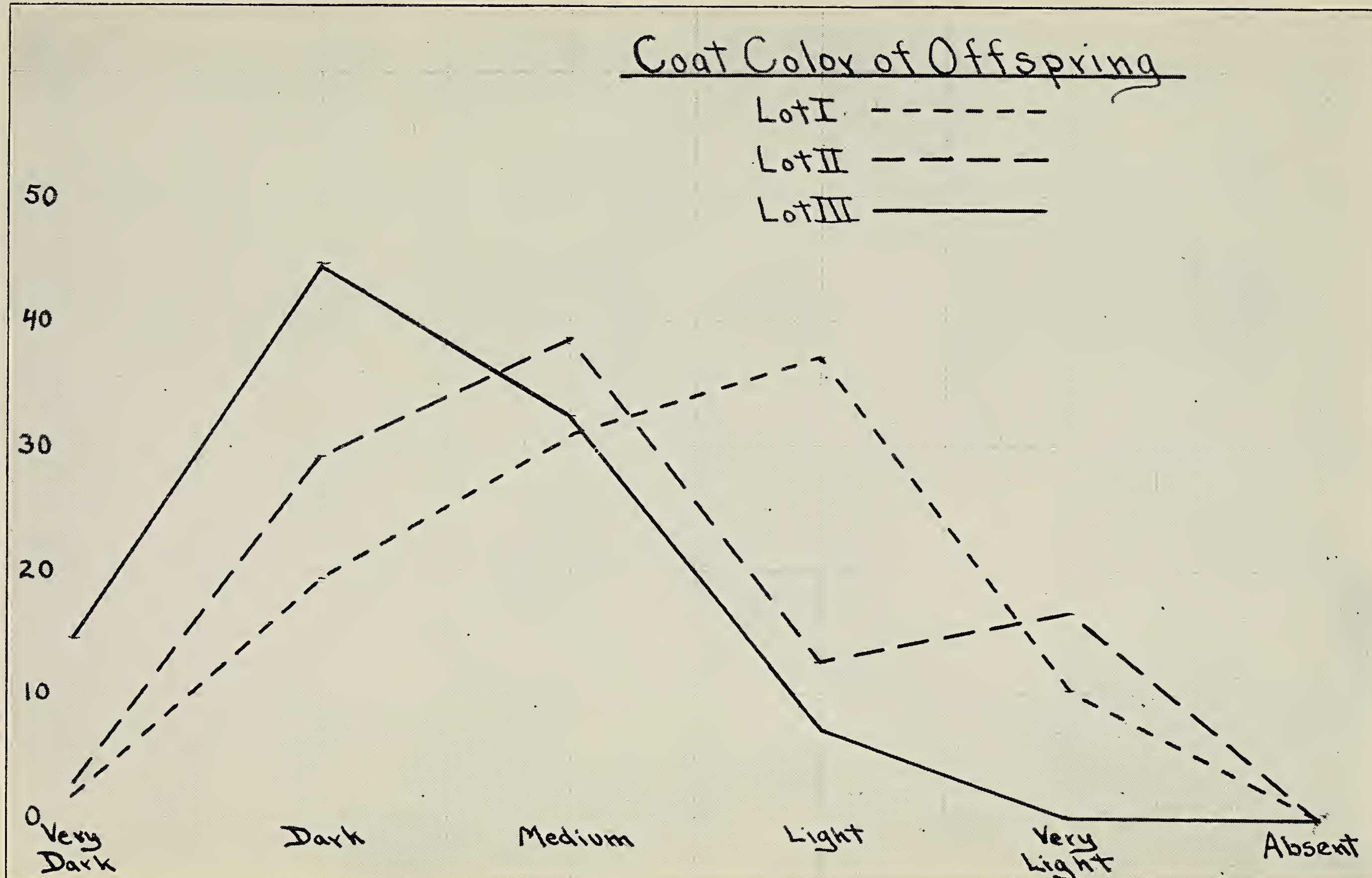
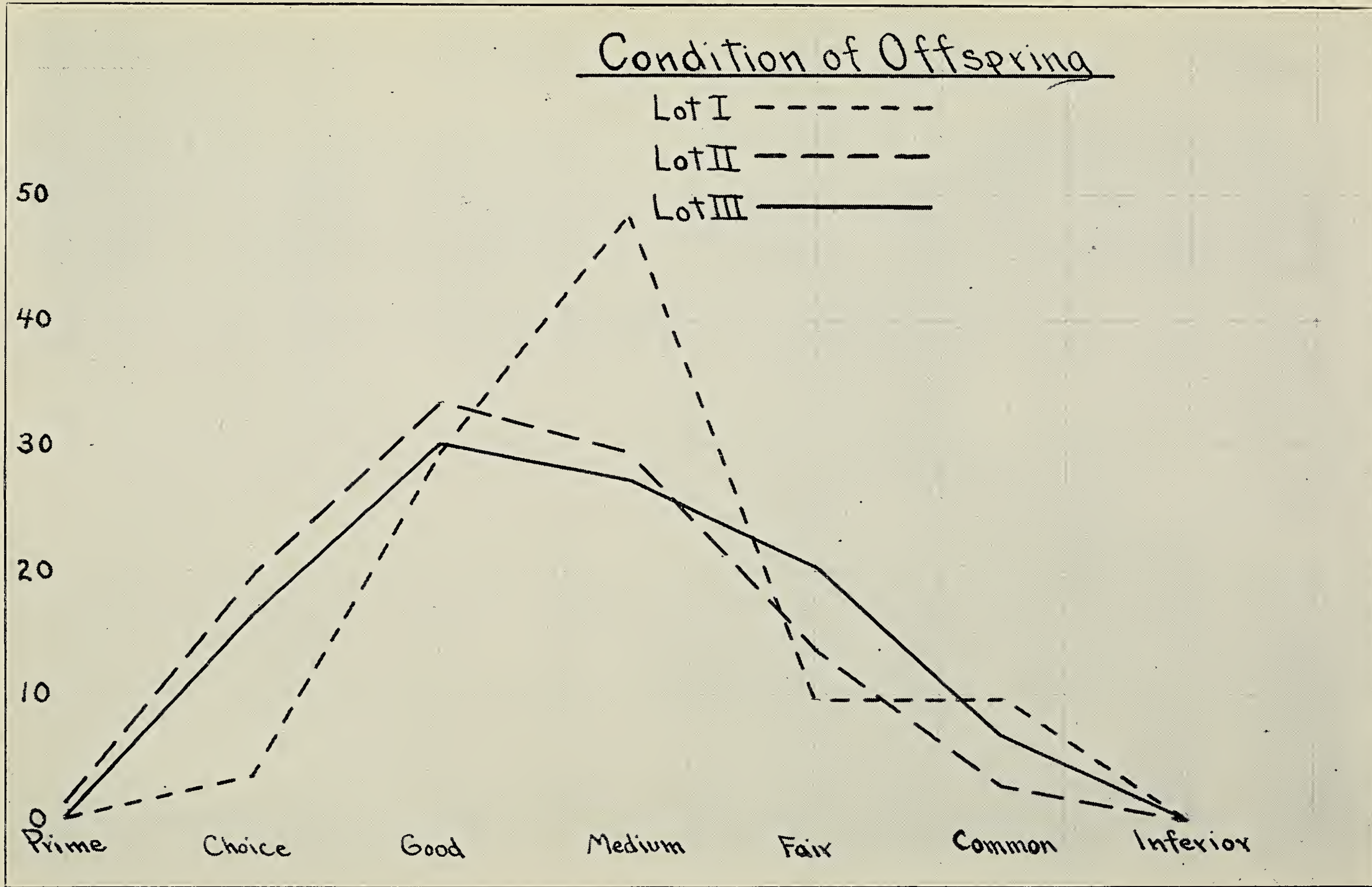

Coat Color of Offspring
Lot I
Lot II
Lot III
50
40
30
20
10
0
Very Dark
Dark
Medium
Light
Very Light
Absent

Plate XXXIV


Condition of Offspring
Lot I
Lot II
Lot III
50
40
30
20
10
0
Prime
Choice
Good
Medium
Fair
Common
Inferior

A LIST OF THE LEPIDOPTERA OF LINN COUNTY, IOWA.

GEO. H. BERRY.

This list is based upon twenty years' collecting in Linn county by the author, together with the examination of the collection made by Dr. E. P. Childs, now in the Coe College museum; and of private collections in Maine, Grant, College, Brown and Fairfax townships.

The identification of all rare and doubtful species was made by an eastern firm who are engaged in the business of supplying entomological specimens and supplies. The nomenclature and check numbers are in conformity with those used in Dyar's check list of North American Lepidoptera. It was found impossible to give English names, as but few of the species have them, and those few only locally.

The empirical terms used to indicate the relative frequency of the species are Abundant, Common, Fairly Common, Rare, and Very Rare. In a few species where varieties are listed, Less Common has been used to designate the relative abundance between the species and the variety. In those listed (Very rare) the actual number of specimens taken has been given. I have realized the need of a working list many times in the past years, and have encountered the same need among others in the same field of investigation; and give this need as a reason for presenting this paper at this time.

ABBREVIATIONS.

Bai. ....Bailey
Beut. ....Beutenmuller
Borkh. ....Borkhausen
Bsdv. ....Boisduval
Butl. ....Butler
Charp. ....Charpentier
Chamb. ....Chambers
Clem. ....Clemens
Cram. ....Cramer
Dall. ....Dallman
Dru. ....Drury
Edw. ....Edwards
Grt. ....Grote
G. & R. ....Grote & Robinson
G-M. ....Guerrin-Meneville
Gey. ....Geyer
Gu. ....Guenee
Kir. ....Kirby
Sm. ....Smith
Snel. ....Snellen
Steph. ....Stephens
Spey. ....Speyer
S. & A. ....Smith & Abbot
Fer. ....Fernald
Fabr. ....Fabricius
Harr. ....Harris
Hbn. ....Hubner
Haw. ....Haworth
Hy. Edw. ....Henry Edwards
Herr.-Schf. ....Herrich-Schaeffer

Led. .... Lederer
L. .... Linnaeus
Ochs. .... Ochsenheimer
Tausch. .... Tauscher
Treitsch. .... Treitschke
D. & S. ..Dennis & Schiffermuller
Dy. .... Dyar
Ril. .... Riley
Rag. .... Ragonet
Rob. .... Robinson
Rott. .... Rottemburg
Zell. .... Zeller
Walk. .... Walker

CLASS INSECTA.

ORDER LEPIDOPTERA.

Superfamily PAPILIONOIDEA.

Family Papilionidae.

IPHIDICLES Hubner.

5 *ajax* Hbn.................Very rare, 1 specimen

PAPILLO L.

11 *glaucus* L.................Very common
11a *Turnus* L.................Rare
13 *troilus* L..................Very rare, 2 specimens
14 *thoas* L....................Common
22 *polyxenes* Fabr............Common

LAERTIAS Hbn.

23 *philenor* L................Rare

Family Pieridae

PONTIA Fabr.

32 *monuste* L................Very rare, 1 specimen
37 *protodice* Bsdv. & LeC......Common
38b *virginiensis* Edw...........Very rare, 2 specimens
40 *rapae* L...................Abundant
40a *novanglae* Scud...........Common
40b *immaculata* S. & A........Common

NATHALIS Bsdv.

41 *iole* Bsdv..................Rare

SYNCHLOE Hbn.

48 *genuste* Fabr.............Rare

CALYDRYAS Bsdv&LeC.

52 *eubule* L..................Very rare, 3 specimens

ZERENE Hbn.

61 *caesonia* Stoll.............Common
61a *rosa* McNeill..............Fairly common

EURYMUS Swain.

65 *eurytheme* Bsdv............Common
65a *ariadne* Edw..............Fairly common
66 *philodice* Gdt..............Abundant
66a *anthyale* Hbn..............Rare

PYRASITA Butl.

81 *mexicana* Bsdv.............Very rare, 1 specimen[1]

EUREMA Hbn.

83 *nicippe* Cram..............Very rare
85 *euterpe* Mene..............Common
87 *delia* Cram................Locally common
88 *jucunda* Boisd. & LeC......Very rare, 1 specimen

Family Nymphalidae.

EUPTOIETA Dbld.

92 *claudia* Cram..............Fairly common

SPEYERIA Scud.

95 *idalia* Dru................Locally common

ARGYNNIS Fabr.

99 *cybele* Fabr...............Common
100 *aphrodite* Fabr...........Common
100a *alcestis* Edw..............Common

BRENTHIS Hbn.

131 *myrina* Cram..............Common
141 *bellona* Fabr..............Common

EUPHYDRYAS Scud.

146 *phaeton* Drury............Very rare, 1 specimen

CHARIDRYAS Scud.

185 *nycteis* D. & H............Common

PHYCIODES Hbn.

188 *phaon* Edw................Very rare
189 *tharos* Dru................Common
190 *Batesii* Reak...............Fairly common
196 *picta* Edw.................Very rare, 1 specimen

POLYGONIA Hbn.

205 *interrogationalis* Fabr.......Common
205a *umbrosa* Lint..............Common
206 *comma* Harr..............Common
206a *dryas* Edw................Less common
209 *faunus* Edw...............Very rare
214 *progne* Cram..............Common

[1]This specimen, taken by Mr. Bigelow, is in perfect condition, neither frayed nor faded.

EUVABESSA Scud.

217 *antiopa* L................Very common[2]

AGLAIS Dal.

218 *milbertii* God.............Rare

VANESSA Fab.

219 *atalanta* L................Common
220 *huntera* Fab...............Fairly common
221 *cardi* L...................Variable; some seasons abundant; others rare.

JUNONIA Hbn.

223 *coenia* Hbn................Fairly common

ANARTIA Hubn.

224 *jatrophae* L...............Very rare

BASILARCHIA Scud.

236 *astyanax* Fabr............Common
239 *archippus* Cram............Common
240 *floridensis* Streck........Fairly common

CHLORIPPE Boisd.

244 *celtis* Boisd. & LeC.......Fairly common
247 *alicia* Edw................Rare
248 *clyton* Boisd. & LeC.......Rare

ANARTIA Hbn.

254 *andria* Scud...............Rare

Family Agapetidae.

CERCYONIS Speyer.

258 *alope* Fabr................Very common
258a *texana* Edw...............Rare

ENODIA Hbn.

286 *portlandia* Fab............Rare

SATYRODES Scud.

288 *canthus* L.................Fairly common

CISSIA Doub.

299 *eurytus* Fabr..............Abundant

[2] A specimen in the possession of Mr. Bigelow lacks the row of blue spots along the wings; the marginal stripe is very wide and nearly white.

Family Lymnadidae.

ANOSIA Hbn.

308 *plexippus* L...............Abundant
309 *berenice* Cram.............Very rare, 1 specimen

Family Libytheidae.

HYPATUS Hubn.

311 *bachmanni* Kirt............Very rare, 2 specimens

Family Riodinidae.

CALYPHELIS G.&R.

321 *borealis* G. & R...........Very rare, 1 specimen

Family Lycaenidae.

EURANOTES Scud.

335 *melinus* Hubn.............Very rare, 1 specimen

THECKLA Fabr.

339 *acadica* Edw..............Very rare, 1 specimen
347 *calanus* Hbn..............Fairly common

MITOURA Scud.

362 *damon* Cram..............Rare

INCISSALIA Minot.

374 *irus* Godt.................Very rare, 1 specimen
378 *niphon* Hbn...............Rare

STRYMON Hbn.

384 *titus* Fabr.................Rare

GAEIDES Scud.

390 *dione* Scud................Locally common

CHRYSOPHANUS Hbn.

393 *thoe* Boisd.................Abundant

EPIDEMIA Scud.

308 *epixanthe* Boisd...........Very rare

HEODES Dall.

399 *hypophleus* Boisd..........Abundant

CYANIRIS Dahl.

440 *ladon* Cram................Common
440a *lucia* Kir.................Common
440c *violacea* Edw..............Fairly common
440f *neglecta* Edw..............Common

EVERTES Hbn.

442 *comyntas* God............Fairly common

LEPTOTES Scud.

452 *theonus* Lucas............Very rare, 1 specimen

Family Hesperidae.

AMBLYCIRTES Scud.

459 *vialis* Edw.................Very rare, 1 specimen
463 *samoset* Scud.............Common

PAMPHILA Fabr.

469 *palaemon* Pallas...........Very rare, 2 specimens

ANCHYLOXYPHA Felder.

472 *numitor* Fabr.............Common

OARISMA Scud.

480 *poweschiek* Park...........Very common

POANES Scud.

482 *massasoit* Scud............Rare

ERYNNIS Schrank.

488 *sassacus* Harr.............Very rare, 3 specimens
491 *ottoe* Edw.................Very rare, 1 specimen
499 *uncas* Edw................Very rare, 2 specimens
501 *attalus* Edw..............Common

THYMELLICUS Hbn.

419a *egremet* Scud.............Rare
523 *cernes* Boisd. & LeC........Common

EUPHYES Scud.

528 *verna* Edw................Rare
529 *vestris* Bsdv..............Common
529a *metacomet* Harr...........Fairly common
535 *fusca* G. & R..............Rare

LEREMA Scud.

543 *hianna* Scud...............Fairly common

LIMOCHROES Scud.

555 *bimacula* G. & R...........Fairly common
556 *pontiac* Edw...............Very rare, 1 specimen
557 *manataqua* Scud............Common

PHYCANASSA Scud.

566 *vitellus* Fabr..............Rare

EUPARGYREUS Hbn.

584 *tityrus* Fabr............... Very common

THORYBES Scud.

599 *bathyllus* S. & A........... Rare
601 *phylades* Scud............ Common

PHOLISORA Scud.

605 *catulus* Fabr...............Fairly common

THANNAOS Bsdv.

617 *brizo* Bsdv. & LeC......... Fairly common
618 *icelus* Lint................ Rare
625 *juvenalis* Fabr............. Rare

HESPERIA Fabr.

642 *tessellata* Scud............ Fairly common
649 *nessus* Edw................ Rare

Superfamily **SPHINGOIDEA.**

Family **Sphingidae.**

HEMARIS Dal.

653 *diffinis* Bsd................ Fairly common
653a *axilaris* G. & R............. Common
653b *tenuis* Grt................. Common
656 *thysbe* Fabr................Common

TRIPTODON Men.

665 *lugubris* L.................. Very rare, 2 specimens

AMPHION Hbn.

667 *nessus* Cram.............. Common

SPHECODINA Bsdv.

668 *abbotii* Swain............. Rare

DEIDAMIA Clem.

669 *inscriptum* Harr........... Fairly common

DEILEPHILA Och.

670 *galli* Rott..................Very rare, 1 specimen
671 *lineata* Fabr............... Abundant

ARGEUS Hbn.

674 *labruscae* L................ Very rare, 1 specimen

PHOLUS Hbn.

679 *achemon* Dru...............Common

AMPHELOPHAGA B.&G.

681 *choerilus* Cram............Rare
682 *myron* Cram..............Common
682a *enotus* Hbn...............Rare
683 *versicolor* Harr............Fairly common

PHLEGETHONTIUS Hbn.

696 *quinquemaculata* Haw.......Abundant
697 *sexta* Johan..............Common

SPHINX L.

700 *kalmiae* S. & A............Rare
701 *drupeferrarum* S. & A.......Rare
703 *gordius* Stoll...............Common
706 *chersis* Hbn...............Common
716 *eremittus* Hbn............Fairly common

DOLBA Walk.

719 *hyaeus* Dru...............Fairly common

CERRATOMIA Harr.

721 *amyntor* Gey.............Common
722 *undulosa* Walk............Common
724 *catalpae* Bsdv.............Rare

LAPARA Walk.

725 *bombycoides* Walk.........Rare

MARUMBA Moore.

728 *modesta* Harr..............Common
728a *imperator* Streck...........Very rare, 3 specimens

SMERINTHUS Latr.

729 *jamaicensis* Dru............Common
730 *cerysi* Kirby...............Fairly common

PAONIAS Hbn.

731 *excaecatus* S. & A...........Common
732 *myops* S. & A.............Common

CRESSONIA G. & R.

734 *juglandis* S. & A...........Fairly common

Superfamily **SATURNOIDEA.**

Family **Saturniidae.**

PHILOSAMIA Grt.

736 *cynthia* Dru...............Very rare, 2 specimens

SAMIA Hubner.

739 *cecropia* L.................Common
740 *gloveri* Stck...............Very rare, 2 specimens

CALLOSAMIA Pack.

744 *promethea* Dru............ Locally common

TROPAEA Hbn.

747 *luna* L.................... Fairly common
747a *dictynna* Walk............. Very rare, 1 specimen

TELEA Hbn.

748 *polyphemus* Cram.......... Common

AUTOMERIS Hbn.

753 *io* Fabr.................... Common

HEMELEUCA Walk.

757 *maia* Dru.................. Very rare, 1 specimen

Family Ceratocampidae.

ANISOTA Hbn.

767 *stigma* Fabr............... Rare
768 *senatoria* S & A........... Fairly common
770 *virginiensis* Dru........... Rare
771 *rubicunda* Fabr............ Common

ADELOCEPHALA Herrick-Schaeffer.

772 *bicolor* Harr............... Fairly common
772a *suprema* Neum............. Rare
772b *immaculata* Jew........... Very rare, 2 specimens

SYSSPHINX Hbn.

773 *quadrilineata* G. & R........ Fairly common

CITHERONIA Hbn.

776 *regalis* Fabr............... Very rare, 1 specimen

BASSILONA Bsdv.

778 *imperialis* Dru............. Fairly common
778a *didyma* DeB............... Rare

Superfamily BOMBYCOIDEA.

Family Syntomidae.

COSMOSOMA Hubner.

779 *auge* L.................... Very rare, 1 specimen

SCEPSIS Walker.

787 *fulvicollis* Hbn............. Common

LYCOMORPHA Harris.

792 *pholus* Dru................. Rare

CTENUCHA Kirby.

798 *virginica* Charp............ Fairly common

Family Lithosiidae.

CRAMBIDIA Packard.

800 *pallida* Pkd. . . . . Common

LEXIS Wall.

806 *bicolor* Grt. . . . . Rare

HYPROPEPIA Hbn.

807 *miniata* Kby. . . . . Fairly common
808 *fuscosa* Hbn. . . . . Common

CLEMENSIA Packard.

817 *albata* Walk. . . . . Very rare, 1 specimen

ILLICE Walker.

821 *subjecta* Walk. . . . . Very rare, 2 specimens

Family Arctidae.

EUBAPHE Hubner.

833 *immaculata* Reak. . . . . Rare
834 *aurantiaca* Hbn. . . . . Fairly common
834d *quinnaria* Grt. . . . . Fairly common

UTETHEISA Hubn.

836 *bella* Butl. . . . . Common
836a *hybrida* Butl. . . . . Fairly common
837 *ornatrix* L. . . . . Rare

HAPLOA Hbn.

839 *colona* Hbn. . . . . Locally common
840 *lecontei* Bsdv. . . . . Common
840c *millitaris* Harr. . . . . Common
840d *harrisii* Dy. . . . . Fairly common
840e *smithii* Dy. . . . . Common
840f *vestalis* Pack. . . . . Rare
842 *contigua* Walk. . . . . Very rare

ECPANTHERIA Hbn.

846 *deflorata* Fabr. . . . . Rare

ESTIGMENE Hbn.

851 *acreae* Dru. . . . . Common
854 *congrua* Walk. . . . . Fairly common

HYPANTRIA Harr.

855 *cunea* Dru. . . . . Common
856 *textor* Harr. . . . . Common

ISIA Walk.

859 *isabella* S. & A. . . . . Abundant

PHRAGMATOBIA Steph.

860 *fulginosa* L. . . . . Rare

DIACRISIA Hbn.

862 *virginica* Fabr............. Abundant
863 *lattipennis* Strck........... Rare

APANTESIS Walk.

874 *virgo* L.................... Common
875 *virguncula* Kby............ Fairly common
875a *otiosa* Neu................ Fairly common
876 *michabo* Grt............... Rare
879a *retilinea* Frch............. Common
880 *anna* Grt.................. Rare
880a *persephone* Grt............ Fairly common
882 *arge* Dru.................. Very common
894 *nais* Dru.................. Common
895 *vittata* Fabr............... Rare
895a *phalerata* Harr............ Fairly common

ARCTIA Shrank.

904 *caia* L..................... Fairly common
904a *americana* Harr............ Rare

AMMALO Walk.

905 *tenera* Hbn................ Rare

HALESIDOTA Hbn.

919 *tessalaris* S. & A........... Common
920 *harrisii* Walsh............. Rare
922 *maculata* Harr............. Very rare, 2 specimens
923 *caryae* Harr............... Very common

Family **Agaristidae.**

ALPHYA Fabr.

949 *octomaculata* Fabr......... Common

COPIDRYAS Grt.

956 *gloveri* G. & R............. Fairly common

Family **NOCTUIDAE.**

Subfamily NOCTUINAE.

PANTHEA Hbn.

960 *acronyctoides* Walk......... Common

CHARADRA Walk.

964 *deridens* Gu............... Fairly common

RAPHIA Hbn.

968 *frater* Grt................. Common
970 *abrupta* Grt............... Common

APATELLA Hbn.

972 *americana* Harr............Abundant
975 *dactylina* Grt..............Common
983 *populi* Ril.................Common
984 *lepusculina* Gu............Rare
989 *betulae* Ril................Rare
990 *morula* Grt................Common
991 *interrupta* Gu.............Common
993 *lobeliae* Gu................Common
1002 *clarescens* Gu..............Very rare, 2 specimens
1003 *hamamelis* Gu.............Rare
1004 *superans* Gu...............Very rare, 1 specimen
1005 *lithospila* Grt..............Fairly common
1023 *increta* Morr...............Common
1026 *brumosa* Gu...............Rare
1028 *retardata* Walk............Common
1030 *noctivaga* Grt..............Common
1039 *impleta* Walk...............Common
1041 *oblinata* S. & A............Common

ARSILONCHE Led.

1049 *albovenosa* Goeze...........Common
1049a *fumosum* Morr.............Very rare, 1 specimen
1049c *evanidum* Grt..............Very rare, 2 specimens

MICROCOELIA Gu.

1054 *dipteroides* Gu.............Common.

DIPTHERA Hubn.

1060 *fallax* Herr.-Sch...........Common.

BAILEYA Gu.

1073 *ophthalmica* Gu............Common.

CRAMBODES Gu.

1087 *talidiformis* Gu............Common

BALSA Walk.

1092 *malana* Fitch..............Very rare, 1 specimen
1094 *labecula* Grt...............Rare

CARADRINA Ochs.

1102 *multifera* Walk............Rare
1109 *miranda* Grt...............Fairly common

PERIGEA Gu.

1117 *vecors* Gu.................Very rare

OLIGIA Hbn.

1138 *versicolor* Grt..............Rare
1141 *grata* Hbn..................Fairly common

HADENA Schrank.

1152 *leucocelsis* Grt............. Rare
1158 *modica* Gu................. Common
1159 *hausta* Grt................. Very rare, 1 specimen
1166 *mactata* Gu................. Common
1189 *barnesii* Sm................ Fairly common
1190 *dionea* Sm.................. Rare
1205 *semicana* Walk............. Common
1205a *fractilinea* Grt............. Common
1210 *niveivenosa* Grt............ Rare
1211 *stipata* Morr................ Fairly common
1219 *suffusca* Morr.............. Rare
1220 *vultuosa* Grt............... Common
1224 *finitima* Gu................. Rare
1227 *dubitans* Walk............. Fairly common
1231 *impulsa* Gu................ Common
1232 *devastatrix* Bruce.......... Abundant
1235 *arctica* Bsdv............... Fairly common
1241 *verbascoides* Gu............ Common
1243 *cariosa* Gu.................. Rare
1244 *vulgaris* G. & R............ Fairly common
1250 *lignicolor* Gu.............. Common

MACRONOCTUA Grt.

1255 *onusta* Grt................. Common

PACHYPOLIA Grt.

1257 *atricornis* Grt.............. Fairly common

TRACHEA Hbn.

1289 *delicata* Grt............... Fairly common

PYROPHILA Led.

1295 *pyramidoides* Gu........... Abundant
1295a *inornata* Gu................ Common

HELIOTROPHA Led.

1297 *reniformis* Grt............. Common
1297a *atra* Grt.................... Rare

PRODENIA Gu.

1300 *ornithogalli* Gu............ Common
1300a *eudiopta* Gu................ Rare

LAPHRYGMA Gu.

frugiperda S. & A......... Common
obscura Ril................. Less common

HOMOHADENA Grt.

1312 *badistriga* Grt............. Rare

ONCOCNEMIS Led.

1333 *saundersiana* Grt.......... Fairly common

RYNCHAGROTIS Smith.

1389 *gilvipennis* Grt.............Very rare, 2 specimens
1390 *rufipectus* Morr............Fairly common
1393 *anchocelioides* Gu..........Common
1395 *placida* Grt................Fairly common
1397 *alternata* Grt..............Common

ADELPHIGROTIS Smith.

1415 *prasina* Fabr..............Rare

PLATAGROTIS Smith.

1418 *pressa* Grt.................Common
1419 *condita* Gu.................Rare

EUERAGROTIS Smith.

1422 *sigmoides* Gu...............Common
1423 *peratenta* Grt..............Less common
1424 *attenta* Grt................Very common

AGROTIS Och.

1451 *badinodis* Grt..............Fairly common
1454 *ypsilon* Rott...............Common
1455 *geniculata* G. & R..........Very rare, 1 specimen

PERIDROMA Hbn.

1462 *occulta* L..................Very rare, 3 specimens
1464 *astricta* Morr..............Very rare, 1 specimen
1467 *margaritosa* Haw...........Common
1467a *saucia* Hbn................Common

NOCTUA L.

1475 *smithii* Snell..............Very rare, 2 specimens
1476 *normaniana* Grt............Common
1478 *bicarnea* Gu................Common
1481 *C-nigrum* L.................Abundant
1489 *fennica* Tausch............Rare
1490 *plecta* L...................Rare
1493 *haruspica* Grt.............Rare
1496 *clandestina* Harr...........Common
1511 *cynica* Smith...............Very rare, 1 specimen
1514 *lubricans* Gu...............Common

FELTIA Walk.

1538 *subgothica* Haw............Abundant
1540 *jaculifera* Gu..............Very common
1540a *herilis* Grt.................Less common
1544 *gladiara* Morr..............Common
1545 *venerabilis* Walk...........Very common
1549 *volubilis* Harvey...........Common
1550 *annexa* Treitsch............Fairly common
1551 *malefida* Gu................Common

POROSAGROTIS Smith.

1552	*vetusta* Walk	Very common
1553	*catenula* Grt	Very rare, 2 specimens
1556	*mimallonis* Grt	Very rare, 1 specimen
1558	*tripars* Walk	Common
1559	*rileyana* Morr	Common

PARAGROTIS Pratt.

1620	*scandens* Riley	Common
1621	*detersa* Walk	Fairly common
1649	*messoria* Harr	Common
1655	*fulda* Smith	Very rare, 2 specimens
1707	*insulsa* Walk	Rare
1707a	*verticallis* Grt	Common
1711	*tesselata* Harr	Common
1732	*nordica* Smith	Very rare, 1 specimen
1736	*divergens* Walk	Rare

ANYTUS Grt.

1753	*privatus* Walk	Rare

UFEUS Grt.

1760	*unicolor* Grt	Fairly common

MAMESTRA Ochs.

1771	*discalis* Grt	Very rare, 1 specimen
1773	*nimbosa* Gu	Very rare, 2 specimens
1774	*imbrifera* Gu	Very rare, 1 specimen
1781	*meditata* Grt	Fairly common
1782	*lustralis* Grt	Common
1783	*detracta* Walk	Common
1796	*subjuncta* G. & R	Rare
1801	*trifolii* Rott	Common
1803	*rosea* Haw	Very rare, 1 specimen
1807	*picta* Harr	Very common
1808	*cristifera* Walk	Rare
1832	*olivacea* Morr	Fairly common
1832b	*comis* Grt	Common
1837	*laudabilis* Gu	Very rare, 2 specimens
1842	*lorea* Gu	Fairly common
1858	*nugatis* Smith	Rare

MORRISONIA Grt.

1885	*sectilis* Gu	Rare
1889	*mucens* Hbn	Fairly common
1890	*confusa* Hbn	Common

ULOLONCHE Sm.

1921	*modesta* Morr	Very rare, 1 specimen

TRICHOPOLIA Grt.

1946	*serrata* Smith	Very rare, 1 specimen

NEPHELODES Gu.

1950 *minians* Gu................ Common
1950a *violans* Gu................ Common

HELIOPHILA Hbn.

1953 *unipuncta* Haw............ Abundant
1954 *pseudargyria* Gu........... Common
1957 *luteopallans* Sm............ Common
1963 *albilinea* Hbn.............. Common
1965 *diffusa* Walk............... Fairly common
1975 *insueta* Gu................. Fairly common
1978 *multilinea* Walk........... Very rare, 2 specimens
1979 *commoides* Gu.............. Common
1980 *phragmitidicola* Gu........ Very rare, 2 specimens

ORTHODES Gu.

1996 *crenulata* Butl............. Fairly common
1997 *cynica* Gu.................. Common
1998 *vecors* Gu.................. Very rare, 2 specimens

HIMELLA Grt.

2007 *intractata* Morr............ Very rare, 1 specimen

GRAPHIPHORA Hbn.

2012 *culea* Gu.................. Rare
2026 *peredia* Grt................ Rare
2040 *alia* Gu.................... Common
2043 *subterminata* Smith........ Very rare, 3 specimens

TRICHOLITA Grt.

2060 *signata* Walk.............. Very rare, 1 specimen

XYLINA Ochs.

2078 *disposita* Morr............. Very rare, 2 specimens
2090 *antennata* Walk............ Very rare, 1 specimen
2091 *laticinerea* Grt............. Fairly common
2096 *amanda* Smith............. Fairly common
2109 *querquera* Grt............. Very rare, 2 specimens
2113 *capax* G. & R.............. Very rare, 1 specimen

CALOCAMPA Steph.

2118 *nupera* Lint................ Fairly common

CUCULLIA Schrank.

2127 *asteroides* Gu.............. Common

SPIDA Grt.

2149 *obliqua* Walk............... Fairly common

NONAGRIA Ochs.

2150 *permagna* Grt............. Common
2151 *subflava* Grt............... Rare

GORTYNA Och.

2161 *velata* Walk...............Common
2162 *nictitans* Borkh............Fairly common
2167 *obliqua* Haw...............Rare

PAPAIMENA Smith.

2171 *cerina* Grt.................Very rare, 1 specimen
2173 *speciosissima* G. & R........Very rare, 2 specimens
2179 *nitella* Gu.................Fairly common
2179a *nebris* Gu.................Common
2182 *limpida* Gu.................Very rare, 1 specimen
2187 *cataphracta* Grt............Rare
2190 *rutilla* Gu.................Common

PYRRHIA Hbn.

2197 *umbra* Hfn.................Common
2197a *exprimens* Walk............Less common

JODIA Hbn.

2202 *rufago* Hbn................Fairly common

BROTOLEMIA Led.

2203 *iris* Gu....................Common

TRIGONOPHORA Hbn.

2204 *perriculosa* Gu.............Fairly common

CONSERVULA Grt.

2205 *anodonta* Gu...............Rare

ENCIRROEDIA Grt.

2206 *pampina* Gu...............Very rare, 2 specimens

SCOLIOPTERYX L.

2207 *libatrix* L..................Common

CHOEPHORA G.&R.

2208 *fungorum* G. & R..........Fairly common

FAGITANA Walk.

2216 *littera* Gu.................Very rare, 2 specimens

COSMIA Ochs.

2217 *palacea* Eps...............Common

ORTHOSIA Ochs.

2222 *bicolorago* Gu..............Fairly common
2222a *ferruginoides* Gu...........Common
2225 *aurantiago* Gu............Rare
2230 *helva* Grt..................Common
2231 *lutosa* Andrews............Common

SCOPELOSOMA Curtis.

2236 *indirecta* Grt..............Rare
2241 *walkerii* Grt..............Very rare, 2 specimens
2242 *sidus* Gu..................Fairly common
2243 *morrisonii* Grt.............Fairly common
2244 *devia* Grt..................Rare

GLAEA Hbn.

2247 *inulta* Grt.................Common
2249 *serrica* Morr...............Rare

EPIGLEAE Grt.

2255 *decliva* Grt................Rare

CALYMNIA Hbn.

2259 *orina* Gu...................Common

IPHIMORPHA.

2261 *pleonectusa* ....Common

CHLORIDEA West.

2296 *virescens* Fabr.............Very rare, 1 specimen

HELIOTHIS Ochs.

2300 *armiger* Hbn..............Abundant
2300a *umbrosa* Grt...............Very common
2301 *phlogophagus* G. & R.......Common
2301a *luteitinctus* Grt...........Very rare, 1 specimen

RHODOPHORA Gu.

2307 *florida* Gu.................Rare

PSEUDACONTIA Smith.

2316 *crustaria* Morr.............Very rare, 1 specimen

PORRINA Grt.

2319 *sanguinea* Geyer...........Rare

SCHINIA Hbn.

2332 *trifascia* Hbn..............Common
2346 *lynx* Gu...................Rare
2351 *tertia* Grt.................Common
2353 *jaguirina* Gu..............Rare
2361 *marginata* Haw............Common
2366 *brevis* Grt.................Fairly common
2371 *meskeana* Grt..............Very rare, 1 specimen

EUTHISANOTIA Hbn.

2428 *unio* Hbn..................Fairly common
2430 *grata* Fabr................Common

BASILODES Gu.

2443 *pepita* Gu.................Rare

POLYCHRISIA Hbn.

2473 *formosa* Grt...............Very rare, 1 specimen

PLUSIA Hbn.

2474 *aerea* Hbn.................Common
2475 *aeroides* Grt...............Common
2476 *baluca* Gey................Rare

EUCHALCIA Hbn.

2478 *contexta* ....Common
2479 *festucae* ....Fairly common
2480 *venusta* Walk.............Rare

AUTOGRAPHA Hbn.

2483 *bimaculata* Steph...........Fairly common
2485 *biloba* Steph ....Variable, fairly common to rare
2487 *rogationis* Gu..............Common
2488 *precationis* Gu.............Common
2493 *ou* Gu.....................Rare
2496 *brassicae* Ril...............Common
2498 *oxygramma* Gey............Very rare, 2 specimens
2519 *falcigera* Kirb ....Fairly common
2519a *simplex* Gu................Common

PAECTES Hbn.

2542 *delineata* Gu...............Rare
2548 *oculatrix* Gu...............Very rare, 1 specimen

ALABAMA Grt.

2555 *argillacea* Hbn..............Fairly common[3]

ANOMIS Hbn.

2557 *exacta* Hbn................Very rare, 1 specimen

AMOLITA Grt.

2567 *fessa* Grt..................Common

RIVULA Gu.

2568 *propinquis* Gu... ....Fairly common

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[3]2555 While this species is usually fairly common during the autumn months a case of unusual abundance may here be noted. In September, 1910, a heavy shower came up from the southeast. During this shower swarms of moths were noticed around the electric lights. I visited the locality the next day and found the moths in myriads. Houses, fences and herbage were brown with them. By the use of the telephone, supplemented by some field work, the limits of the swarm (if it might be called such) were determined. The line of occurrence was from southeast to northwest and extended nearly fifteen miles in length with a width of from one-half to three-fourths of a mile. The center of abundance was about a fourth of a mile wide and three miles long and very few were found in the extreme limits. The maxima of moths and of rainfall were coincident. The reason I leave for others to explain, my part being only to record the occurrence.

EUSTROTIA Hbn.

2601 *albidula* Gu.............. Common
2604 *concinnimacula* Gu......... Rare
2606 *musta* G. & R.............. Fairly common
2607 *muscoscula* Gu............. Fairly common
2612 *apicosta* Haw.............. Rare
2616 *aeria* Grt.................. Very rare, 1 specimen

GALULA Gu.

2618 *hepera* Gu.................. Fairly common
2618a *partita* Gu................ Common

LITHOCODIA Hbn.

2622 *bellicula* Hbn.............. Rare

XANTHROPTERA Gu.

2631 *nigrofimbria* Gu............ Rare

TRIPUDIA Grt.

2642 *quadrifera* Zell............ Rare

TARACHE Hbn.

2664 *abdominalis* Grt............ Very rare, 2 specimens
2673 *biplaga* Gu................. Rare
2676 *erastrioides* Gu............ Common
2691 *candefacta* Hbn............ Fairly common

FRUVA Grt.

2699 *apicella* Grt............... Very rare, 2 specimens

HYAMIA Walk.

2727 *sexpunctata* Grt........... Very rare, 2 specimens

HYPSOROPHA Hbn.

2740 *monilis* Fabr.............. Very rare, 1 specimen

Subfamily CATOCALINAE.

CISSURA Walk.

2743 *spadix* Cram.............. Very rare, 1 specimen

DRASTERIA Hbn.

2754 *erechtea* Cram............ Common
2755 *crasiuscula* Haw.......... Abundant

CAENURGIA Walk.

2758 *convalescens* Gu.......... Very rare, 1 specimen

EUCLIDIA Ochs.

2760 *cuspidea* Hbn.............. Common

MELIOPOTIS Hbn.

2774 *jucunda* Hbn.............. Rare

SYNEDA Gu.

2781 *graphica* Hbn.............. Common

CATOCOLA Schrank.

2806	*epione* Dru	Very rare, 1 specimen
2807	*sappho* Streck	Very rare, 3 specimens
2813	*vidua* S. & A	Common
2815	*retecta* Grt	Rare
2819	*obscura* Streck	Fairly common
2820	*residua* Grt	Fairly common
2821	*insolabilis* Gu	Rare
2826	*relicta* Walk	Common
2826a	*bianca* Hy Edw	Rare
2826b	*phrynia* Hy Edw	Very rare, 1 specimen
2827	*cara* Gu	Common
2827a	*carissima* Hulst	Less common
2828	*amatrix* Hbn	Fairly common
2828a	*nurus* Walk	Common
2829	*marmorata* Edw	Rare
2830	*concumbens* Walk	Common
2836	*luciana* Edw	Very rare, 2 specimens
2836a	*somnus* Dodge	Very rare, 1 specimen
2846	*pura* Hulst	Very rare, 1 specimen
2848	*unijuga* Walk	Fairly common
2849	*beaniana* Grt	Very rare, 1 specimen
2857	*parta* Gu	Common
2857a	*perplexa* Strck	Fairly common
2857b	*petulans* Hulst	Locally common
2864	*ultronia* Hbn	Common
2864a	*celia* Hy Edw	Fairly common
2864b	*mopsa* Hy Edw	Common
2865	*illia* Cram	Very rare, 1 specimen
2866	*hinda* French	Very rare, 2 specimens
2868	*piatrix* Grt	Common
2870	*neogamma* S. & A	Rare
2871	*subnata* Grt	Very rare, 1 specimen
2872	*cerogama* Gu	Rare
2873	*paleogama* Gu	Fairly common
2875	*muliercula* Gu	Rare
2876	*delilah* Streck	Fairly common
2881	*illecta* Streck	Rare
2882	*serana* Edw	Rare
2883	*amatrix* Streck	Very common
2889	*abreviatella* Grt	Common
2890	*whitneyii* Dodge	Rare
2891	*nuptialis* Walk	Fairly common
2897a	*aholah* Streck	Rare
2907	*amica* Hbn	Very rare, 2 specimens
2907a	*lineella* Grt	Rare

EUPARTHENOS.

2911 *nubilis* Hbn................Common
2911a *apache* Poling.............Common

PARALLELIA Poling.

2921 *bistriaris* Hbn.............Fairly common

REMIGIA Gu.

2923 *repandra* Fabr.............Common

ZALE Hbn.

2977 *horrida* Hbn..............Rare

HOMOPTERA Bsdv.

2986 *lunata* Dru................Abundant
2986a *edusa* Dru.................Abundant
2999 *penna* Morr...............Very rare, 1 specimen
3000 *unilineata* Grt.............Rare

EREBUS.

3006 *odora* L...................Rare[4]

THYSANIA.

3007 *zenobia* Cram..............Very rare, 1 specimen (perfect)

Subfamily HYPENINAE.

EPIZEUXIS Hbn.

3008 *americalis* Gu..............Common
3009 *aemula* Hbn................Common
3012 *lubricalis* Geyer............Very rare, 2 specimens
3013 *denticulatis* Harvey.........Very rare, 1 specimen
3016 *rotundalis* Walk............Fairly common

ZANCLOGNATHA Led.

3019 *laeviga* Grt.................Fairly common
3019a *modestalis* Fitch............Common
3019b *reversa* Dy................Fairly common
3019c *obsoleta* Sm................Common
3026 *lituralis* Hbn...............Rare
3027a *gypsalis* Grt...............Very rare, 1 specimen

HORMISSA Walk.

3031 *absorbtalis* Walk...........Common

PHILOMETRA Grt.

3036 *metonalis* Walk............Common
3037 *emelusalis* Walk............Common

[4]3006 I have taken battered specimens of this species nearly every season while sugaring for catocalas.

CRYTOLITA Grt.

3039 *morbidalis* Gu..............Common
3039a *petrealis* Grt...............Less common

RENIA Gu.

3041 *salusalis* Walk.............Very rare, 2 specimens
3042 *discoloralis* Gu.............Rare
3048 *flavipunctalis* Gey..........Common

BLEPTINA Gu.

3049 *caradrinalis* Gu............Common
3050 *inferior* Grt...............Very rare, 1 specimen

HETEROGRAMMA Gu.

3054 *pyramusalis* Walk..........Common

GABERASA Walk.

3055 *ambigualis* Walk...........Rare

PALTHIS Hbn.

3058 *angulalis* Hbn.............Common

CAPIS Grt.

3060 *curvata* Grt................Very rare, 1 specimen

LOMANALTES Grt.

3063 *eductalis* Walk.............Common

BOMOLOCHA Hbn.

3064 *manalis* Walk..............Fairly common
3065 *baltimorealis* Gu...........Rare
3066 *bijugalis* Walk.............Very rare, 2 specimens
3070 *sordidula* Grt..............Common
3073 *deceptalis* Walk............Common
3074 *edictalis* Walk.............Rare
3076 *umbralis* Fabr.............Very rare, 1 specimen

PLATHYPENA Grt.

3079 *scabra* Fabr...............Common
3079a *subrufalis* Grt.............Rare

HYPENA Schrank.

3080 *humuli* Harr..............Fairly common

Family Nycteolidae.

NYCTEOLA Hubner.

3083a *lintneria* Spey.............Rare
3084 *proteela* ....Very rare, 1 specimen

Family Notodontidae.

APATELODES Pack.

3090 *torrefacta* S. & A.......... Rare

MELALOPHA Hbn.

3092a *ornata* G. & R............. Common
3094 *inclusa* Hbn............... Rare
3094a *inversa* Pack.............. Fairly common
3096 *albosigma* Fitch............ Very rare, 2 specimens

DATANA Walsh.

3098 *ministra* Dru.............. Common
3100 *angusii* G. & R............ Common
3106 *perspicua* G. & R.......... Fairly common
3108 *integerrima* G. & R......... Fairly common
3110 *contracta* Walsh............ Common

HYPERAESCHRA Butler.

3112 *georgica* Herr-Schf......... Very rare, 2 specimens

NOTODONTA Och.

3116 *basitriens* Walk............ Rare

PHEOSIA Hbn.

3118 *dimiadata* Herr-Schf........ Common

LOPHODONTA Pack.

3120 *ferruginea* Pack........... Fairly common

NADATA Walk.

3123 *gibbosa* S. & A............. Common
3123a *doubledayi* Pack........... Fairly common

SYMMERISTA Hbn.

3125 *albifrons* S. & A........... Fairly common

DASYLOPHIA Pack.

3127 *anguina* S. & A............ Rare

HETEROCAMPA Doub.

3133 *obliqua* Pack.............. Fairly common
3134 *picta* Fel.................. Very rare, 3 specimens
3137 *manteo* Doubd............. Common
3141 *guttivitta* Walk............ Common
3142 *bilineata* Pack............. Fairly common

SCHIZURA Doubd.

3148 *ipomoeae* Doubd........... Rare
3149 *concinna* S. & A........... Fairly common
3151 *unicornis* S. & A.......... Rare
3153 *badia* Pack................ Very rare, 2 specimens

HYPARPAX Hbn.

3155 *aurora* S. & A.............Rare

CERURA Schr.

3160 *occidentalis* Lint...........Rare

HARPYIA Ochs.

3162 *cinerea* Walk..............Common
3163 *nivea* Neum...............Very rare, 1 specimen

GLUPHISIA.

3166 *septentrionalis* Walk........Common
3166a *ridenda* Hy Edw...........Rare

Family Thyatiridae.

PSEUDOTHYATIRA Grt.

3177 *expultrix* Grt..............Fairly common

Family Liparidae.

HEMEROCAMPA Dy.

3190 *leucostigma* S. & A.........Abundant
3191 *inornata* Beut.............Rare
3192 *definata* Pack..............Very common

OLENE Hbn.

3193a *tepha* Hbn................Rare
3194 *leucophaea* S. & A.........Common

Family Lasiocampidae.

TOLYPE Hbn.

3208 *velleda* Stoll...............Fairly common
3211 *laricis* Fitch...............Common

MALACOSOMA Hbn.

3214 *americana* Fabr............Common
3221 *disstria* Hbn...............Common

HETEROPACHA Harr.

3222 *rileyana* ....Rare

EPICNAPTERA Rambur.

3223 *americana* Harr............Common
3223a *ferruginea* Pack...........Less common

Family Platypterygidae.

ORETA Walk.

3226 *rosea* Walk................Fairly common
3226a *marginata* Walk...........Common

DREPANA Walk.

3229 *arcuata* Walk..............Very rare, 1 specimen

Family GEOMETRIDAE.

Subfamily DYSPTERIDINAE.

NYCTOBIA Hulst.

3235 *fusifasciata* Walk..........Rare

Subfamily HYDRIOMENINAE.

PALEACRITA Riley.

3245 *vernata* Peck..............Common

EUDULE Hbn.

3248 *mendica* Walk.............Common
3251 *unicolor* Rob...............Rare

NANNIA Hulst.

3260 *refusata* Walk.............Common

HETEROPHLEPS Herr-Schf.

3262 *triguttaria* Herr-Schf.......Very common

TEPHROCLYSTIS Hbn.

3271 *implicata* Walk............Very rare, 1 specimen
3277 *miserulata* Grt.............Rare
3294 *absinthiata* Clerk...........Fairly common
3295 *fumosa* Hulst..............Rare

EUCMATOGE Hbn.

3323 *anticaria* Walk.............Very rare, 2 specimens
3327 *intestinata* Gu.............Common

VENUSIA Curtis.

3329 *cambrica* Curtis............Rare

EUCHOECA Hbn.

3332 *albovittata* Hbn............Fairly common
3335 *lucata* Gu..................Fairly common
3336 *albifera* Walk.............Common

HYDRIA Hbn.

3340 *undulata* L................Common

EUSTROMA Hbn.

3348 *diversilineata* Hbn..........Common
3350a *remota* Walk..............Very rare, 2 specimens
3355 *explanata* Walk............Rare

RHEUMAPTERA Hbn.

3361 *sociata* Bork..............Rare

PERCNOPTILOTA Hulst.

3370 *fluviata* Hbn..............Common

MESOLEUCA Hbn.

3371 *ruficilliata* Gu..............Rare
3374 *lacustrata* Gu..............Common
3376 *intermedia* Gu..............Fairly common
3386 *vassaliata* Gu..............Very rare, 2 specimens

HYDRIOMENA Hbn.

3402 *latirupta* Walk.............Fairly common

TRIPHOSA Steph.

3416 *dubitata* L.................Rare

COENOCALPE Hbn.

3418 *aurata* Grt................Very rare, 1 specimen
3431 *formosata* Strck............Common

GYPSOCHROA Hbn.

3438 *designata* Hnfn............Fairly common

PETROPHORA Hbn.

3457 *ferrugata* Clerk............Rare

Subfamily MONOCTENIINAE.

HAEMATOPSIS Hbn.

3468 *grataria* Fabr..............Common

Subfamily STERRHINAE.

ERASTRIA Hbn.

3469 *amaturaria* Walk...........Very rare, 1 specimen

DEPTALIA Hulst.

3477 *insularia* Gu..............Common

COSYMBIA Hbn.

3478 *culicaria* Gu...............Very rare, 1 specimen
3480 *lumenaria* Hbn.............Common

SYNELYS Hulst.

3487 *ennucleata* Gu.............Fairly common

XYSTROLA Hulst.

3494 *hepaticaria* Gu.............Rare

CINGLIS Gu.

3497 *similaria* Walk.............. Common
3501 *fuscata* Hulst.............. Very rare, 1 specimen

EOIS Hubn.

3521 *demissaria* Hbn.............Rare
3546 *inducta* Gu................Fairly common

Subfamily GEOMETRINAE.

NEMORIA Hbn.

3564 *subcroceata* Walk........... Common

APLODES Gu.

3587 *mimosaria* Gu.............. Fairly common
3590 *bistriaria* Hbn............. Common

Subfamily ENOMINAE.

EPELIS Hulst.

3603 *truncataria* Walk........... Fairly common

ORTHOFIDONIA Pack.

3605 *exornata* Walk............. Very rare, 3 specimens
3606 *semiclarata* Walk........... Rare
3608 *vestaliata* Gu.............. Common

GUENERIA Pack.

3619 *basiaria* Walk.............. Common

DEILINIA Hbn.

3623 *variolaria* Gu.............. Common
3636 *liberaria* Walk............. Rare

SCIAGRAPHIA Hulst.

3643 *sublacteolaria* Hulst........Fairly common
3645 *maculifascia* Hulst.......... Rare
3647 *granitata* Gu.............. Fairly common
3664 *melistrigata* Grt............ Rare

PHILOBIA Dupon.

3666 *notata* L..................Rare
3667 *enotata* Gu................ Very rare, 2 specimens

MACARIA Curtis.

3668 *infimata* Gu............... Very rare, 2 specimens
3673 *eremiata* Gu...............Rare
3682 *septemfluaria* Grt..........Fairly common

CYMATOPHORA Hbn.

3690 *riberaria* Harvey........... Fairly common
3704 *evagaria* Hulst............. Very rare, 1 specimen
3705 *subcessaria* Walk........... Common

HOMOCLODES Hulst.

3748 *frittilaria* Gu.............. Fairly common

CATOPYRRHA Hbn.

3759 *coloraria* Fabr............. Rare

ALCIS Curtis.

3784 *sulphuraria* Pack........... Rare
3786 *dislocaria* Pack............. Rare
3798 *maestosa* Hulst............ Very rare, 1 specimen

SELIDOSEMA Hbn.

3838 *humarium* Gu.............. Fairly common

CLEORA Curt.

3850 *pampinaria* Gu............. Fairly common

MELANOPHORIA Hulst.

3858 *canadaria* Gu.............. Rare

ECTROPIS Hbn.

3862 *crepuscularia* D. & S....... Common

ERANNIS Hbn.

3884 *tiliaria* Harr.............. Common

CINGILIA Walk.

3886 *catenaria* Dru............. Common

EUGONOBAPTA Warren.

3916 *nivosaria* Gu............... Common

ENNOMOS Tr.

3922 *subsignarius* Hbn.......... Fairly common
3923 *magnarius* Gu.............. Rare

XANTHOTYPE Warren.

3925 *crocataria* Fabr............ Common

HYPERITIS Gu.

3934 *amicaria* Herr-Sch......... Rare
3934a *alienaria* Herr-Sch......... Rare

ANIA Haw.

3939 *limbata* Haw................ Fairly common

GONODONTIS Hbn.

3944 *duaria* Gu................. Common

METANEMA Gu.

3981 *inatomaria* Gu............. Fairly common
3982 *determinata* Walk.......... Rare
3986 *quercivoria* Gu............ Common
3988 *textrinaria* G. & R........ Very rare, 1 specimen

SYNSAURA Hbn.

4005 *infensata* Gu............... Very rare, 2 specimens

CABERODES Gu.

4007 *confusoria* Hbn............ Common
4007a *metrocamparia* Gu.......... Less common

TETRACIS Gu.

4011 *crocallata* Gu.............. Common

SABULODES Gu.

4014 *arcassaria* Walk............ Very rare, 1 specimen
4026 *transversata* Dru........... Common

ABBOTANA Hulst.

4028 *transducens* Walk.......... Very rare, 4 specimens

Subfamily SPAECECELODINAE.

SPHAECELODES Gu.

4033 *vulneraria* Hbn............ Rare

Superfamily **TINEOIDEA.**

Family **Nolidae.**

CELAMA Walk.

4046 *triquetana* Fitch........... Common

ROESELIA Hbn.

4055 *minniuscula* Zeller.......... Very rare, 2 specimens

Family **Lacosomiidae.**

LACOSOMA Grt.

4060 *chiridota* Grt.............. Rare

Family **Psychidae.**

THYRIDOPTERYX Steph.

4065 *ephemeraeformis* Haw...... Fairly common

SOLENOBIA.

4072 *walshella* Clemens..........Fairly common

Superfamily **Tineoidea.**

Family **Cochlidiidae.**

EUCLEA Hbn.

4080 *chloris* Herr-Schf..........Rare

LITHOCODES Pack.

4097 *fasciola* Herr-Schf..........Fairly common

Family **Megalopygidae.**

LAGOA Harris.

4110 *crispata* Pack..............Rare
4111 *pyxidifera* S. & A.........Very rare, 2 specimens

Family **Pyromorphidae.**

HARRISINA Packard.

4129 *americana* G-M............Rare

Family **Thyridae.**

DYSODIA Clemens.

4134 *oculatana* Clem............Rare

Family **Cossidae.**

ZUEZERA Latreille.

4141 *pyrina* L..................Fairly common

COSSUS Fabr.

4142 *centerensis* Lint............Fairly common

PRIONOXSTUS Grt.

4147 *robinae* Pack..............Common
4147a *quercus* Ehr...............Fairly common

COSSULA Bailey.

4151 *magnifica* Strick...........Very rare, 1 specimen

Family **Sesiidae.**

MELITTIA Hbn.

4162 *satyriniformis* Hbn.........Common

PODOSESIA Moschler.

4173 *syringae* Harr.............Common

AEGERIA Fabr.

4188 *apiformis* Clerk............Rare
4190 *tibialis* Harr...............Very rare, 1 specimen

BEMBECIA.

4191 *marginata* Harr............Rare

SANSINOIDEA Beut.

4194 *exitiosa* Say. Jr............Fairly common

ALBUNA HyEdw.

4197 *pyramidalis* Walk...........Common

SESIA.

4203 *rutilans* Hy Edw...........Very rare, 1 specimen
4208 *tipuliformis* Clerk..........Very common
4216 *pictipes* G. & R............Rare
4217 *albicornis* Hy Edw.........Fairly common
4221 *acerni* Clemens.............Common
4225 *scitula* Harr...............Rare

Family **PYRALIDAE.**

Subfamily PYRAUSTINAE.

GLAPHRIA Hbn.

4264 *sesquistrialis* Hbn..........Rare

HYMENIA Hbn.

4275 *perspectalis* Hbn...........Fairly common
4276 *fascialis* Cram.............Rare

DESMIA Westwood.

4277 *funeralis* Cram............Common

DIASTICTIS Hbn.

4287 *argyralis* Hbn.............Common

PILOCROCIS Led.

4291 *ramentalis* Led.............Rare

PANTOGRAPHA Led.

4307 *limata* G. & R.............Fairly common

DIAPHANA Hbn.

4320 *hyalinata* L...............Common
4321 *quadristigmalis* Gu.........Common

EVERGESTES Hbn.

4336 *straminalis* Hbn...........Common

CROCIDOPHORA Led.

4337 *serratissimalis* Zell.........Common

LOXOSTEGE Hbn.

4345 *dasconalis* Walk............Fairly common
4347 *chortalis* Grt...............Rare
4349 *obliteralis* Walk............Common
4354a *rantalis* Gu.................Very rare, 1 specimen
4358 *stricticallis* Grt.............Very rare, 2 specimens

PHLYCTAENIA Hbn.

4401 *ferrugalis* Hbn.............Common
4409 *acutella* Walk..............Fairly common
4411 *extricalis* Gu..............Common
4413 *tertialis* Gu................Common

CINDAPHIA Led.

4414 *bicoloralis* Gu..............Common

PYRAUSTA Schrank.

4417 *pertextalis* Led.. ....Common
4440 *inconcinnalis* Led...........Fairly common
4443 *unifascialis* Pack...........Rare
4454 *insequalis* Gu...............Rare
4461,1 *signatalis* Walk............Common
4472 *funebris* Strom............Common

LINEODES Gu.

4484 *integra* Zeller..............Rare

Subfamily NYMPHULINAE.

NYMPHULA Schrank.

4487 *icciusalis* Walk.............Common
4492 *badiusalis* Walk............Common
4496 *obliteralis* Walk............Rare

Subfamily SCOPARIINAE.

SCOPARIA Haw.

4507 *basalis* Walk...............Common
4510 *centuriella* D. & S..........Rare

Subfamily PYRALINAE.

PYRALIS L.

4516 *farinalis* L.................Very common

HERCULIA Walk.

4521 *olinalis* Gu................Common

OMPHALOCERA Led.

4525 *dentosa* Grt.................Rare

Subfamily CHYSAUGINAE.

SALOBRANA Walk.

4526 *tecomae* Ril.................Very rare, 2 specimens

GALASA Walk.

4533 *rubidana* Walk............Rare

Subfamily SCHOENOBINAE.

AMESTRIA Ragonet.

4536 *occuliferralis* Rag..........Very rare, 1 specimen

SCHOENOBIUS Duponchel.

4542 *sordidellus* Zinck...........Very rare, 1 specimen
4545 *melinellus* Clem............Fairly common

Subfamily CRAMBIDAE.

CRAMBUS Fabr.

4558 *hastiferellus* Walk..........Fairly common
4560 *hamellus* Thun.............Common
4563 *pascuellus* L...............Common
4565 *leachellus* Zinck............Rare
4567 *praefectellus* Zinck.........Common
4573 *lasqueatellus* Clem..........Common
4577 *albellus* Clem..............Rare
4585 *vulgivagellus* Clem.........Fairly common
4604 *trisectus* Walk.............Common
4609 *luteolellus* Clem............Fairly common

ARGYRIA Hbn.

4620 *nivalis* Dru................Fairly common
4621 *argenta* Martyn............Common
4622 *auratella* Clem.............Common

CHILO Zinken.

4631 *comptulatalis* Hulst........Common
4632 *forbesellus* Fernald.........Very rare, 1 specimen

Subfamily EPIPASSCHINAE.

EPIPASCHIA Clemens.

4637 *superatalis* Clem...........Rare
4639 *zelleri* Grt.................Very rare, 2 specimens

BENTA Walk.

4648 *asperatella* Clem...........Rare

LANTHAPE Clem.

4652 *plantanella* Clem...........Common

WANDA Hulst.

4654 *baptisiella* Fern............Rare

Subfamily PHYCITINAE.

MYELOIS Hubn.

4676 *bistriatella* Hulst...........Common

ACROBASIS Zeller.

4688 *caryae* Grt................Fairly common
4692 *rubrifasciella* Pack.........Common

MEROPTERA Grt.

4746 *pravella* Grt...............Common

SALRBRIA Zeller.

laevigatella Hulst..........Common

LAODAMIA Ragonet.

4776 *fusca* Haw.................Fairly common

EPISCHNIA Hubner.

4793 *boisduvaliella* Gu...........Very rare, 1 specimen

MELITARA Walk.

4816 *prodenialis* Walk...........Very rare, 1 specimen

CANARTIA Hulst.

4843 *ulmiarrosorella* Clem.......Rare

HOMOEOSOMA Curtis.

4865 *electellum* Hulst...........Fairly common

EPHRESTIA Guenee.

4879 *eleutella* Hbn..............Rare

Subfamily ANERASTINAE.

SALURIA Ragonet.

4905 *tetradella* Zell..............Very rare, 3 specimens

PEORIA Ragonet.

4911 *aproximella* Walk.......... Common

Family **Pterophoridae.**

OXYPTILUS Zeller.

4933 *delewaricus* Zell............Rare

PLATYPTILIA Hubner.

4941 *carduidactyla* Riley.........Fairly common
4955 *tesseradactyla* L.............Rare
4956 *marginidactyla* Fitch......Very rare, 1 specimen

PTEROPHORUS Geoffrey.

4962 *homodactylus* Walk.........Rare
4973 *paleaceus* Zell..............Common
4981 *monodactylus* L............Common
4982 *cretidactylus* Fitch.........Rare
4990 *inquinatus* Zeller...........Very rare, 2 specimens

Family Orneodidae.

ORNEODES Latreille.

4997 *hexadactyla* L. .... Rare

Family Tortricidae.

Subfamily OLETHREUTINAE.

POLYCHROSIS Ragonet.

5005 *botrana* Schiffermuller...... Fairly common

BACTRIA Stephens.

5006 *lanceolata* Hbn............. Rare

EXARTEMA Clemens.

5015 *permundanum* Clem........ Common
5021 *fasciatonum* Clem.......... Fairly common

EUCOSMIA Hbn.

5101 *giganteana* Riley........... Very rare, 2 specimens
5142 *otiosana* Clem............. Common

THIODIA Hbn.

5164 *olivaceana* Ril.............. Rare
5165 *formosana* Clem............ Fairly common

EPINOSIA Hbn.

5226 *saliciana* Clem............. Very rare, 1 specimen

ENARMONIA Hbn.

5269 *prunivora* Walsh........... Rare

LIPOPTYCHA Lederer.

5293 *maculana* Fernald.......... Very rare, 1 specimen

CYDIA Hubner.

5296 *pomonella* L............... Common

Subfamily TORTRINAE.

ALCERIS Hubner.

5309 *hastiana* L................. Common

ARCHIPS Hbn.

5363 *zapulata* Rob.............. Fairly common
5366 *semiferrana* Walker........ Rare
5372 *grisea* Rob................. Very rare, 1 specimen
5375 *virescana* Clem............. Common
5377 *clemensiana* Fernald........ Common

TORTRIX Linnaeus.

5397 *lata* Rob....................Very rare, 2 specimens
5401 *bergmaniana* L.............Fairly common
5402 *peritana* Clem.............Rare
4606 *fumiferrana* ....Locally common

EULIA Hbn.

5418 *ministrana* L..............Rare
5423 *politana* Haw..............Rare
5426 *colorodana* Fer.............Very rare, 1 specimen

AMORBIA Clem.

5429 *humerosana* Fer...........Rare

Subfamily PHALONIINAE.

PHALONIA Hbn.

5452 *bunteana* Rob..............Rare

Family **Yponomentidae.**

MATYRINGA Busck.

5476 *lattipenis* Walsh...........Fairly common

PLUTELLA Schrank.

5503 *maculipennis* Curtis........Rare

GLYPHIPTERYX Hbn.

5513 *impigritella* Clem..........Very rare, 1 specimen

BRENTHIA Clem.

5532 *pavonacella* Clem...........Rare

Family **Gelechiidae.**

MENTZERIA Zeller.

5539 *lappella* L..................Fairly common

ARISTOTELIA Hbn.

5575 *roseosuffusella* Chambers....Rare
5582 *elegantella* Chambers.......Very rare, 2 specimens

GNORIMOSCHEMA Busck.

5620 *gallaesolidaginus* Ril........Common
5638 *lavernella* Busck...........Rare

TRICHOTAPHE.

5657 *serrativitella* Zel............Fairly common

YPSOLOPHUS Fabr.

5678 *ligulellus* Hbn..............Rare

GELECHIA Hbn.

5744 *discoöcella* Chamb..........Fairly common

Family **Zyloricti̇dae.**

STENOMA Zeller.

5834 *schlaegeri* Zeller............Rare

Family **Oecophoridae.**

DEPRESSARIA Haw.

5854 *atrodorsella* Clem..........Fairly common
5882 *robiniella* Pack.............Rare

Family **Tineidae.**

BUCCULATRIX Zeller.

6246 *pomifoliella* Clem..........Rare

LITHOCOLLETES Packard.

6256 *clemensella* Chamb.........Very rare, 2 specimens
6264 *alniella* Zell................Rare
6333 *salicifoliella* Clem..........Rare

BEDELLIA Stainton.

6338 *minor* Busck...............Very rare, 1 specimen

GRACILLARIA Haw.

6364 *lespezaefoliella* Clem........Fairly common

XYLESTIA Clem.

6476 *pruniramiella* Clem.........Very rare, 2 specimens

INCURVARIA Haw.

6477 *acerifoliella* Fitch..........Rare

MONOPIS Hbn.

6489 *rusticella* Hbn.............Rare

TINEA L.

6520 *pellionella* L...............Fairly common

PRONUBIA Riley.

6574 *yucasella* Riley............Very rare, 1 specimen

Superfamily **MICROPTERYGOIDAE.**

Family **Hepialidae.**

HEPIALUS Fabr.

6608 *hyperboreas* Morchler......Very rare, 2 specimens

CEDAR RAPIDS.

THE COLEOPTERA OF HENRY COUNTY, IOWA.

INEZ NAOMI KING.

The members of the order Coleoptera can be distinguished readily from all other insects, except the earwigs, by the horny, veinless wing-covers which meet in a straight line down the back, beneath which there is a simple pair of membraneous wings. Beetles differ from earwigs mainly in not having the pincer-like appendages at the tail-end of the body, characteristic of the earwigs.

Of the 12,000 species of beetles indigenous to North America about 500 species, representing upwards of forty-five families, are known to occur in Henry county, Iowa. The beetles and their larvæ differ very greatly in their habits and some species are beneficial while others are extremely noxious.

One of the most common of the injurious beetles known to occur in this county is the Elateridæ or wire-worm—a slender, cylindrical worm one-half to one inch in length. This worm is the larva of the Click or Snapping beetles. It is covered with a shining, brown skin through which the segments show quite plainly. It infests a variety of field and garden crops, working in or on the roots or tubers. Ordinarily the beetles breed in sod ground, the worm feeding on the roots of grasses. Their presence in meadows is seldom noticed as the ground is usually so well filled with roots that their work of devastation does not attract attention. But as soon as the sod is broken up and corn or potatoes are planted, the worms have comparatively little to feed upon and quickly become a virulent pest. The wire-worm is especially injurious to corn and potatoes and it often attacks oats, wheat and other cereals.

The dying off of plants here and there throughout fields and gardens is the first indication of the presence of the white grubs of the Lachnostera (May-beetles or June Bugs). A careful examination of the soil beneath affected plants discloses the soft-bodied grubs lying somewhat curled up. These grubs have brown heads and are about an inch and a quarter in length. The adults are brown nocturnal flyers, feed upon the leaves of various trees and are attracted by electric lights. They lay their eggs in the soil and it requires about two years for the development of the grub. Grass-land is their natural breeding place, so the greatest devastation occurs in fields that have been in sod for a number of years and which have been broken up recently for other crops. The gardener or farmer of Henry county who wishes to plant sod ground will find that a carefully planned rotation of crops is the best means of ridding his fields of this troublesome grub.

Many fields of corn in this and the adjoining counties are greatly damaged by a small, slender worm which mines in the main roots, tunneling here and there, seriously checking the growth of the plants if not killing them completely. In its adult form this beetle is the *Diabrotica longicornis.* It is small, greenish in color, and about one-fourth of an inch in length. It may be seen occasionally on melon and squash vines, but it is found more frequently on sunflowers and golden-rod.

Corn planted in low or peaty ground is often injured and even destroyed by a beetle a little less than half an inch long, dark red in color, somewhat flattened, with a large thorax and a narrow waist. This beetle is known as the ground beetle, *Clavinia impressifrons.* It passes the winter in the ground as an adult and destroys the grain by eating the heart out of the sprouting kernels.

The *Ligyrus gibbosus,* the enemy of the market gardener, is black above and reddish beneath and works near the surface of the ground. It eats into the roots of carrots, parsnips, sugar-beets, potatoes, celery and corn. The most serious damage to this class of crops may occur either in the spring or in the fall.

The Weevils, whose larvæ are soft, white maggot grubs, destitute of feet, feed chiefly on fruits, seeds and nuts, though all parts of the plant are subject to their ruinous attacks.

Swarms of rather long-legged beetles, black, gray or striped yellow and black, with distinct heads and necks and elongated straight-cut bodies sometimes descend on gardens and fields and quickly destroy all foliage. This family is called Meloidæ (Blister-beetles) and is particularly destructive to sugar-beets, potatoes, beans and other legumes. The younger stages of this insect are spent in the soil, the larvæ feeding upon the egg-clusters of the grasshopper.

Perhaps the most destructive of the household pests is the *Anthreus scrophulariae,* popularly known as Buffalo Moth or Carpet-beetle. Generally it appears in the fall and continues throughout the winter and spring; but in heated houses it may be found all the year round. It is an active brown larva a quarter of an inch in length, clothed with stiff brown hairs which are longer at the ends than on the back. It feeds on woolen goods, carpets, etc. It works along the under surface, sometimes making irregular holes, but more frequently it cuts a slit in a carpet by following the floor-cracks. When disturbed, the insect folds up its legs and antennæ and feigns death.

Some families of the order Coleoptera are quite extensively represented in Henry county. Among the most common and most widely dispersed are the Carabidæ or ground beetles. To this family belong the *Calosomia scrutator* so destructive to caterpillars; the "bombardiers" with their ill-smelling little popguns.

There are swarms of Lamellicorn or Leaf-chafers; of Chrysomelidæ or Leaf-beetles, the largest of which is the Colorado potato-beetle. Close in pursuit of the Chrysomelidæ we find the *Lebia grandis,* the most destructive foe of the Colorado beetle.

In the groves are the Prionids of the pines, the maple-borer, the locust-borers, the hickory-borers, and the oak-pruners of the Cerambycidæ. Among the peas, beans and grains are the Bruchidæ; and the Diabroticus and Curculionidæ infest the orchards and fruit trees. Widely scattered over the county are many species of the Silphidæ or Carrion-beetles, Dytiscidæ or Diving-beetles, Hydrophilidæ or Water Scavenger-beetles, Gyrinidæ or Whirligig-beetles, Lucanidæ or Stag-beetles, Lampyridæ or Fire-flies, Buprestidæ or Wood-borers, Elateridæ or Click-beetles and the Erotylidæ which so closely resemble the Click-beetles.

Though many of the families of Coleoptera are classified as pests, yet the Henry county agriculturist is compelled to admit that a very beneficent aid is given to him by the carnivorous Cucujidæ, and Staphylinidæ or Rove-beetles that feed upon decaying vegetable and animal matter; by the Coccinellidæ or Lady Bugs which feed upon small insects and the eggs of the larger species and rid his orchard of the destructive and troublesome scale.

Cicindelidae. (Tiger Beetles.)

TETRACHA Linn. (Gr., "in four parts.")

virginia Linn.................... Occurs beneath electric lights

CICINDELA Linn. (L., "a candle or taper.")

hirticollis Say.................... Occurs in sand heaps along the river
repanda Dej...................... Sand banks
vulgares Say...................... Occurs in sand along streams
unipunctulata Fab............... Along woodland paths
sexguttata Fab................... Electric lights and among sand
formoso generoso Dej............ In sand heaps
purpures Oliv.................... Meadow paths
punctulata Oliv.................. Vicinity of electric lights

Carabidae. (Ground Beetles.)

OMOPHRON. (Gr., "savage-like.")

robustum Horn..................Near and beneath electric lights
tessellatum Say..................Vicinity of electric lights
americanum Dej.................Occurs under rubbish

CYCHRUS Fab. (Gr., "a ground runner.")

lecontei Dej....................Found in lowland woods

CARABUS Linn. (Gr., "a horned beetle.")

serratus Say.....................Beneath logs in damp localities

CALOSOMA Webber. (Gr., "beautiful body.")

externum Say....................Occur singly or in pairs beneath cover in the open woods
scrutator Fab....................(Sometimes called searchers or caterpillar hunters)
willicoxi Lec.....................Often attracted by the electric lights
calidum Fab.....................(Sometimes called "fiery hunter")
frigidum Kirby(?)...............Attracted by electric lights

ELAPHRUS Fab. (Gr., "light in moving i. e. swift.")

ruscarius Say...................Found along the margins of streams and ponds
cicatricosus Lec..................Found along mud flats

NOTIOPHILUS Dum. (Gr., "spring loving.")

novemstriatus Lec................At the base of trees and stumps
semistriatus Say..................In cultivated fields
aeneus Hbst.....................Occurs beneath leaves

PASIMACHUS Bon. (Gr., "all fight.")

depressus Fab...................Occurs beneath stones
elongitas Lec....................Vicinity of electric lights

SCARITES Fab. (Gr., "a scratcher.")

subterraneus Fab................Occurs beneath rubbish
subtriatus Hald..................Found beneath electric lights

DYSCHIRIUS Bon. (Gr., "bad hand.")

nigripes Lec.....................Taken from wet sandy places
globulosus Say...................Beneath the loose bark of logs
sphaericollis Say.................Vicinity of electric lights

CLIVINIA Lat. (A proper name.)

bipustulata Fab..................Beneath electric lights
impressifrons Lec................Along sandy margins of streams and ponds
dentipes Dej.....................Occurs in damp places
rufa Lec.........................Found in damp places

ARDISTOMIS Putz. (Gr., "high mouth.")

puncticollis Putz.................Found beneath bark

BEMBIDIUM Latr. (Gr., "a buzzing insect, little.")

intermedium Kirby..............Along damp places
cordatum Lec....................Beneath electric lights
variegatum Say..................Attracted by electric light
inaequale Say...................Found in damp places
littorale Oliv...................Occurs in damp places

PATROBUS Dej.

longicornis Say..................Found beneath stones

PTEROSTICHUS Bon. (Gr., "wing compact.")

lucublandus Say.................Occurs beneath logs
adoxus Say......................Found beneath logs and stones
coracinus Newm ....Found beneath logs and stones
erythropus Dej..................Beneath rubbish in sandy places
femorales Kirby..................Beneath rubbish in sandy places

EVARTHRUS Lec. (Gr., "good joint.")

orbatus Newm....................Beneath electric lights
sodalis Lec......................Vicinity of electric lights
seximpressus Lec.................Occurs on dry wooded slopes beneath stones

AMARA Bon. (Gr., "to shine.")

obesa Say........................Electric lights
chalcea Dej......................Around electric lights
interstitialis Dej.................Beneath the electric lights

DICAELUS Bon. (Gr., "two pitted.")

sculptilis Say....................Electric lights
purpuratus Bon...................Beneath stones in the open woods
dilatatus Say....................Beneath stones in the open woods
splendidus Say...................Under stones and logs
elongatus Bon....................Beneath stones and logs

BADISTER Clairv. (Gr., "a fast walker.")

pulchellus Lec...................Beneath logs along the margins of ponds
maculatus Lec..................

CALATHUS Bon. (N.L. "a circular basket.")

opaculus Lec.....................Found beneath logs
impunctatus Say..................Occurs beneath logs

PLATYNUS Bon. (Gr., "flat or depressed.")

extensicollis Say.................Beneath electric lights
viridis Lec.......................Beneath rubbish in damp localities
sinuates Dej.....................Vicinity of electric lights
decorus Say......................Beneath logs
octopunctatus Fab...............Occurs in all sandy localities

OLISTHOPUS Dej. (Gr., "slippery foot.")

doralis Fab......................Beneath electric lights

CASNONIA Lat. (Gr., "to look toward nothing.")

pennsylvanica Linn..............Beneath electric lights

TETRAGONODERUS Dej. (Gr., "four angle.")

fasciatus Hald...................Vicinity of electric lights

LEBIA Lat. (Gr., "shallow, thin.")

lobulata Lec......................Found beneath stones
grandis Hentz...................Occurs near electric lights
atriventris Say..................Occurs near electric lights

CALLIDA Dej. (Gr., "beautiful.")

purpurea Say....................Occurs near electric lights
punctata Lec....................Vicinity of electric lights

BRACHYNUS Web. ("Bombardier Beetles.") (Gr., "short back.")

deyrolilei Laf....................Vicinity of electric lights
ballistarius Lec..................Occurs near electric lights
americanus Lec..................Occurs beneath electric lights
perplexus Dej....................Occurs beneath electric lights

CHLAENUS Bon. (Gr., "a cloak, a mantle.")

sericens Forst....................Along the margins of ponds and streams
tomentosus Say..................Vicinity of electric lights
pennsylvanicus Say..............Beneath rubbish
tricolor Chd.....................Electric lights
diffinis Chd......................Beneath electric lights
purpuricollis Rand..............Beneath logs
solitarius Say....................Occurs near electric lights
brevilabris Lec..................Under stones
laticollis Say....................Occurs under electric lights

ANOMOGLOSSUS Chd. (Gr., "irregular tongue.")

emarginatus Say.................Electric lights

BRACHYLOBUS Lec. (Gr., "short lobe.")

lithophilus Say..................Beneath electric lights

GEOPINUS Lec. (Gr., "earth, dirt.")

incrassatus Dej...................Under electric lights

CRATACANTHUS Dej. (Gr., "strong spine.")

dubius Beauv.....................In gardens and fields

AGONDERUS Dej. (Gr., "without angle, neck.")

pallipes Fab.....................In gardens; under electric lights
lineola Fab.....................In gardens
partiarius Say.....................Occurs near electric lights

HARPALUS Lat. (Gr., "greedy.")

caliginosus Fab.....................Beneath stones
pennsylvanicus Dej.....................Vicinity of electric lights

ANISODACTYLUS Dej. (Gr., "unequal-toed.")

sericens Harr.....................Vicinity of electric lights
rusticus Say.....................In the open woods
interstitialis Say.....................Under logs

LOXANDRUS Lec. (Gr., "oblique male.")

brevricollis Lec.....................Occurs about electric lights

ASPIDOGLASSA Putz. (Gr., "shield tongue.")

subangulata Chaud.....................Beneath logs

DIPLOCHILA Lec. (Gr., "double lip.")

laticollis Lec.....................Beneath stones

GLATERITA Fab. (L., "a helmet.")

janus Fab.....................Under electric lights
bicolor Drury.....................Under electric lights

Haliplidae. (The Crawling Water Beetles.)

HALIPHLUS Lat. (Gr., "the sea sail.")

leivisii Crotch.....................Shallow water along the margin of brooks
ruficollis Dej.....................Shallow water along the margin of streams and ponds
borealis Dej.....................Shallow water along streams
fulvius Fab.....................Shallow water around streams and ponds

CNEMIDOTUS Ill. (Gr., "wearing leg armor.")

12-punctata Say.....................Taken from the shallow water of ponds
edentulus Lec.....................Taken from the shallow water of ponds

Dytiscidae. (Predacious Diving Beetles.)

HYDROPORUS Clairv. (Gr., "water, to walk.")

consimilis Lec.....................Taken from ponds

ILYBIUS Er. (Gr., "mud life.")

biguttulus Germ..................Taken from ponds

COPTOTOMUS Say. (Gr., "cut joint.")

interrogatus Fab................Electric lights

COLYMBETES Clairv. (Gr., "dive, swim.")

sculptilis Harr..................Taken from ponds

DYTISCUS Linn. (Gr., "a driver.")

verticalis Say...................Vicinity of electric lights
fascinventris Say................Found under electric lights
sublimatus Lec...................Found under electric lights
hybridus Aube....................Found under electric lights

ACILIUS Leach. (L., a Roman name.)

semisulcatus Aube................Electric lights and ponds
mediatus Say.....................Electric lights and ponds

Gyrinidae. (The Whirligig Beetles.)

GYRINUS Linn. (Gr., "a circle or ring.")

ventralis Kyb....................Taken from quiet flowing water
minutus Fab......................Occurs on ponds and lakes
natator Linn.....................Occurs on ponds and lakes
fraternis Coup...................Occurs on ponds and lakes

DINEUTES Mcl. (Gr., "to whirl or swim in an eddy.")

emarginata Say...................Taken from a quiet place in flowing water
assimilis Aube (''apple-bugs'')....Taken from a pond
discolor Aube....................Occurs on rivers and ponds
hornii Amer......................Occurs on rivers and ponds

Hydrophilidae. (The Water Scavenger Beetle.)

HYDROPHILUS Geoff. (Gr., "water loving.")

ovates G. & H....................Vicinity of electric lights
triangularis Say.................About the electric lights

HYDROCHORIS Sol. (Gr., "water delight.")

obtusatus Say....................Beneath logs, and stones close to the edge of the water; electric lights

PHILYDRUS Sol. (Gr., "love water.")

cinctus Say......................Found on the margins of ponds and streams

TROPISTERNUS Sol. (Gr., "keel breast.")

dorsalis Brule...................Found frequently in ponds
nimbatus Say.....................Found in slow flowing streams
mixtus Say.......................Occurs in slow flowing streams

Leptinidae. (Mammal Nest Beetles.)

LEPTINUS Mul. (Gr., thin, small.)

testaceus Mull....................Found in old, deserted nests

Silphidae. (Carrion Beetles.)

NECROPHORUS Fab. (Gr., "a dead body bearing.")

americanus Oliv..................Near electric lights
pustulatus Hersch................Vicinity of electric lights
marginatus Fab...................Under electric lights
orbicollis Say...................Under electric lights
tomentosus Web...................Under electric lights
postfaciatum Can.................Under electric lights

SILPHIA Linn. (Gr., "a beetle.")

americana Linn...................Found on carrion
inaequalis Fab...................Found on carrion
surinaminsis Fab.................Found on carrion
noveboracensis Forst.............Found about carrion

Scydmaenidae. (The Antlike Stone Beetles.)

CONNOPHORON Csy. (Gr., "compact.")

formale Sasey....................Occurs beneath rubbish

Staphylinidae. (The Rove Beetle—The Short Winged Beetle.)

CREOPHILUS Mann. (Gr., "flesh to love.")

villosus Grav.....................Occurs on decaying fungi and carrion

OCYPUS Kirby. (Gr., "swift foot.")

ater Grav........................Found about carrion

ALEOCHARA Groh. (Gr., "warmth, gladness.")

fata Groh........................Occurs beneath carrion

OVEDIUS Steph. (L., "filth to eat.")

vernix Lec.......................Found frequently along the margins of streams

HESPREOBIUM Casey. (Gr., "western life.")

pallipes Grav....................Found beneath cover along the sandy banks of streams and ponds

ACTOBIUS Fauvel. (Gr., "shore I live.")

paederoides Lec..................Margins of brooks and ponds

HOMALIUM Grav. (Gr., "even or smooth.")

hamatum Fauv.....................Occurs beneath rubbish
fractum Fauv.....................Found beneath bark in moist places
florale Payk.....................Found beneath rubbish

STAPYLINUS Linn. (Gr., "a kind of insect.")

vulpinus Nordam.................Along the sandy margins of streams
maclosus Grav...................Occurs in carrion
tomentosus Er...................Found in decaying fungi
mysticus Er.....................Occurs in carrion

Coccinellidae. (The Lady-Bugs and The Plant-Louse Beetles.)

MEGILLA Muls. (A mythological name.)

maculata De Geer................Found in gardens

HIPPODAMIA Chev. (A mythological name.)

13-punctata Linn................Found in gardens
convergens Guer.................Found beneath mullein leaves
15-maculata Muls................Occurs in gardens
parenthesis Say.................Found in gardens
glacilis Fab....................Found beneath rubbish

ADALIA Muls. (N. L., An invented name.)

bipunctata Linn.................On garden foliage

COCCINELLA Linn. (Gr., "scarlet insect.")

sanguinea Linn..................Occurs on the flowers of the golden-rod
9-notata Herbst.................Found on mullein leaves
abominalis Say..................Occurs in gardens

ANATIS Muls. (Gr., "harmless.")

15-punctata Oliv................Brown and yellow. Found in gardens
15-punctata mali Say............Found on flowers

CAILOCORUS Leach. (Gr., "lip or labrum, shield.")

bivulnerus Muls.................Occurs on the flowers of the red haw

ANISOSTICATA Duponchet. (Gr., "unequal spot.")

strigata Thumb..................Beneath rubbish and electric lights

EPILACHNA Chev. (Gr., "above woolly-hair.")

corrupta or borealis Fab..........(Squash-Lady-Bird) Found in gardens

Endomychidae. (The Handsome Fungus Beetle.)

ENDOMYCHUS Panz. (Gr., "within nook or corner.")

biguttatus Say..................Occurs beneath logs

Erotylidae. (The Pleasing Fungus Beetle.)

LANGUIRA Lat. (L., "a kind of lizard.")

bicolor Fabr. . . . . Found in gardens
angustata Beauv. . . . . Taken from the flowers of the goldenrod.
gracilis Newm. . . . . Occurs on ragweed and other low herbs
mozardi Lat. (''clover-stem borer'')
trifasciata Say. . . . . Found on wild lettuce

MEGALODACNE Cr. (Gr., "large bite.")

fasciata Fabr. Found in rotten wood
heros Say(?) . . . . Found under loose bark and under sidewalks

ISCHYRUS Lac. (Gr., "robust.")

4-punctata Oliv. . . . . Found feeding on sap

Cucujidae. (The Flat Barked Beetles.)

CATHARTUS Reiche. (Gr., "to cleanse.")

quadricollis Quer. . . . . Found under bark

CUCUJUS Fab. (N.L., a word of South American origin.)

clavipes Fab. . . . . Occurs beneath bark

Cryptophagidae. (The Silken Fungus Beetles.)

LOBERUS Lec.

impressus Lec. . . . . Found beneath bark

CRYPTOPHAGUS Hbst. (Gr., "cryptogam eating.")

croceus Zinn. . . . . Beneath decaying fungi
fungicola Zinn. . . . . Under decaying fungi

ATOMARIA Steph. (Gr., "an atom.")

ovalis Casey. . . . . Found on the dry fungi on stumps
ephippiata Zinn. . . . . Found on dry fungi about stumps

Mycetophagidae. (The Hairy Fungus Beetles.)

MYCETOPHAGUS Hellix. (Gr., "mushroom eating.")

punctatus Say. . . . . Occurs beneath loose bark

Dermestidae. (The Skin Beetles.)

DERMESTES Linn. (Gr., "skin devour.")

talpinus Mann. . . . . Found on bones
lardarius Linn (''ham-beetle''). . . . A household pest
fasciatus Lec. . . . . Occurs on dead animals
vulpinus Fabr. . . . . Occurs on dead animals

ANTHRENUS Geoff. (Gr., "a buzzing insect.")

verbasci Linn.....................One of the most destructive of museum pests
scrophularia Linn...............("carpet-beetles")
thoracicus Melsh.................Household pest

ATTAGENUS Latr. (Gr., "a woodcock.")

piceus Oliv.......................("black carpet-beetles")

Histeridae. (The Hister Beetles.)

HOLOLEPTA Payk. (Gr., "all thin.")

fissularis Say....................Found along the sidewalk

HISTER Linn. (L., "a clown or mimic.")

abbreviatus Fab..................Found beneath dead fish along the sandy margins of ponds. Rarely in fungi, cow-dung, etc.
carolinus Payk...................Found beneath bark
merdarius Hoffm.................Under dead chickens
americanus Payk.................Beneath logs
harrissili Kirby..................Occurs beneath bark

SAPRINUS Eurichs. (G., "rotten.")

pennsylvanicus Payk.............Beneath dead material
assimilis Payk...................Occurs beneath carrion

TRIBALUS Euchs. (Gr., "worthless.")

americanus Lec..................Occurs beneath bark

Nitidulidae. (The Sap-Feeding Beetles.)

BRACHYPTERUS Er. (G., "short wing.")

utricae Fab.......................Found on moss

CARPOPHILUS Steph. (Gr., "fruit loving.")

niger Say.........................Sap of the soft maple
trachypterus Say.................Occurs on apple blossoms

NITIDULA Fab. (L., "shining or bright.")

rufipes Linn......................Occurs on foliage
bi-punctata Linn.................Found on bones
ziczac Say........................Occurs on dead birds

PROMENTOPIA Er. (Gr., "before spot.")

sexmaculata Say.................Occurs in sap

IPS Fab. (Gr., "a worm that eats horn and wood.")

quadriguttatus or fasciatus Fab...Occurs beneath chips
sanguinolentus Oliv..............Taken at sap; decaying fungi

EPURAEA Erichs. (Gr., "upon tali.")

helvola Erichs.................... Taken at sap
duryi Sp.......................... Taken while feeding on sap
erichsonii Reitt.................. Found at sap

COLASTUS Erichs. (Gr., "to mutilate.")

truncatus Rand.................... Sap of the maple

CONOTELUS Erichs. (Gr., "cone end.")

obscurus Erichs................... Found on the hollyhock

STELIDOTTA Erichs. (Gr., "a column.")

geminata Say...................... Occurs at spring sap

MELIGETHES Steph. (Gr., "honey, rejoice.")

aeneus Fabr....................... Found on old stumps in the woods
mutatus Harold.................... Occurs on the flowers of the nettle

RHIZOPHAGUS Herbst. (Gr., "root, eat.")

bipunctatus Say................... Beneath the bark of the maple

CRYPTARCHA Shuck. (Gr., "hidden anus.")

concinna Muls..................... Found at the sap of the soft maple

Trogositidae. (The Grain and Bark-Gnawing Beetles.)

ALINDRIA Erichs. (Gr., "to roll or to turn.")

cylindrica Geoff.................. Beneath the bark of the hickory

TENEBROIDES Pillar. (Gr., "tenebrio resemble.")

corticalis Melsh.................. Beneath bark
dubia Melsh....................... Occurs beneath logs

Monotomidae. (The Monotomid Beetles.)

MONOTOMA Herbst. (Gr., "one cut.")

fluivipes Melsh................... Around wood houses

Derodontidae. (The Tooth-Necked Fungus Beetles.)

DERODONTUS Lec. (Gr., "neck tooth.")

maculatus Melsh(?)................ Common on fungi

Byrrhidae. (The Pill Beetles.)

Heteroceridae. (The Variegated Mud-Loving Beetles.)

HETEROCERUS Bosc. (Gr., "different from.")

ventralis Melsh................... Occurs on low moist places
brunneus Melsh.................... Found along the river bank
undatus Melsh..................... Found along the banks of streams
collaris Kies..................... Found in low damp places

Dascyllidae. (The Soft-Bodied Plant Beetles.)

HELODES Payk. (Gr., "marshy.")

fuscipennis Guer.................Found by sweeping

Phipceridae. (The Cedar Beetles.)

SANDALUS Knock. (Gr., "slipper or sandal.")

petrophyus Knock...............Occurs beneath bark
niger Knock.....................Found in an old stump

ZENOA Say. (Gr., "a stoic.")

picea Beauv.....................Beneath logs

Elateridae. (Gr., "Click Beetles: Spring Beetles: Snapping Beetles: Skip Jacks.")

NEMATODES Latr. (Gr., "threadlike.")

atropos Say.....................Vicinity of the electric lights

AGRIOTES Esch. (Gr., "wild.")

pubescens Melsh.................Occurs on flowers
oblongicollis Melsh..............Found in gardens

ALAUS Esch. (Gr., "to wander.")

oculatus Linn...................Around half-rotten stumps
myops Linn.....................Beneath bark

MELANOTUS Esch. (Gr., "black back.")

piceus De Geer..................Along the sidewalk
communis Gyll...................Around electric lights
fissilis Say.....................Around electric lights
americanus Herbst...............Under rubbish

DRASTERIUS Esch. (Gr., "active.")

elegans Fab.....................Found in rubbish

MONOCREPIDIUS Esch. (Gr., "single little shoe.")

lividus DeG.....................Found in the garden
auritus Herbst..................Found in a rubbish heap
vespertinus Fab.................Occurs beneath mullein leaves

ELATER Linn. (Gr., "to drive or to set in motion.")

nigricollis Herbst...............Occurs beneath rotten bark

CORYMBITES Lat. (Gr., "a brush or pencil.")

hieroglyphicus Say..............Taken from tall grass
hamatus Say.....................About maple stumps; along ponds

Buprestidae. (The Metallic Wood-Boring Beetles.)

ANTHAXIA Esch. (Gr., "a flower, worthy of.")

viridifrons Lap..................Beneath electric lights
viridicornis Say..................In gardens
quercata Fab....................On garden foliage
divaricata Say(?)...............On garden foliage
cyanella Gory...................Beneath electric lights

DICERA Esch. (Gr., "two tail.")

divaricata Say...................Found along the trunks of maple trees

Lampyridae. (The Fire-flies or Lightning Bugs.)

CALOPTRON Guer. (Gr., "beautiful wing.")

reticulatum Fab..................On flowers of the hydrangea

PHENGODES Ill. (Gr., "shining.")

plumosa Oliv.....................Around electric lights

PHOTURIS Lec. (Gr., "shining.")

pennsylvanica De Geer...........In the garden
pyralis Linn.....................In the garden

CHAULIOGNATHUS Hentz. (Gr., "with exposed jaws or maxillae.")

pennsylvanicus De Geer..........On flowers of the goldenrod

PODABRUS Fisch. (Gr., "foot delicate.")

tomentosus Say...................Around electric lights
protensus Lec....................Found on wood
tricostatus Say..................Occurs on garden flowers

TELEPHORUS Schaff. (Gr., "afar bearing i. e. of wide distribution.")

bilineaus Say....................Occurs on foliage
simphungius Say.................Occurs on foliage

PLATEROS Bourg. (Gr., "broad Eros.")

floralis Melsh....................Beaten from vegetation
canaliculata Say.................Occurs on the leaves of milkweed

Malachiidae. (The Soft-Winged Flower Beetles.)

COLLOPS Erichs. (Gr., "embrace eye or face.")

quadrimaculatus Fabr............Occurs in gardens

ATTALUS Erichs. (Gr., After King Attalus.)

circumscriptus Say...............Found by sweeping plants

Cleridae. (The Checkered Beetle.)

CYMATODERA Gray. (Gr., "wave neck.")

undulata Say.................... Occurs on oak foliage

THANASIMUS Latr. (Gr., "mortal.")

dubius Fab..................... Occurs under chips

ZENODOSUS Wollcott. (Gr., A proper name.)

sanguineus Say.................. Occurs beneath bark

ENOCLERUS Gahan. (Gr. "in, noxious to hives.")

quadriguttatus Oliv.............. In gardens
quadrisignatus Say.............. About electric lights

Ptinidae. (The Death-Watch Beetle: The Drug-Store Beetle.)

Bostrichadae. (The Powder Post Beetle.)

SINOXYLON Dufts. (Gr., "harm wood.")

basilare Say.................... Beneath the bark of the hickory

LYCTUS Fab. (A proper name.)

opaculus Lec.................... Occurs on the dead limbs of oak

Lucanidae. (The Stag Beetles.)

LUCANUS Linn. (L., "to shine.")

elaphus Fab.................... Old stumps in the garden
dama Thunk..................... Vicinity of electric lights
placidus Say.................... Vicinity of electric lights

PASSALUS Fabr. (Gr., "a post or peg.")

cornutus Fab (Bess Beetles)..... Beneath the electric lights

DORCUS McLeay. (L. "antelope.")

parallelus Say ("Antelope Beetles") .... Occur about the roots of oak and maple

Scarabaeidae. (The Lamellicorn Beetles.)

CANTHON Hoffm. (Gr., a kind of beetle.)

viridis Beauv.................... Electric lights
minutes Drury.................... Occurs in barnyards
nigricornis Say.................. Beneath electric lights
laeves Drury (Tumble-bug)....... Around electric lights

CHOERIDIUM Lep. (Gr., "a young pig.")

histeroides Web.................. Found beneath cow-dung and rubbish

CORPIS Geoff. (Gr., "dung.")

anaglyplicus Say................ Found beneath dung

APHODIUS Ill. (Gr., "excrement, way.")

vittalus Say..................... Vicinity of electric lights
granarius Linn.................. Under logs in a barnyard
femoralis Say.................... Electric lights
grandius Linn.................... Occurs in dung; electric lights
fimetarius Lun.................. Beneath logs on sandy banks
serval Say....................... Beneath leaves and rubbish
rubeolus Beauv.................. Beneath electric lights
hamatus Say..................... Electric lights
stercorosus Melsh............... Electric lights

ATAENUS Harold. (Gr., "without a fetter.")

cognatus Lec..................... Occurs beneath dry cow-dung

ODONTAEUS Kl. (Gr., "a tooth.")

cornigerus Melsh................ Beneath electric lights
filicornis Say.................... Occurs beneath logs

GEOTRUPES Lat. (Gr., "the earth bore.")

splendidus Fab.................. Found along sidewalks
opacus Hald...................... Around the electric lights

TROX Fab. (Gr., "a gnawer.")

suberosus Fab................... Electric lights
tuberculatus De Geer............. Electric lights
sordidus Lec..................... Electric lights
monachus Herbst................. Electric lights
punctatus Ger.................... Electric lights
scabrosus Beauv................. Electric lights

ANOMALA Samonelle. (Gr., "unlike.")

lucicola Fab...................... On the foliage of the wild grape

PHANEUS Linn. (Gr., "light-bearer.")

torrens Lec....................... In the garden
carnifex Linn.................... Electric lights

OSMODERMA Lep. (Gr., "odor, skin.")

eremicola Knock................. In gardens and under electric lights

LACHNOSTERNA Hope. (Gr., "wool breast.")

fusca Froh.....................Electric lights
micans Knock....................Electric lights
longitarsis Say..................Electric lights
prunina Lec.....................Occurs on raspberry bushes
nova Smith......................In the garden
spreta Horn.....................Electric lights

PELIDNOTA MacL. (Gr., "to make livid.")

punctata Linn...................Around stumps; electric lights

COTALPA Burm. (Gr., "with, mole.")

lanigera Linn...................In the woods

LIGYRUS Brum. (Gr., "flexible.")

gibbosus DeG....................Electric lights
ruginasus Lec...................Electric lights
relictus Say....................Beneath rubbish; electric lights

TRICHIUS Fab. (Gr., "heavy.")

piger Fab.......................Occurs on the flowers of Jersey tea

CYCLOCEPHALA Latr. (Gr., "circle head.")

villosa Brum....................Electric lights

ONTHOPHAGUS Lat. (Gr., "dung eating.")

pennsylvanica Harold............Occurs in carrion dung

STRIGODERMA Brum. (Gr., "stria skin.")

arboricola Fab..................Occurs most commonly on flowers

XYLORYCTES Hope. (Gr., "wood digger.")

satyrus Fab.....................Beneath rubbish heaps

DYSCINETUS Harold. (Gr., "bad moving.")

trachypygus Brum................Electric lights

Spondylidae. (The Abberrant Long-Horned Beetle.)

PARANDA Lat. (Gr., "equal male.")

brunnea Fab.....................Beneath the bark of soft maples

Cerambycidae. (Long-Horned Wood-Boring Beetles.)

ORTHOSOMA Dej. (Gr., "straight body.")

brunneum Forst..................Occurs on pine trees; attracted by electric lights

PRIONUS Geoff. (Gr., "a saw.")

imbricornis Linn (Tile-horned Prionus) .... Electric lights
pocularis Dalm.................. Electric lights

EPHALIDION Serv. (Gr., "a deer, little.")

villosum Fab ("oak-pruner")..... On a fallen tree in the woods
mucronatum Say................Occurs on oak, hackberry, beech
incertum Newm.................. Under the electric lights

CHION Newm. (Gr., "snow.")

cinctus Drury.................... On hickory trees; under the electric lights

CYLLENE Newm. (Gr., the name of a mountain in Gr.)

robiniae Forst.................... On goldenrod and black locust trees
pictus Drury..................... ("Hickory-tree Long-horn")

STRANGALIA Serv. (Gr., "a rope or halter.")

luteicornis Fab (Jaques.)......... Occurs on the flowers of the wild rose

XYLOTRECHUS Chev. (Gr., "wood runner.")

colonus Fab.......................Occurs on oak, maple, beech

TETRAOPES Serv. (Gr., "four eyes.")

tetraophathalnus Forst............Occurs on milkweed
femoratus Lec.................... Occurs on milkweed

PLAGIONOTUS Muls. (Gr., "oblique back.")

speciosus Fab..................... (Soft-maple Long-horn)

EBUREA Serv. (Gr., "worry.")

quadrigemenata Say..............Found on the honey locust tree

SAPERIDA Fabr. (Gr., "a kind of flesh.")

candida Fabr (apple-tree borer)... Found in an apple orchard
tridentata Oliv (elm-tree borer)... Found in the woods
puncticollis Say (poison ivy)......Jaques
vestita Say (linden borer)........Jaques

LEPTOSTYLUS Lec. (Gr., "slender point.")

aculiferus Say.................... Sycamore, oak and apple trees

RHAGIUM Fab. (Gr., "to tear.")

lineatum Oliv.(?)................ Beneath the bark of the pine

ARHOPALUS Serv. (Gr., "without club.")

fulminans Fab.................... Occurs on oak, butternut, chestnut trees

AMPHIONYCHA Lec. (Gr., "on both sides, claw.")

flammata Newm.................. Jaques.

OBERIA Muls. (a proper name.)

bimaculata Oliv.................. Sweeping low herbage along marshes

DESMOCERUS Serv. (Gr., "band horn.")

palliatus Forst.................. Occurs on the flowers and foliage of alder

LEPTURA Linn. (Gr., "slender.")

(subhamata Rand.) C. P. O. Jaques. .... Found on wild hydrangea

NEOCLYTUS Thom. (Gr., "new, noisy.")

erythrocephalus Fab.............. Found on the foliage of the hickory

Chrysomelidae. (Leaf Beetles.)

DONACIA Fabr. (Gr., "a reed.")

piscatrix Lac.................... Found on the yellow water-lily

LEMA Fabr. (N. L. meaning unknown.)

brunnicollis Lac................. Low damp places
trilineata Oliv.................... (Old fashioned potato beetle)
collaris Say...................... Occurs on spider-wort

CRYPTOCEPHALUS Geoff. (Gr., "concealed head.")

quadruplex Newm................ Found by beating herbage
leucomelas Suffr.................. Occurs on poplar
venustus Fabr.................... Occurs on timothy in meadows

CHELYMORPHA Chev. (Gr., "a tortoise shape.")

argus Herbst (Jaques.)........... Occurs on milkweed and wild potato

PHYSONATA Bon. (Gr., "swollen back.")

unipunctata Say.................. Occurs on horsemint

DIABROTICA Chev. (Gr., "through, gnaw.")

longicornis Say.................. Occurs on the silk and leaves of ripening corn
atripennis Say.................... Occurs in the garden
vittata Fabr...................... (Striped cucumber beetle)
12-punctata Fab.................. Occurs on the foliage of cucumber

DORYHORA Ill.

decemlineata Say.................. (Colorado potato beetle)

HALTICA Geoff. (Gr., "leaping.")

ignita Ill........................ The foliage of plants

COSCINOPTERA Lac. (Gr., "sieve, a wing.")

domincana Fab. (?) .... On the foliage of oak and wild grape

CALLIGRAPHA Erich. (Gr., "beautiful writing.")

similis Rogers .... Found on the ground of cultivated fields

CALERUCELLA Grotch. (Gr., diminutive of Caleruca.)

notulata Fabr .... Found on mullein leaves

COPTOCYCLA Chev. (Gr., "cut circle.")

signifera Herbst .... On the foliage of thorn and mullein
bicolor Fabr .... On the morning-glory
aurichalcea Fab (Jaques.) .... In the garden
clevata Fab .... In the garden

ZYGOGRAMMA Chev. (Gr., "yoke together.")

suturalis Fab .... Found on ragweed and goldenrod

NODONATA Lec. (Gr., "knot back.")

tristis Oliv .... On herbs and shrubs on dry uplands
puncticollis Say .... On foliage of various herbs

DISONYCHA Chev. (Gr., "two claw.")

pennsylvanica Ill .... Occurs in meadows
triangularis Say .... On the foliage of herbs and shrubs
xanthomelaena Dalm .... (Spinnach flea beetle)

CHRYSOCHUS Chev. (Gr., "goldsmith.")

auratus Fab .... Occurs on milkweed

LEPTINOTARSA Stal. (Gr., "slender tarsa.")

decemlineata Say .... (Colorado potato-bugs)

PHYLLOBROTICA Redt. (Gr., "leaf gnaw.")

limbata Fab .... Plants on the margin of marshes

BLEPHARIDA Roger. (Gr., "eye lid.")

rhois Forst. (Jumping sumac beetle) .... Common on sumac

OEDIONYCHIS Lat. (Gr., "swollen joint.")

thoracia Fabr .... In the garden
vians Ill .... Found in the woods on flowers

LABIDONURA Chev. (Gr., "forceps femur.")

clavicollis Kirby .... Common on milkweed

CEROTOMA Chev. (Gr., "horn joint.")

trifurcata Forst.................. (Bean-leaf Beetle)

PHYLLOTRETA Chev. (Gr., "leaf bore.")

picta Say......................... Found by sweeping tall grass
armorachae Kock................... Found on horseradish
bipustulata Fab................... In the garden

CASSIDA Linn. (N. L. "helmet.")

nigripes Oliv..................... On morning-glory vines
atripes Lec....................... In the garden

TYPOHORUS Erichs. (Gr., "impression bearing.")

viridicyancus Crotch.............. In the garden
canellus Fab...................... In the foliage of wild grape
sellatus Horn..................... Found in the woods

XANTHONIA Baly. (Gr., "yellow.")

villosuta Melsh................... Beaten from foliage

METACHROMA Lec. (Gr., "after color.")

parallelum Horn................... About the electric lights

COLASPIS Fab. (Gr., "mutilated shield.")

brunnea Fabr...................... In the garden

LUPERODES Motsch. (Gr., "troublesome.")

cyanellus Lec..................... Occurs on flowers of the wild rose

PHYLLECTHRUS Lec. (Gr., "leaf eating.")

gentilis Lec...................... Occurs on bush clover

CHAELOCNEMA Stephens. (Gr., "spine tibiæ.")

denticulata Ill................... Occurs on grass

CHALEPUS Thumb. (Gr., "difficult.")

trachypgus ....

GLYPTENA Lec. (Gr., "sculptured.")

brunnea Horn...................... Occurs on foliage

LINA Meg. (Gr., "flax.")

scripta Fab....................... Under the electric lights
interrupta Fab. (known as laponica) .... Under the electric lights

PSYLLIODES Latr. (Gr., "flealike.")

convexior Lec..................... Occurs in moist meadows

Bruchidae. (The Pea and Bean Weevil.)

SPERMOPHAGUS Sch. (Gr., "seed eating.")

robinae Fab.......................Occurs on the seeds of the honey and the black locust

BRUCHUS Linn. (Gr., "a locust without wings.")

obtectus Say. (Bean-weevil).......Found on beans
pisorum Linn. (Pea-weevil).......Found on peas
exigures Horn...................Occurs on the flowers of the wild parsnip

Tenebrionidae. (The Darkling Beetles.)

TENEBRIO Linn. (Gr., "darkness.")

obscurus Fab. (Meal worms)......Found in meal
molitor Linn. (Meal worms)......Found in meal
tenebriodes Beauv................Common beneath bark
castaneus Knock.................Common beneath bark

DIAPERIS Geoff. (Gr., "through to pass.")

maculata Oliv....................Found beneath bark
hydni Fab.......................Under bark

DOBEMA Say. (Gr., "insidious.")

pallida Say......................Occurs beneath bark

MERACANTHA Kirby. (Gr., "thigh spine.")

contracta Beauv..................Beneath logs and bark

ARRHENOPHLITA Kirby. (Gr., "strong weapon.")

viridipennis Fab.................Occurs beneath bark
bicornis Oliv.....................Occurs beneath bark

BOLETOTHERUS Candeze. (Gr., "fungus to hunt.")

bifurcus Fab.....................Around fungi; electric lights

CAENOCORSE Thom. (Gr., "common.")

ratzeburgi Wessm................Occurs in grain feed

GNATHOCERUS Fab.

maxillosus Fab. ("corn-meal")....Found in corn meal

Cistelidae. (The Comb-Clawed Bark Beetles.)

ANDROCHIRUS Lec. (Gr., "a male hand.")

erythropus Kirby.................Occurs on stumps

Lagriidae. (The Lagriid Bark Beetles.)

ARTHROMACOR Kirby. (Gr., "a joint, long.")

aenea Say.......................Occurs on the foliage of trees
glabricollis Sp...................Found while beating the foliage of trees

Melandryidae. (The Melandrid Bark Beetles.)

PISENUS Casey.

humeralis Kirby.................Occurs on common fungi

Pythidae. (The Pythid Bark Beetles.)

NOTHUS Oliv. (Gr., "a bastard.")

varians Lec......................Occurs on flowers

Mordellidae. (The Tumbling Flower Beetles.)

MORDELLA Linn. (Gr., "to bite.")

scutellaris Fab..................Occurs in numbers on flowers

Meloidae. (The Oil and Blister Beetles.)

MACROBASIS Lec. (Gr., "long base.")

unicolor Kby. (Ash-gray beetle)...Under electric lights
immaculata Say..................Occurs on goldenrod

EPICAUTA Redt. (Gr., "upon, to burn.")

trichus Pal......................Occurs on Jersey-tea
cinerea Forst. (Gray blister beetles) Under electric lights
vittata Fabr. (Old fashioned potato beetle)
pennsylvanica De Geer...........Occurs on goldenrod
marginata Fab. (margined blister beetles) ....On a clematis vine

PYROTA Lec. (Gr., "fire.")

engelmanni Lec..................In the garden

Otiorhynchidae.

EPICAERUS.

imbricatus ....Along the sidewalk

ARMIGUS.

fulleri (Rose beetles).............Under electric lights

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By W. S. Blatchley.

This is the Descriptive catalogue used in classifying the foregoing list of Beetles.

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THE BUTTERFLIES OF WOODBURY COUNTY.

BY A. W. LINDSEY.

As I have been interested in the study of Lepidoptera in and about Sioux City for a number of years, I am undertaking this paper with great pleasure and with the sincere hope that it may prove of interest to other scientists in the state. My work has been somewhat handicapped by a lack of sufficient literature, and the fact that I have been unable to consult any authority on the order, so I have been careful to omit any species of whose identity I am uncertain. I have followed the classification and terminology used by Doctor Holland in his "Butterfly Book," since it is the most familiar to me, though the light in which some entomologists regard the work warns me that many names may be unfamiliar and perhaps objectionable. For greater convenience in treating my subject I will give a short description of the territory included in my researches, in so far as it concerns the distribution of the insects under consideration. Further, before entering upon my discussion, I wish to express my deepest gratitude to Dr. T. C. Stephens of Morningside College for the assistance which he has so kindly given me and for the suggestion of this paper.

The territory over which I have worked lies in the vicinity of Sioux City, including a corner of Nebraska and South Dakota, though no butterflies have been found in the latter states which have not also been observed in our own. The presence of shade trees in the city which are not native to this region accounts for the presence of many insects in certain localities, though its bearing on the taxonomy which it is my purpose to set forth is hardly great enough to warrant mention of the subject. Many remnants of the prairie typical of this part of the country which harbor great numbers of butterflies are to be found both in and near the town. The flora of such land is familiar to every student of nature.

One place has been made a favorite in this study, not only because of its great natural beauty, but also for the abundance of insects within its bounds. This is a large tract of timber northwest of the city, which was once known as Talbot's Farm, but has since passed into the ownership of the city under the name of Stone Park. It consists of two long hollows and a multitude of smaller branches draining several hundred acres of land. Most of the ravines are heavily timbered with small trees, all native species, including the Burr Oak, White Oak, Basswood, Elm, Hackberry, Black Walnut, Kentucky Coffee Bean, Cottonwood, Prickly Ash, White Ash, Hawthorn, and Wild Plum, both *Prunus chickisaw* and *Prunus americana.* The timber is bordered on the hillsides by dwarfed Burr Oaks which blend into the wild grasses with a fringe of Sumac and Snowberry thickets. Near the mouth of the hollows are a number of sparsely wooded, grassy meadows which are the favorite haunt of many species of butterflies. There are numbers of wild gooseberry bushes in these meadows and the woods nearby, and of late years innumerable weeds have sprung up to blot out the former carpet of grass and clover.

The nearest communication with the park from the car line, two miles distant, is by a level road following Big Sioux river, and locally known as the Sioux or River Road. It passes through one and one-half miles of the heaviest timber found here, and runs across each of the two large valleys. Between these and bounded by the road and the river, is a marshy thicket of willows and small shrubs. On a number of pasture thistles by the roadside may always be found hordes of frittilaries during the hot days of August and September. Here too *Papilio cresphontes* always makes his appearance and *Catopsilia eubule* flashes his golden wings.

Family Nymphalidae.

Subfamily EUPLOEINAE.

(1) *Anosia plexippus* Linn. This insect is perhaps the most common of our local species, with the exception of the cabbage butterfly. It is one of the first forms to appear in the spring and among the last to be seen in the fall. The larvæ occur on two of the numerous species of milkweed in the vicinity. Both eggs and larvæ are readily found, and the chrysalids may often be seen on overhanging surfaces of frame buildings.

Subfamily NYMPHALINAE.

(2) *Euptoieta claudia* Cramer. *E. claudia* is among the less plentiful of our butterflies. It is found every year quite widely distributed in the open prairies, but never in large numbers.

(3) *Argynnis idalia* Drury. This beautiful fritillary is found throughout the summer, and is very widely distributed. It is most common in the fields of wild hay, where it apparently breeds.

(4) *Argynnis cybele* Fab. Cybele is the most numerous of the three fritillaries found in this locality. It appears in early summer and is present in great numbers until cold weather. Many haunt the meadows in Stone Park and the thistles along the River Road. Formerly a field of alfalfa north of town offered an excellent collecting ground for them.

(5) *Argynnis alcestis* Edwards. Small numbers of this species are found every summer. Their habits are more like those of idalia than cybele, in that they prefer the hot, open fields and roadsides to wooded meadows.

(6) *Brenthis myrina* Cramer.

(7) *Brenthis bellona* Fab. Some years ago a single stroke of my net captured four butterflies which at the time I thought to be of one species. They were in a company of perhaps ten insects fluttering about a flower head, and all presented to the eye the same appearance. On identifying these four it was found that one was a specimen of *B. bellona* and the other three of *B. myrina.* Since that time a few specimens of myrina have been seen each year, and at rare intervals one of bellona. They have been seen more often in the city than in the country.

(8) *Phyciodes tharos* Drury, is plentiful during the heat of summer along the River Road near Stone Park and in other places.

(9) *Phyciodes batesi* Reakirt, has been seen only in the year 1909, though this dearth of records is probably due to insufficient observation of the genus.

(10) *Phyciodes camillus* Edwards, is quite plentiful throughout the summer, and is widely distributed.

(11) *Phyciodes nycteis* Doub.-Hew., is found during July. It is the most common species of the genus in this locality.

(12) *Grapta interrogationis* Fab., is seen very often, but in small numbers. It occurs in two forms, *fabricii,* Edwards, and *umbrosa,* Lintner. One remarkable aberration was noted a few years ago in a specimen whose wings were a reddish fulvous above and a pronounced cinnamon below instead of the ordinary gray color.

(13) *Grapta comma* Harris, forms *harrisi,* Edwards, and *dryas,* are common. The insect is found in nearly all the timber where its food plant is plentiful. It was once observed in great numbers (1909) about the fallen apples in an old farm yard. The crop was entirely wasted, and the crushed fruit lying about under the trees made a feast for hundreds of these little angle wings and many Mourning-cloaks and Cosmopolitans. Chrysalids were abundant under the eaves of buildings and the rails of a bridge nearby, but most of them were parasitized.

(14) *Pyrameis atalanta* Linn. Another of our early spring arrivals is *P. atalanta.* It appears with the hibernating forms in the first warm days of spring. It may be seen in any kind of surroundings, from the deep woods to open roads. It is very quick of flight, darting hither and thither from one sunny spot to another in a way to tantalize the net of the collector. Though very common, its brightly colored wings, so wonderfully mottled beneath, place it among the most beautiful Lepidoptera, and it can never become tiresome.

(15) *Pyrameis huntera* Holland. This little Hunter's butterfly of Doctor Holland is rather a rare form. A few are seen each year, but they are never numerous. Like atalanta it wanders in every habitat.

(16) *Pyrameis cardui* Linn., is a lover of the open. Its larval webs may be seen on thistles in any roadside field. Every stage of the larva and a number of chrysalids have been found on a single plant.

(17) *Vanessa antiopa* Linn., is without doubt the most beautiful of our large butterflies. It hibernates in the adult stage, and with *Grapta comma,* is the first to appear in the spring.

(18) *Junonia coenia* Hubner. This wonderfully colored insect is now less common than in former years. It is found in the hayfields and along the roads.

(19) *Basilarchia astyanax,* Fab. The name of this species is rather doubtful to me. Older works figure the form occurring here as *Limenitis ursula.* Doctor Holland's figure under the name *B. astyanax* varies in a small, though very marked particular, from the specimens at hand, but Doctor Comstock applies the name to just such a form as I possess. The insect is common. In the days when sanitation laws were not as strict as at present a number might be seen flitting about any open garbage box. They are quite plentiful in the woodland meadows of Stone Park.

(20) *Basilarchia disippus* Godart, is also a common form. It is found everywhere in the open, but is more common in the city than in the country.

(21) *Chlorippe celtis* Boisd.-Lec. This is one of the most peculiar and interesting butterflies that I have ever seen. Its quick, darting flight makes it very noticeable in the open woods where it makes its home, though its colors are admirably protective. It possesses one extraordinary habit. This is that it has never failed to alight on the person or garments of some human being nearby in all the observations I have made of it. I once carried one on my hand for some minutes, when it was brushed off by accident, though even then it seemed loth to quit its place. In the meadows of Stone Park and along the River Road celtis is very common.

(22) *Chlorippe clyton* Boisd.-Lec. Clyton is not a common insect. It was found in abundance in July, 1910, along a limited portion of the River Road, but has never since been at all numerous.

Subfamily SATYRINAE.

(23) *Neonympha eurytus* Fab. In the darkest woods these frail little creatures are always plentiful. Myriads arise before an invasion of their domain, and there is hardly a dimly lighted valley but fur-

nishes them a retreat. Though inconspicuous and probably unknown to the casual observer, it is hardly presumptuous to place them among the most common local species.

(24) *Satyrus alope* Fab., form *nephele* Kirby. This is the only species of the genus which is known to occur here. It is common in all meadows, especially in midsummer.

Family **Lycaenidae.**

Subfamily LYCAENINAE.

(25) *Thecla melinus* Hubner. Only three specimens of *T. melinus* have been observed. Two of these were found in 1912 on opposite sides of the city, and in view of this wide separation it is probable that they are more plentiful than the number seen would imply. All were found in late August and early September in open prairies.

(26) *Thecla calanus* Hubner. During early July great numbers of this dainty little hair-streak may be found on the Burr Oaks at the edge of the timber in Stone Park.

(27) *Chrysophanus thöe* Boisduval, once plentiful, is now seldom seen. It was formerly taken about weed covered lots in the city.

(28) *Lycaena pseudargiolus* Boisd.-Lec.

(29) *Lycaena comyntas* Godart. The blues are very erratic in their appearance, sometimes frequenting one spot, sometimes another, but always in considerable numbers. Two forms of Pseudargiolus have been taken, but neither is constant or common. Comyntas, on the other hand, is abundant. In late summer dozens of the tiny creatures hover about every mudhole in the country roads.

Family **Papilionidae.**

Subfamily PIERINAE.

(30) *Pieris protodice* Boisd.-Lec., is a comparatively common species.

(31) *Pieris rapae* Linn. This costly pest need hardly be mentioned, for here, as everywhere else, hundreds may be seen in every cabbage patch. It is one of the first forms to appear, and the most common butterfly we have.

(32) *Nathalis iole* Boisduval. Iole is very common. It prefers the hottest of exposed roads, where it may be seen gathering about muddy spots or over the dusty flowers from midsummer until fall.

(33) *Catopsilia eubule* Linn. The summer of 1913 brought this species to my notice for the first time. These butterflies were seen in late August hovering about the treetops in Stone Park, and later were observed in various parts of the city in considerable numbers until cold weather.

(34) *Meganostoma caesonia* Stoll. The Dog-face may always be found in the warm months, in every kind of surroundings, though it is never a very common insect.

(35) *Colias eurytheme* Boisduval. It need not be said that this species is very plentiful and widespread, when it is known as one of the common yellow butterflies. The form *ariadne* Edwards, and the albino female are occasionally found.

(36) *Colias philodice* Godart, is less abundant than the preceding species, but is always present. Both forms are found in the open.

(37) *Terias lisa* Boisd.-Lec. This little insect has been a subject of much wonder to me in my researches. In 1909 they could be seen everywhere. In 1910 not a single specimen was recorded. Since then the number has gradually increased until in 1913 a considerable number were seen.

Subfamily PAPILIONINAE.

(38) *Papilio turnus* Linn., may be seen in great numbers in the meadows of Stone Park during the spring and summer. It is also quite common in town. The female dimorphic form *glaucus* Linn., is very seldom seen. One dwarfed male is at hand, its expanse being only 2.5 in., .7 below normal.

(39) *Papilio cresphontes* Cramer, has never been seen except near the swampy spot on the River Road mentioned above. Here it makes its appearance every year in small numbers.

(40) *Papilio asterias* Fab., is rather rare. It frequents the woods and has been taken in widely separated localities. Two other species of Papilio are known to occur here, but neither has ever been taken.

It was my intention to include the Skippers in this paper but the greater difficulty attending a study of this group, and the limited time which I have been able to give to the work makes it necessary to omit them for the present. The moths offer such a large field of research that they too must remain for a later treatise. At present I have specimens of a few less than one hundred identified species, a majority of which are the only ones of their kind that I have ever seen. It is possible that in the next few years I may be able to bring together enough data concerning them to be of interest, and also add to what I have already done with the other Lepidoptera.

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BUTTERFLIES OF CHANCE OCCURRENCE IN CASS COUNTY, IOWA.

FRANK C. PELLETT.

The distribution of butterflies is strangely local with many species. Not having sufficient data at hand to justify an attempt to catalogue the butterflies of this locality, I am led to offer a list of a few species that are so seldom seen here as to make it unlikely that they would be taken by one making a study of only a few weeks' duration.

Some species that one would expect to find present in considerable numbers have been seen but seldom during the three years over which my collecting has extended. Other species known to be fairly common only about sixty miles distant have never been met with at all, though more or less time has been spent in the field in every month of the season. It is a well known fact that the relative abundance varies greatly in different seasons. I have noted that some species extremely abundant one season will be almost entirely absent, perhaps, the next. Those of which only from one to three or four specimens are taken during a period of three summers are not very likely to prove abundant at any time.

The Queen. *Anosia berenice* Cramer.

On August 31, 1912, I took a single specimen of this species, the only one ever taken in this part of the state to my knowledge. The difference in coloring between this species and *plexippus,* its near relative, is very marked. It is also somewhat smaller than that species. The difference in the markings is not so apparent as in the coloring. The camera, unfortunately, does not bring out these differences prominently in the photo.

Clouded Wood Nymph. *Satyrus alope nephele* Kirby.

I have found this species to be very abundant in western Nebraska and South Dakota. Although from its range it would be expected here, I have not found it except on two or three occasions and then only in the varietal form, *nephele.*

The Buckeye. *Junonia coenia* Hubner.

A single frayed specimen was taken October 17, 1911. I do not recall ever seeing another in this locality.

The Snout Butterfly. *Libythea bachmanni* Kirtland.

From the range given in the books this species may be expected almost anywhere, but the only specimen falling under my eye was taken on July 8, 1913.

Cloudless Sulphur. *Catopsilia eubule* Linnaeus.

Although this species is reported as of frequent occurrence within less than one hundred miles, I have succeeded in taking only one, a female, on September 6, 1913. One or two others have been seen on the wing that resembled this specimen, but as they were not captured the identity is uncertain.

The Mexican Yellow. *Terias mexicana.*

The only specimen in my collection is dated August 19, 1912. One other specimen of the same species was taken previously, but was too badly damaged to be of value. Apparently very rare in this locality.

The Common Eastern Swallowtail. *Papilio asterias* Fabricus.

This species is to be taken occasionally, but is by no means common. Some seasons it will not be seen at all.

The Papaw Butterfly. *Papilio ajax* Linnaeus.

In July, 1912, a specimen of this species was taken at my home, the only specimen so far secured. One or two others have been seen on the wing which appeared to be the same. The fact that its food plant, the papaw, is absent from the locality probably accounts for its rarity.

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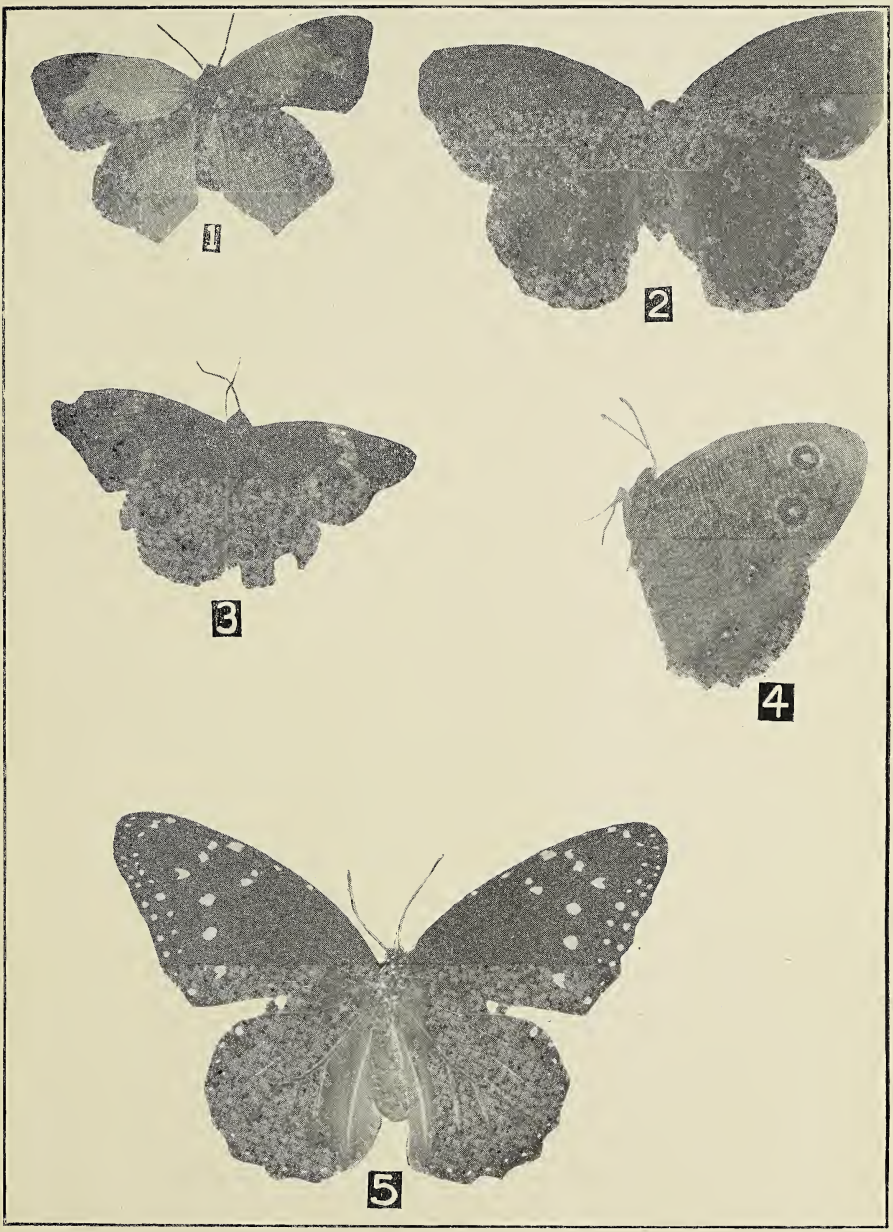

FIG. 1.—Mexican Yellow Butterfly, *Terias mexicana*. Cass county, August 19, 1912.
FIG 2.—Clouded Wood Nymph, *Satyrus alope*, var. *nephele*. Wings open. Cass county, August, 1912.
FIG. 3.—Buckeye, *Junonia coenia* Hubner. Atlantic, October 17, 1911.
FIG. 4.—Clouded Wood Nymph. Wings closed.
FIG. 5.—The Queen, *Anosia berenice*. Cass county, August 31, 1912.

AN OBSERVATION OF LONGITUDINAL DIVISION OF HYDRA.

L. S. ROSS.

Upon stopping at the laboratory table of one of the members of the class in freshman zoology one day in the fall semester of 1913, my attention was attracted to a drawing of a Hydra that aroused my interest at once. At first I thought the student had found two Hydras attached to debris close together, and through an error in observation had made a drawing representing them as connected. But upon looking at the specimen I saw, for the first time in my experience, a Hydra

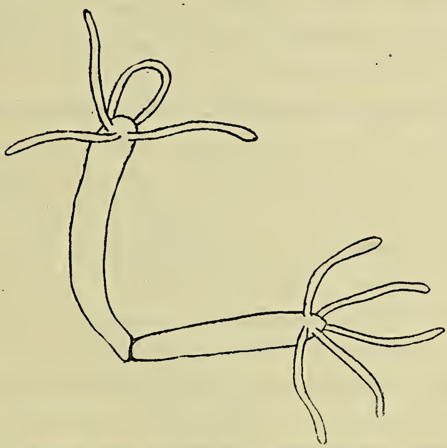

Fig. 10. Hydra divided through length of body.

in the process of longitudinal division, the fission having proceeded through the length of the body, the two parts being connected only at the foot. There could be no question as to its being a case of longitudinal division as the two parts were of equal size and the point of connection was so near the end of the specimen. The specimen was kept under observation for several days but fission did not seem to extend any further. One day the specimen showed an injury to one of the tentacles as though it had been slightly crushed and the next day two tentacles were grown together into a loop as represented in figure 10. This connection remained several days but finally it separated at the outer part of the loop into two tentacles.

During a portion of the time the specimen was under observation, another larger individual was located near by. A fragment of meat being offered, the two parts of the double specimen and the larger individual all siezed upon it; the large Hydra succeeded in ingulfing the meat but as the double individual would not release its hold it was ingulfed also, the tentacles and at least two-thirds of the body being taken in. In a few minutes, however, the specimen withdrew itself leaving the meat in the possession of the larger Hydra. Another observation somewhat similar to this was made upon another Hydra that had ingulfed one of its own tentacles together with some prey it had captured. The tentacle was withdrawn in about five minutes after it was first noticed.

As I wanted to preserve the double Hydra as a permanent specimen I did not wait for division to be completed. Upon attempting to anesthetize it with chloretone I added the solution too rapidly when it was almost anesthetized and the result was its sudden contraction.

Not many days after finding the first specimen in process of longitudinal division, I found another in the aquarium. Division had proceeded through the hypostome and a short distance down the length of the body. This one was kept under observation several days and then it was killed by flooding with hot corrosive sublimate to be preserved as a permanent specimen. It is shown in plate XXXVII.

It seems that this method of multiplication is rarely seen as only a few instances are recorded. The latest paper I found upon the subject is by W. Koelitz in the Zoologischer Anzeiger, XXXV Band, 1910. In 1744 Trembly reported a two-headed polyp, and a little over 100 years later, in 1847, Thomson reported a similar observation. In 1880 Asper found dividing Hydra in Silser See, evidently very similar to one found and figured by Zoja in 1890. Koelitz considers the instance of division reported by Jennings in 1883 to be a case of accidental injury rather than a normal longitudinal division. In 1900 Parke observed four or five dividing specimens; in one instance four to five days being the time occupied in division while in another it was nearly four weeks. *Hydra viridis* required the longer period and a brown Hydra the shorter. In 1908 Annandale described the division in *H. viridis* and *H. grisea,* Leiber one in 1909, and Koelitz several instances as described in 1910.

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PLATE XXXVII. Hydra divided through hypostome and into body. (Photomicrograph.)