PROCEEDINGS

OF THE

Iowa Academy of Science

FOR 1915

VOLUME XXII

EDITED BY THE SECRETARY

PUBLISHED BY THE STATE

234716

DES MOINES
ROBERT HENDERSON, STATE PRINTER
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LETTER OF TRANSMITTAL

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

In accordance with the provisions of title 2, chapter 5, section 136, code supplement, 1913, I have the honor to transmit herewith the proceedings of the twenty-ninth annual session of the Iowa Academy of Science and request that you order the same to be printed.

Respectfully submitted,

James H. Lees,

Secretary.

OFFICERS OF THE ACADEMY

1914-15.

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.

1915-16.

President—H. M. Kelly, Mount Vernon.
First Vice-President—G. W. Stewart, Iowa City.
Second Vice-President—Charles R. Keyes, Des Moines.
Secretary—James H. Lees, Des Moines.
Treasurer—A. O. Thomas, Iowa City.

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Elective—E. J. Cable, B. H. Bailey, L. B. Spinney.

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

PAST PRESIDENTS—Continued

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
Conard, H. S....................1914

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Beyer, S. W................Ames
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Conard, Henry S........Grinnell
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Williams, Mabel C.....Iowa City
Wylie, R. B............Iowa City

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Kunerth, Wm. ....Ames
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Wilson, Guy West....Iowa City
Woodward, S. M.......Iowa City

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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.
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Hammer, B. H.............Ames
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.............Independence, Kan.
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Larson, G. A.........Des Moines
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Moon, Helen..........Iowa City
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Overn, O. B., Lutheran College,
.... Decorah
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..............Stillwater, Okla.
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.... Lamoni
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Robinson, C. L..........Norwalk
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Schultz, Orville ......Postville
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Smith, Orrin H.......Mt. Vernon
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Stanley, Forrester C..Oskaloosa
Stevens, Wilbert A........Tabor
Stewart, Katherine L.Davenport
Stiles, Harold ....Ames
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Thone, Frank E. A...Des Moines
Tisdale, Wilbur E.....Iowa City
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Truax, T. R...............Ames
Utz, Carl R...........Iowa City
Verink, E. D.......Cedar Rapids
Vorhies, Fred ....Lansing
Watson, E. E...........Fairfield
Webster, C. L.......Charles City

ASSOCIATE—Continued

Weigle, O. M.........Cedar Falls
Weld, L. D.........Cedar Rapids
Whitney, Thomas H....Atlantic
Wifvat, Samuel, U. P. Station ....Des Moines
Williams, Arthur J...Iowa City
Wolden, B. O........Wallingford
Woods, Dr. C. S.......Iowa City
Wylie, Charles A......Audubon
Yothers, J. F............Toledo

CORRESPONDING MEMBERS.

Andrews, L. W...Davenport
Arthur, J. C......................Purdue University, Lafayette, Ind.
Bain, H. F.......................................London, England
Ball, C. R...............Department of Agriculture, Washington, D. C.
Ball, E. D..................State Agricultural College, Logan, Utah
Barbour, E. H.......................State University, Lincoln, Neb.
Bartsch, Paul ....Smithsonian Institution, Washington, D. C.
Beach, Alice M....................University of Illinois, Urbana, Ill.
Bruner, H. L...Irvington, Ind.
Carver, G. W..Tuskegee, Ala.
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, Kan.
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....................................College Station, Texas

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Proceedings of the Twenty-Ninth Annual Session of the Iowa Academy of Science

REPORT OF THE SECRETARY.

Fellows and Members of the Iowa Academy of Science:

During the past year a number of problems have suggested themselves, which it seems fitting to discuss briefly.

The membership of the Academy has grown so much in recent years that it is now impossible to furnish all members with cloth bound copies of the Proceedings. It has proven a hard task this year to make 200 volumes supply 280 persons. As soon as its finances will permit the Academy should provide for a larger number of copies to be bound in buckram. This number should be 300 at least, in place of the present 200.

In his last report to the Academy my predecessor, Professor Ross, suggested that original workers in science from other states when chosen as corresponding fellows of the Iowa Academy "are really elected to honorary fellowships, the honor, sometimes perchance, being to the Academy rather than to the one so elected". The constitution provides that in addition to those scientists who are elected from other states as corresponding fellows, active fellows removing to other states from this may be classed as corresponding fellows. The procedure of the Academy in regard to this latter point evidently has not been consistent and some fellows have been transferred to the correspondents' list while others have not. Moreover there are three persons in the list of corresponding fellows whose residence is given as Iowa. I would suggest that this list be carefully revised by a committee well informed and with a definite plan in mind; and that the clause of the constitution providing for transferring of fellows from the active to the corresponding list be *very rarely* applied. If the intention of the founders of the Academy was to make the class of corresponding fellows an honorary one that purpose should be conserved by a careful guarding of the list so that it shall really stand for what it is supposed to represent. The suggestion has been made, and I am glad to endorse it here, that Past Presidents of the Academy, should they remove from the state, be transferred to the corresponding fellows' class, in recognition of their service to the Academy.

The committee on Secretary's report at the last meeting submitted resolutions calling for the discontinuance of the present annual fee for corresponding fellows and also for the raising of the present life membership fee from $7.00 to $15.00. Although the report was adopted the required amendments to the constitution have not been submitted.

The question of giving prizes for meritorious work by members of the Academy has been raised at different times. Would it not be desirable to carry into execution some plan for the recognition by the Academy of the additions to knowledge made by its members? It may not be advisable or feasible to assist in the prosecution of research, but it may be quite possible to reward it when completed.

The secretary at times has calls for a list of the papers published by the Academy. These calls come from libraries and from scientists over the nation. There is no such list, so far as I am aware, but it would be of great convenience. If it is your desire I will be glad to prepare an index of the published volumes, this list to be of such character and published in such form as you shall decide.

In reading over the constitution I am impressed by the absence of any clauses defining the status of that class of members known as associates. They seem to be assured of no rights, privileges or immunities except the right of paying one dollar each year. Would it not be well to specify clearly the duties and privileges of each class of members? And this leads to the further suggestion that the constitution makes no provision for the adoption of any by-laws. However, I shall abstain from making further recommendations at this time.

I am glad to take this opportunity of thanking the members of the Academy who published papers in Volume XXI for their assistance to the secretary in editing and proof reading the volume. Almost without exception proof was returned promptly by authors and a very gratifying spirit of helpfulness was manifested. Still it may not be amiss to mention a few points which not only will lighten the labors of the secretary, if observed, but, what is of more consequence, will increase the value of the Proceedings. It ought not to be needful to say here that the English of our publications should be of a high order. But nine years experience in similar work gives me grounds for saying that such an admonition is not needless, even among scientific men, where accuracy is the watchword. I have wished that it were possible to have a training school where investigators might be given instruction in the use of model English phraseology; uniformity in the use of standard expressions, abbreviations, punctuation, and other helps to intelligibility; the proper structure of the sentence; the use and misuse of the paragraph; typewriting and the appearance of the finished paper; and other points which might suggest themselves. I have had occasion often to wish for myself such instruction. But at least if we cannot attend such a training school, we can read our productions to our wives. They are likely to be good critics, and not too lenient. This will outline in brief what I wish for every member of our Academy who aspires to bring to the attention of the reading public his own accomplishment in this inner world of research of which we are each a part. Surely the children of our intellectual life are worthy the best clothing we can provide, and the criticism so often made of technical experts—that they can not prepare a creditable report—ought not to hold against scientific authors.

Respectfully submitted,

James H. Lees,
Secretary.

TREASURER'S REPORT.

RECEIPTS.

Cash on hand, April 25, 1914	$ 4.97
Refund from L. S. Ross, due to excess payment	10.45
Dues and initiation fees from members and fellows	187.00
Life member dues	14.00
Sale of proceedings	4.25
Exchange not used by the bank	.20
	$220.87

EXPENDITURES.

Expense of lecturer, 28th meeting	$ 28.01
Postage and stenographic work for treasurer	11.20

Programs, letterheads, and postage for secretary	12.64
Letterheads, receipt blanks, and supplies for treasurer	7.25
Printing and binding expense, extra pp. Volume XX	144.12
Wrapping and sending out Volume XX	10.00
Balance on hand, May 1, 1915	7.65
	$220.87

A. O. Thomas,
Treasurer.

REPORT OF COMMITTEE ON SECRETARY'S REPORT.

Your committee to whom was referred the secretary's report beg leave to recommend as follows:

1. In regard to the binding of the Proceedings in buckram, three hundred copies should be bound in buckram. This is made possible because the State has assumed some of the burden of the Academy so far as publication is concerned.

2. It is the opinion of your committee that honorary membership should be awarded only to such scientists as have rendered science some distinguished service, and then this honor should be awarded only on the recommendation of a committee report presented to the Academy at one of its regular sessions. With reference to the transfer of fellows from active to the corresponding lists, this to include also the past presidents who have moved from the State, this article or section of the constitution should be revised in such a way as to safeguard the principles for which the Academy stands. It might be well to have this change from active to corresponding membership apply only to persons who have been members for ten years.

3. The Academy should adopt some plan as soon as practicable to give a diploma or some other suitable recognition for meritorious scientific work done in the State. This might be an annual event, some such plan as the following:

The Iowa Academy, etc., hereby awards this diploma, etc., for distinguished work done in chemistry.

....
President of the Iowa Academy of Science.

....
Secretary of the Iowa Academy of Science.

4. It would seem desirable to publish a complete index to the Academy when twenty-five volumes are completed.

5. In regard to associates, it was the original idea that this class of members are preparing to become fellows.

They should have the right to vote on all Academy matters as well as to present papers. They have frequently presented papers. It might be well for a committee to recommend suggestive changes in the constitution as well as the adoption of by-laws.

G. W. Stewart,
L. H. Pammel,
B. H. Bailey.

The membership committee, Messrs. Lees, Thomas and Kenoyer, submitted the following names. The report was adopted and the persons named were declared elected.

Elected Fellows—G. W. Stookey, Cedar Rapids; Arthur W. Hixson, Iowa City; George A. Chaney, Ames; Dr. A. L. Grover, Iowa City.

Transferred from Associates to Fellows—Morris M. Leighton, Rosenwald Hall, University of Chicago; Miss Alison E. Aitchison, Cedar Falls; T. C. Stephens, Sioux City.

Elected as Associates—Eric Eastman, Ames; Wm. Diehl, Ames; Dr. E. Curran, Cedar Rapids; G. V. Emery, Ames; Rev. H. K. Fakkenberg, Davenport; Dr. H. E. Ewing, Ames; H. A. Scullen, Ames; J. V. Howell, Iowa City; M. Louisa Sargent, Grinnell; W. E. Tisdale, Iowa City; L. Oncley, Fayette; P. T. McNally, Iowa City; C. J. Knock, Iowa City; Frank A. Thone, Des Moines; H. H. Gould, Iowa City; J. W. Doolittle, Iowa City; J. L. Seal, Ames; Victor A. Hoersch, Iowa City; Samuel Geiser, Independence; Thesle T. Job, Iowa City; Carl Utz, Iowa City; Siegel Overholt, Iowa City; L. V. Fees, Iowa City; Dr. Fanny C. Gates, Grinnell; Dr. W. S. Elliott, Eldora; O. E. Reynolds, Iowa Falls; C. F. Reed, Lamoni; O. B. Overn, Decorah; J. E. Fulcher, Des Moines; Dr. Orrin H. Smith, Mount Vernon; Dr. C. S. Woods, Iowa City; Paul S. Helmick, Iowa City; Miss Helen Moon, Iowa City; Wm. J. Rusk, Grinnell; E. L. Palmer, Cedar Falls; Daniel M. Brumfiel, Iowa City; Miss Jessie P. Hastings, Iowa City; J. J. Hinman, Iowa City.

OFFICERS OF THE ACADEMY FOR 1915-1916.

President........................H. M. Kelly, Mount Vernon
First Vice President............G. W. Stewart, Iowa City
Second Vice President..........Charles R. Keyes, 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; B. H. Bailey, Cedar Rapids; L. B. Spinney, Ames.

LIST OF MEMBERS AND VISITORS REGISTERED AT THE IOWA CITY MEETING.

Alison E. Aitchison, Cedar Falls, Geography; Henry Albert, Iowa City, Medicine and Bacteriology; Frank F. Almy, Grinnell, Physics; M. F. Arey, Cedar Falls, Zoology; C. G. Armstrong, Ames, Chemistry; B. H. Bailey, Cedar Rapids, Zoology; D. E. Bailey, Ames, Chemist; J. A. Baker, Indianola, Chemistry; R. P. Baker, Iowa City, Mathematics; A. L. Bakke, Ames, Botany; Clifford L. Bartlett, Iowa City, Bacteriology and Pathology; C. O. Bates, Cedar Rapids, Chemistry; H. F. Bauer, Cedar Rapids; L. Begeman, Cedar Falls, Physics; Friederich Berninghausen, Eldora, General; Geo. H. Berry, Cedar Rapids, Natural Science, Chemistry; P. L. Blumenthal, Ames, Chemist; P. A. Bond, Cedar Falls, Chemistry; David H. Boot, Iowa City, Botany; F. C. Brown, Iowa City, Physics; P. E. Brown, Ames, Soils; D. M. Brumfiel, Iowa City, Animal Biology; J. H. Buchanan, Ames, Chemist; E. J. Cable, Cedar Falls, Geography; C. L. Coffin, Oskaloosa, Physics; R. M. Cole, Ames, Chemist; Henry S. Conard, Grinnell, Botany; Ruth H. Cotten, Iowa City, Zoology; John S. Coye, Ames, Chemistry; Mae Cresswell, Cedar Falls, Teaching of Science; W. E. Davis, Cedar Falls, Agriculture; E. O. Dieterich, Iowa City, Physics; H. R. Dill, Iowa City, Zoology; L. E. Dodd, Iowa City, Physics; H. L. Dodge, Iowa City, Physics; J. W. Doolittle, Iowa City, Physics; A. W. Dox, Ames, Chemistry; R. W. Getchell, Cedar Falls, Chemistry; C. E. Gillette, Mount Vernon, Chemistry; Harry H. Gould, Iowa City, Psychology; A. L. Grover, Iowa City, Medicine; A. C. Grubb, Cedar Falls, Physics; J. E. Guthrie, Ames, Zoology; J. P. Hastings, Iowa City, Physics and Chemistry; R. W. Henderson, Iowa City, Biology; W. S. Hendrixson, Grinnell, Chemistry; S. F. Hersey, Cedar Falls, Physics; F. G. Higbee, Iowa City, Engineering; Ruth Higley, Grinnell, Zoology; J. J. Hinman, Jr., Iowa City, Chemistry; A. W. Hixson, Iowa City, Chemistry; Victor A. Hoersch, Davenport, Physics; Gilbert L. Houser, Iowa City, Animal Biology; Jessie V. Howell, Iowa City, Geology; E. A. Jenner, Indianola, Biology; T. T. Job, Iowa City, Biology; Axel Justesen, Cedar Falls, Geology; W. J. Karslake, Iowa City, Chemistry; G. F. Kay, Iowa City, Geology; Harry M. Kelly, Mount Vernon, Zoology and Botany; L. A. Kenoyer, Toledo, Biology; C. R. Keyes, Des Moines, Geology; C. N. Kinney, Des Moines, Chemistry; H. B. Kinney, Ames, Soil; Nicholas Knight, Mount Vernon, Chemistry; Carl J. Knock, Iowa City, Psychology; William Kunerth, Ames, Physics; S. B. Kuzirian, Ames; A. R. Lauch, Ames, Chemist; James H. Lees, Des Moines, Geology; Leslie W. Lyon, Burlington, Physics and Chemistry; P. T. McNally, Dunlap, Physics; R. Monroe McKenzie, Fairfield, Chemistry and Physics; Helen Moon, Iowa City, Mathematics; C. C. Nutting, Iowa City, Zoology; Lawrence Oncley, Fayette, Physics; E. L. Palmer, Cedar Falls, Botany; L. H. Pammel, Ames, Botany; J. N. Pearce, Iowa City, Chemistry; F. C. Pellett, Atlantic, Natural Science; J. O. Perrine, Cedar Falls, Physics; H. J. Plagge, Ames, Physics; G. P. Plaisance, Ames, Chemist; J. C. Pomeroy, Ames, Physics; O. B. Reed, Cedar Falls, Chemistry; R. P. Renshaw; E. W. Rockwood, Iowa City, Chemistry; L. S. Ross, Des Moines, Zoology; W. J. Rush, Grinnell, Mathematics; Louisa Sargent, Grinnell, Botany; C. E. Seashore, Iowa City, Psychology; F. H. Schoultz, Ames, Chemistry; B. Shimek, Iowa City, Botany; Ella Shimek, Iowa City, Botany; W. R. Shipton, Iowa City, Geology; L. P. Sieg, Iowa City, Physics; Orrin H. Smith, Mount Vernon, Physics; L. B. Spinney, Ames, Physics; J. L. St. John, Cedar Falls, Chemistry; T. C. Stephens, Sioux City, Biology; G. W. Stewart, Iowa City, Physics; Harold Stiles, Ames, Physics; Dayton Stoner, Iowa City, Zoology; F. A. Stromsten, Iowa City, Zoology; Louis A. Test, Ames, Chemistry; A. O. Thomas, Iowa City, Geology; F. Thone, Grinnell, Botany; John L. Tilton, Indianola, Geology; W. E. Tisdale, Iowa City, Physics; C. M. Traver, Muscatine, Physics; A. C. Trowbridge, Iowa City, Geology; T. F. Vance, Ames, Psychology; Flora Waterbury, Iowa City, Zoology; R. L. Webster, Ames, Zoology; O. M. Weigle, Cedar Falls, Chemistry; LeRoy D. Weld, Cedar Rapids, Physics;

Vern E. Whitney, Ames, Chemistry; Samuel Wifvat, Des Moines, Physics; Louisa Wilken, Iowa City, Medicine; Mabel C. Williams, Iowa City, Psychology; Guy West Wilson, Iowa City, Botany; C. S. Woods, Iowa City, Medicine and Hygiene; R. B. Wylie, Iowa City, Botany.

PROGRAM.

The Academy held its meetings in Room 301, Hall of Physics, beginning at 1:30 p. m., Friday, April 30, 1915. Academy headquarters were the Electrical Laboratory, first floor, Hall of Physics. The Iowa Section, American Chemical Society, had headquarters in the Hall of Physics, and met Saturday forenoon.

Professor Ellery W. Davis of the Department of Mathematics, University of Nebraska, gave the Annual Address at 8:15 p. m., Friday, on the subject "Uncertainties." The lecture was given in the Auditorium, Hall of Natural Science.

Dean Stanton Ford of the University of Minnesota lectured on "The Present Situation of University Research in this Country" in the Auditorium of the Hall of Liberal Arts, Friday at 7:30 p. m.

TITLES OF PAPERS RECEIVED.

An Anomalous Hickory-nut; An Exobasidium on Armillaria; The Role of Soil Fungi .... Guy West Wilson

The Forest and Shrub Flora of Western Iowa .... L. H. Pammel, G. B. MacDonald and H. B. Clark

The Weed Flora of the Lake Superior Region Compared with the Weed Flora of Iowa .... L. H. Pammel

Some Comparative Germination Tests of Sweet Clover ...... H. S. Doty

The Flora of the Ledges, Boone County, Iowa .... Wm. Diehl, Presented by L. H. Pammel

Flora of the Rainy River Region, Minnesota ...... Harriette S. Kellogg

Economic Seaweeds of Alaska; A Hybrid Ragweed .... Robert B. Wylie

The Distribution of Forest and Prairie in the Lake Region of Iowa; The Lichen Flora of the Prairies of Northwestern Iowa; Early Iowa Locality Records .... B. Shimek

The Ecological Histology of Certain Prairie Plants .... Ella Shimek

The Index of Foliar Transforming Power as an Indicator of Permanent Wilting of Plants .... A. L. Bakke

Preliminary Notes on Nectar Production .... L. A. Kenoyer

Flora of the East Slope of the Cascade Mountains in Crook County, Oregon .... Morton E. Peck

Pioneer Plants of a New Levee .... Frank A. Thone, Introduced by H. S. Conard

A New Apparatus for Regulating Temperatures for Work in Polarimetry and Refractivity...
Electrical Conductivity of Solutions of Silver Nitrate in Water and Pyridine and in their Binary Mixtures. (Preliminary Paper.).... } J. N. Pearce

A Convenient Standard Cell: (Cu—Hg)—$CuSO_4$—Hg_2SO_4—Hg. ....Dieu Ung Huong and J. N. Pearce

Some Derivatives of 4-nitro-5-methyl-2-sulphobenzoic Acid........ ....Wm. J. Karslake and P. A. Bond

The Anston Stone from Kiveton Park, England
An Important Building Stone from the Vosges Mountains ....
The Transfusion of Double Salts Through Porous Partitions .... } Nicholas Knight

Comparison of Some Standards in Acidimetry and Alkalimetry ....W. S. Hendrixson

Studies on Barium Sulfate ....P. L. Bluementhal and S. C. Gurnsey, Read by Dr. Bluementhal

A Comparison of Some Kjeldahl Methods for Nitrogen Determination ....P. L. Bluementhal and G. P. Plaisance, Read by Mr. Plaisance

The Ste. Genevieve Formation and Its Stratigraphic Relations in Southeastern Iowa........Stuart Weller and Francis M. Van Tuyl

The Occurrence and Origin of the Iron Ores of Iron Hill, Near Waukon, Iowa..........Jesse V. Howell, Introduced by G. F. Kay

The Extension of the Wisconsin Drift Southwest from Des Moines ....
The Age of the Terrace Near Des Moines and Indianola, Iowa.... } John L. Tilton

The First Coal-Washing Plant in Iowa..........
The Mineral Industry in Iowa During the Past Decade .... } George F. Kay

The Occurrence of Barite in the Lead and Zinc Districts of Iowa, Illinois and Wisconsin....W. D. Shipton

A Remarkable Prairie Synclinorium............
Foundations of Exact Geologic Correlation....
Contraposed Shore-Lines on the Straits of Juan du Fuca .... } Charles Keyes

Progress Report of Physiographic Work in the Driftless Area ....A. C. Trowbridge

The Paleontology and Stratigraphy of the Upper Carboniferous of Iowa....George L. Smith

The Loess of Peczel, Hungary....B. Shimek

The Phenomenon of Leaching in Pleistocene Formations.......... ....M. M. Leighton

Some Unique Niagaran Cephalopods............
A New Crinoid Fauna from Monticello, Iowa....
High Level Gravels in Floyd County, Iowa...... } A. O. Thomas

The Inheritance of Syndactylism....Henry Albert

The Effect of Alcohol on the Liver as Shown Experimentally...... ....A. L. Grover, Introduced by Henry Albert

The Effect of Change of Lamp Voltage on Vision......William Kunerth

A Simple Device for Demonstrating the Tempered Scale..L. B. Spinney

An Attempt to Detect a Change in the Heat Conductivity of Selenium Crystals Under the Influence of Light..........L. P. Sieg

Notes on Certain Elastic Peculiarities of Phosphor Bronze Wires ....L. P. Sieg and A. J. Oehler

On the Wave-Length-Sensibility Curves of Isolated Crystals of Selenium Between Wave Lengths 2000 A. U. and 4500 A. U. ....F. C. Brown and L. P. Sieg

A Design for Electrical Regulation of High Temperature Ovens .... W. E. Tisdale
Notes on Production, and Some Electrical Properties of Tellurium Crystals.................. W. E. Tisdale

A Resonance Method for Measuring the Phase Difference of Condensers ....H. L. Dodge

The Theory of Binaural Beats.—An Experimental Contribution.... ....G. W. Stewart and Harold Stiles

Experimental Evidence of Absence of Liberation and Absorption of Electrons in a Change from the Electrically Conducting to the Electrically Non-Conducting State................L. E. Dodd

The Crystal Optiphone in its Adaptation to Enable the Blind to Read the Printed Page through Ear Impressions......F. C. Brown

The Variation, with Temperature, of the Light-Sensitiveness of Selenium Crystals..........................Kathryn J. Dieterich

The Wave-Length Sensibility Curves of Selenium Blocks.......... ....E. O. Dieterich

Phychology Applied to the Improvement of Control of the Pitch of the Voice in Singing..Carl J. Knock, Introduced by C. E. Seashore

Psychology Applied to Measurement of Merit in Advertisements.. ....Harry H. Gould, Introduced by C. E. Seashore

The Psychogram in Vocational Guidance................C. E. Seashore

A Bacteriological Study of the Wells of Toledo, Iowa.............. ....W. H. Lauderdale and L. A. Kenoyer

Preliminary Notes on the Animal Ecology of Johnson County...... ....D. M. Brumfiel, Introduced by Gilbert L. Houser

Anatomy of the Lymphatic System in the Adult Rat.............. ....Thesle T. Job, Introduced by Gilbert L. Houser

Notes on the Development of the Lymphatic System of Turtles.... ....Frank A. Strómsten

The Present Status of the Hessian Fly in Iowa..........R. L. Webster

Tracheal Capillaries of the Grasshopper....................L. S. Ross

The Inheritance of Fertility in Swine..........Edward N. Wentworth

Is the Appetite of Swine a Reliable Indication of Physiological Needs?......................................John M. Evvard

Notes on Iowa Pentatomoidea............................Dayton Stoner

The Crow.....................................Fred Berninghausen

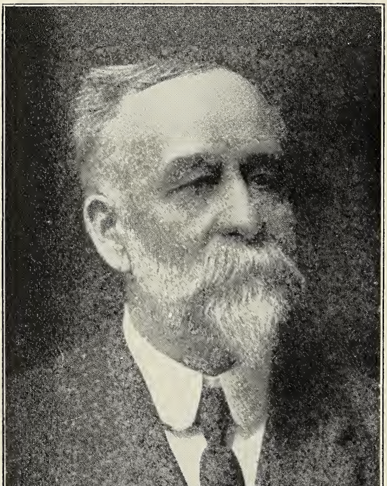
On Snakes "Swallowing" Their Young.....................E. D. Ball

Notes on the Distribution of the Prairie Spotted Skunk in Iowa.. ....B. H. Bailey

The Building and Function of the College Museum........B. H. Bailey

Ictinia Mississippiensis in Nebraska.....................B. H. Bailey
(Published in full in the Wilson Bulletin of Oberlin College.)

PLATE I



Dr. Charles Edwin Bessey.

IN MEMORIAM

DR. CHARLES EDWIN BESSEY.

L. H. PAMMEL.

A host of friends throughout this land were grieved at the death of Dr. Charles Edwin Bessey, whose long years of activity as a teacher, investigator and citizen, were known throughout this broad country of ours. To his many friends in Iowa his death came as a shock, because it was here that he laid the foundations for that broad scientific life, a life devoted most enthusiastically to the science of botany, a life devoted to the teaching profession, a life devoted to the student in the class room and out of it. It was indeed a purposeful life, always full of sunshine and gladness. There were many of the older students at Ames who felt that Dr. Bessey was their personal friend, ready always to do something for them. To these students he gave his best. He gave some of his best years to administrative work at Ames and the University of Nebraska. Chancellor Avery says, "His death is not only a misfortune to the University organization, in the upbuilding of which the effort of the greater part of his life was spent; but also a direct personal loss to students, alumni, and faculty people among whom he numbered his friends by hundreds." The Daily Nebraskan of March 1st says that the summation of the philosophy of life is formed, according to Professor Bessey's own expression, in the word "love".

Doctor Bessey was always temperate. In my long acquaintance with him I never heard him say an unkind thing of anyone. Though he differed in opinion or may have disliked some persons, he tempered his remarks so as to leave the impression that the man or woman had splendid qualities. Professor Pool says "He even sought to temper criticism whenever possible." He was devoted to his family and his friends. Many a young botanist owes his success to the help Doctor Bessey gave him.

He was an inspiring teacher and always youthful. I last met him at the quarter centennial celebration of the Missouri Botanical Garden last October. Though perhaps not as vigorous as formerly he was as enthusiastic as when I met him more than a quarter of a century ago. It was his unbounded enthusiasm that made him such a successful teacher. It enlisted a large number of men to study botany.

Professor R. J. Pool says, "To have met with him was to honor him; to have been taught by him was a priceless privilege; to have been intimately associated with him and to have walked with him into the fields and gardens and to have received from him an insight into the great realm of which he was master was to have been led very close to the Great Omnipotent who causes the snowflakes to fall, O, so softly, when our beloved friend passes beyond the great divide where nothing but flowerland and love will greet him."

Doctor Bessey was linked to Iowa in many ways. He was called to Iowa State College as Professor of Botany and Zoology in 1870 and served until 1884. The State University of Iowa conferred on him the Ph.D. degree in 1879, and Grinnell College the degree of LL.D. in 1898. He received the B.S. degree from Michigan Agricultural College in 1869 and the M.S. degree in 1872. He was born in Milton, Ohio, May 21, 1845, being at the time of his death scarcely seventy years old. One would think years of usefulness were still ahead of him. The last visit I paid Dr. Bessey was a little more than a year ago and I was told he was away in Arizona studying some plant physiological problems. Many honors were given to him. He was president of the Old Iowa Academy of Sciences and one of its founders, and it is natural that he should have associated himself with the New Iowa Academy of Science and should have presented a paper on the Trees of Nebraska at a meeting at Ames inaugurating botanical quarters in the New Central Building standing where the old Main Building stood and where thirty-five years before he gave lectures on botany.

He was also president of the Botanical Society of America 1896; the Miscroscopical Society 1901; the Society for the Promotion of Agricultural Science 1889-1891. He was a member of the leading scientific societies of the United States and Europe.

Plate II

Reverend David MacMillan Houghtelin.

Doctor Bessey published much. Many of the papers embodied the results of searching investigation and reflection. The last paper was one on "The Phylogenetic Taxonomy of Flowering Plants," which was delivered at the Quarter Centennial Celebration of the Missouri Botanical Garden.

His reputation rested largely on his Text Book of Botany, published while Professor at Ames. This passed through several editions. Later only his Essentials of Botany was published. This was revised with the collaboration of his son Ernest Bessey as the "Essentials of College Botany." This embodied his views of how botany should be taught, and he elaborated particularly parts dealing with the classification of plants. For many years he was one of the editors of The American Naturalist and of Science. In addition to various botanical notes he frequently reviewed important botanical papers.

Doctor Bessey has left his impression on American botany by his writing and teaching and botanical science has lost one of its most sincere men, a friend and a great teacher.

THE REVEREND DAVID MACMILLAN HOUGHTELIN.

JOHN L. TILTON.

David MacMillan Houghtelin was born at Gettysburg, Penn., January 14, 1872, and died at the Methodist Hospital, Des Moines, Iowa, June 3, 1913, aged 41 years. He was a graduate of Baker University, Baldwin, Kansas, class of 1896, a graduate of Boston University School of Theology, class of 1900, and a graduate student at the University of Glasgow, Scotland, in 1908. Most of the years since graduation were devoted to the work of the ministry, but from 1910 till the time of his death his life was devoted to the interests of the Methodist Hospital at Des Moines. While not engaged in scientific work his interest in science was such that he became an "associate" member of the Iowa Academy of Science in 1912, retaining his membership till the time of his death. In the death of Mr. Houghtelin the Acadamy has lost one of those many friends whose attitude of sympathy toward scientific work is greatly appreciated by the scientific workers of the state.

ABSTRACTS

of Papers Presented at the Meeting

THE INHERITANCE OF SYNDACTYLISM.

HENRY ALBERT.

(ABSTRACT.)

An instance of thirteen cases of syndactylism (or fused or webbed fingers or toes), traced through four generations was reported. The element of heredity is obviously apparent. In view of the recent report of a family with cases of syndactylism in which the inheritance of the abnormal union of the digits apparently conformed to Mendel's law, as a dominant character, an effort was made to determine if the Mendelian law also applied to the cases in question. It was determined that although the disease was due to a factor which was apparently dominant rather than recessive it did not conform entirely to Mendel's law. That it is not due to a Mendelian recessive character is shown by the fact that in three instances the disease appeared in children, neither of whose parents were affected by it and in each instance the family history of at least one of the parents was negative for the disease in question. To have a disease due to a recessive character appear in an individual, neither of whose parents are affected by it, we must assume that both parents are hybrids as regards the condition in question.

Nor does it entirely conform to a Mendelian dominant character, since if it did, we would expect that if the disease appeared in the offspring it should be present in at least one of the parents.

It is probable that the explanation for the lack of conformity of our cases to Mendel's law is due to an inhibition of the activity of the determiner for the disease in question by some other factor, causing the disease in such cases to be latent. The absence or non-operation of such inhibiting factor may again cause the disease to appear.

Department of Pathology and Bacteriology,
State University of Iowa.

THE THEORY OF BINAURAL BEATS—AN EXPERIMENTAL CONTRIBUTION.

G. W. STEWART AND HAROLD STILES.

(ABSTRACT.)

The experiments here reported were performed in order to secure evidence concerning the cause of the additional maxima which occur in binaural beats. (See G. W. Stewart, Physical Review, Series 2, 3, p. 146, 1914, for a description of the phenomena.) These additional maxima occur at certain phase differences, and the change in these phase differences should depend upon the frequency of the tones, but not upon the frequency of the beats. If the additional maxima are caused by interaural conduction then, as it can be shown, the phase differences should vary as the frequencies. In the accompanying curve the phase differences, shown as fractions of π, are the ordinates and the frequencies, abscissae. Instead of a straight line which should obtain in the case of interaural conduction, we have a curve which is far from a straight line. (See Plate III.) The numbers in parentheses indicate the number of observations used in obtaining the position of the point. Five frequencies were used.

After much consideration of theories involving interaural conduction, none seems to be in agreement with the evidence here shown.

Physics Laboratories,
State University of Iowa.

ON THE LYMPHATIC SYSTEM OF THE COMMON RAT.

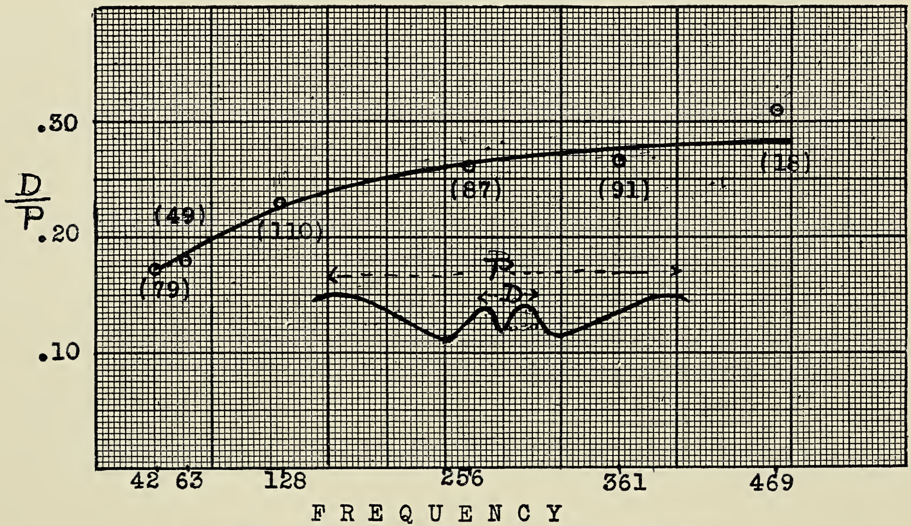
(Epimyus norvegicus)

THESLE T. JOB.

(ABSTRACT.)

From fifty injected specimens, the gross anatomy of the Common Rat has been studied and outlined. The results of the work have further proven the studies of McClure and Silvester on the Lymphatico-venous communications in the Jugulo-subclavian district, and of Silvester on the renal vein communica-

PLATE III.



Displacement of Secondary Maxima with Variation in Frequency.

tions, and have established two additional communications, the portal vein connection and the ilio-lumbar vein connection. The main circulation and disposition of the lymphatic system has been determined and the need of further knowledge concerning the histology of the lymph nodes, of which there appear to be two types, is pointed out.

Laboratories of Animal Biology,
State University of Iowa.

LEACHING OF THE PLEISTOCENE DRIFTS OF EASTERN IOWA.

MORRIS M. LEIGHTON.

(ABSTRACT)

The term leaching is applied by glaciologists to that process of dissolving and carrying out in solution by ground water the soluble constituents of the drift, of which lime carbonate is the most notable in the Mississippi Valley. This discussion of that phenomenon is based on observations made by the writer on Pleistocene deposits of the larger part of the east half of Iowa, and in the vicinity of Chicago, Illinois. Briefly, the evidence warrants the following contentions: (1) The percolation of meteoric waters through clayey drifts is so slow that they become saturated within a few inches after the calcareous zone is encountered. The zone of notable solution is, therefore, limited to a narrow transition zone. (2) The leaching of the drift takes place by the gradual descension of this solution zone. (3) The rate of descension is probably greatest from the surface down to the horizon of the ''ground-water surface for wet seasons,'' less rapid from this horizon down to the so-called permanent ground-water surface, and markedly checked at the latter horizon. (4) The bottom of the leached zone in young drifts may, therefore, not mark the horizon of permanent ground-water surface. (5) the stratigraphic horizon and topographic position of outcrops must be considered in quoting figures for the amount of leaching of a drift sheet. Other important factors are the amount of annual percolation of ground water, the general texture of materials, the size and relative quantity of calcareous constituents, and the amount of carbonaceous materials in the soil. (6) The factor of the rise of ground water into the leached

zone and the precipitation of calcium carbonate is rarely operative. This seems positive from the presence of limestone pebbles in the drift wherever the matrix reacts to acid. (7) The deposition of lime carbonate in an old leached zone by waters which have percolated down from an overlying calcareous formation is also not usually evident in clean exposures. Theoretically the conditions for precipitation in such cases are exceptional. (8) The phenomenon of leaching is one of the practical and legitimate criteria for the age of drift sheets or for differentiating drift-sheets whose general conditions are comparable to those of the east half of Iowa. Like all other criteria it must be used guardedly. Careful records of all the facts should be made.

In addition to the foregoing discussion, the writer points out the need of discriminating in the use of such terms as oxidation, leaching, decomposition, staining, and to avoid as much as possible such general terms as weathering, alteration, etc., without specific definition.

Julius Rosenwald Hall,
University of Chicago.

Papers Presented at the Twenty-ninth Meeting of the Academy

THE NATIVE AND CULTIVATED FOREST TREES AND SHRUBS OF THE MISSOURI RIVER BASIN.

L. H. PAMMEL, G. B. MacDONALD AND H. B. CLARK.

At the twentieth annual session of the Iowa Academy of Science held in Ames on April 20 and 21, 1905, Dr. C. E. Bessey of the University of Nebraska in his address on the Forest trees of Eastern Nebraska,[1] expressed the wish that the Iowa botanists would join with those of Nebraska in making a tree survey of the two sides of the river. During the season of 1914 one of us received a letter from Prof. Sargent[2] asking us to furnish him data on the distribution of Iowa trees. We found, however, that our knowledge of some species was very meager.

Doctor Bessey reported *Carya laciniosa* as far north as Sarpy county. Apparently it does not occur on the Iowa side of the river. Of other species of trees found on the Nebraska side not occurring on the Iowa side, mention may be made of *Carpinus caroliniana, Betula nigra, Rhamnus caroliniana, Aesculus glabra, Rhus copallina, Juglans cinerea, Carya glabra, Quercus marilandica, Populus occidentalis and Salix lucida.*

A large number of scattered papers have been published by Iowa botanists on the flora of western Iowa. Two early papers were written by Bessey[3] and Arthur.[4] These papers do not give any western localities. A third catalogue, "Plants of Iowa", by Wesley Greene[5], lists all of the species previously reported but without locality.

T. J. Fitzpatrick[6] in his Manual of Flowering Plants describes species, giving, in many cases, definite localities of the trees and shrubs. In other papers either as a joint author or alone[7] he gives the distribution of most of the trees and shrubs of southwestern Iowa.

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[1]Proc. of the Ia. Acad. Sci. *13:* 75-87. The paper includes 67 maps.
[2]Sargent wrote to L. H. Pammel asking for a list of the trees in western Iowa.
[3]Fourth Biennial Report Iowa Agricultural College 1871; 90-127.
[4]Contributions to the Flora of Iowa, Catalogue of the Phaenogamous plants, published for the International exhibition by the Iowa Centennial Commission, 43. 1876.
[5]Bull. of the State Horticultural Society, Plants of Iowa, 264. 1907.
[6]Manual of the Flowering Plants of Iowa, 143. Lamoni, 1899.

The paper on the Liliales of Iowa is by T. J. Fitzpatrick[8].

The paper by L. H. Pammel lists the plants found from Missouri Valley, Turin, Sioux City and Hawarden but chiefly from Sioux City and Turin.[9]

The Iowa Geological Survey in the studies of local county geology has included reports on the forest conditions. Papers have been published by Shimek[10] and Macbride[11]. These papers usually included notes on the distribution of trees and their economic uses. In most cases definite localities are assigned to the species. At least the county is given. In those counties where the drainage is to the Missouri river as well as to the Mississippi one must assume that the Mississippian species occur in the latter drainage area.

A number of ecological papers also have been published. The most important paper is the one by Shimek[12], in which weather records and the study of the distribution of trees with reference to the wind and transpiration of water of plants are considered. In another paper Shimek[13] has made a study of the Flora of the Sioux Quartzite. The paper is interesting as showing the distribution of trees on the Sioux quartzite. The species of trees found in this limited area do not differ from those found elsewhere in the region. The only trees found here are *Fraxinus pennsylvanica* var. *lanceolata, Acer Negundo, Tilia americana, Ulmus americana* and *Quercus macrocarpa.* Boot[14] made a comparative study of the field and forest flora in Monona county. His study indicates a correlation between a prairie and a wooded area and that a gradual transition occurs.

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[7]T. J. & M. F. L. Fitzpatrick. The Flora of Southwestern Iowa. Proc. Ia. Acadamey of Sci. *5*, 134-173. (This paper does not touch the plants of western Iowa, but the paper of the same title, Proc. Ia. Acad. Sci. *6:* 173-202, does so.) The two following papers by the same authors give distribution: Betulaceae of Iowa. Proc. Ia. Acad. Sci. *3:* 169-196. The Juglandaceae of Iowa. Proc. Ia. Acad. Sci. *16:* 160-169.

[8]Proc. Ia. Acad Sci. *13:* 115-160.

[9]Notes on the Flora of Western Iowa. Proc. Ia. Acad. Sci. *3:* 106-135.

[10]B. Shimek, in the Geology of Lyon and Sioux Counties by Frank A. Wilder. Rep. Ia. Geol. Survey *10:* 157-184. Bull. Lab. Nat. Hist. Sta. Univ. of Iowa *5:* 215.

[11]T. H. Macbride. Under the head of forestry notes of Osceola and Dickinson counties. Rep. Ia. Geol. Survey *10:* 228-239. Geology of Sac and Ida counties. Forestry notes. Op. Cit., *16:* 549-562. Part of the trees of these counties belong to the Mississippian flora

[12]Geology of Harrison and Monona counties. Botanical Report. Rep. Ia. Geol. Survey *20:* 426-485. pl. *33-39.*

[13]Proc. Ia. Acad. Sci. *4:* 77-81, *5:* 28-31.

[14]Proc. Ia. Acad. Sci. *21:* 53-58.

L. H. Pammel[15] made a study of the flora of western Iowa from a physiographic and ecological standpoint. The plants are discussed under the head of swamps and upland with various subdivisions.

The *Acer saccharinum, A. Negundo, Populus deltoides, Salix nigra* and *S. fluviatilis* belong to the lowlands and *Quercus macrocarpa* and *Tilia americana* belong to the upland.

The forest resources of the region have been discussed by Shimek and Macbride in the papers quoted. G. B. MacDonald[16] has published a paper on the Timber Resources of Iowa.

Name of Species	Shimek—Lyon & Sioux Counties	Macbride—Osceola & Dickinson Counties	Macbride—Cherokee & Buena Vista Counties	Macbride—Sac & Ida Counties	Shimek—Harrison & Monona Counties	Pammel—Harrison, Monona, Woodbury Counties	Fitzpatrick—Fremont County	Fitzpatrick—Pottawattamie County	Von Bayer—Fremont County
Acer saccharinum	+	+	+	+	+	+	+	+	+
Acer nigrum		+							
Acer Negundo	+	+	+	+	+	+	+	+	+
Amelanchier canadensis	+				+				
Amorpha canescens					+	+	+	+	
Amorpha fruticosa	+			+	+		+	+	
Carya cordiformis		+	+				+		
Carya ovata				+			+	+	
Ceanothus americanus	+					+	+	+	
Ceanothus ovatus						+	+	+	
Celastrus scandens	+			+		+	+	+	
Celtis occidentalis	+	+		+	+	+	+	+	
Cephalanthus occidentalis							+		
Cercis canadensis							+[1]		
Cissus ampelopsis							+		
Cornus asperifolia					+		+	+	+
Cornus paniculata		+			+	+	+		
Cornus stolonifera		+			+[2]				
Corylus americana		+	+	+	+	+	+	+	+
Crataegus coccinea	+		+	+			+	+	
Crataegus mollis					+	+	+	+	+
Crataegus punctata				+					
Evonymus atropurpureus	+				+		+	+	
Fraxinus americana		+	+	+			+		+
Fraxinus pennsylvanica	+				+				

[1]Also Hitchcock.
[2]Calhoun.

[15]Preliminary notes on the Flora of Western Iowa especially from the Physiographical, Ecological Standpoint. Proc. Ia. Acad. Sci. *9:* 152-180 *f. 7-18.*

[16]Wood-Using Industries of Iowa. Bull. Ia. Agr. Exp. Sta. in co-operation with U. S. Forest Service, 142: 291-300.

Name of Species	Shimek—Lyon & Sioux Counties	Macbride—Osceola & Dickinson Counties	Macbride—Cherokee & Buena Vista Counties	Macbride—Sac & Ida Counties	Shimek—Harrison & Monona Counties	Pammel—Harrison, Monona, Woodbury Counties	Fitzpatrick—Fremont County	Fitzpatrick—Pottawattamie County	Von Bayer—Fremont County
Fraxinus var. lanceolata				+		+			+
Gleditsia triacanthos				+	+	+	+		+
Gymnocladus dioica	+				+	+	+	+	
Juglans nigra	+	+	+	+	+	+	+	+	+
Juniperus virginiana		+	+[3]	+		+	+	+	+
Lonicera glaucescens					+				
Lonicera Sullivantii					+	+	+		
Menispermum canadense	+				+	+	+	+	
Morus rubra							+		
Ostrya virginiana	+	+	+	+	+	+	+	+	+
Platanus occidentalis							+		
Populus deltoides	+	+	+	+	+	+	+	+	+
Populus tremuloides		+		+					+
Prunus americana	+	+	+	+	+	+	+	+	
Prunus chicasa				+					
Prunus serotina		+	+	+			+	+	
Prunus virginiana	+	+	+	+	+	+	+	+	
Psedera quinquefolia	+			+	+	+	+	+	
Pyrus ioensis		+	+	+				+	
Quercus acuminata							+		+
Quercus macrocarpa	+	+	+	+	+	+	+	+	+
Quercus imbricaria								+[4]	
Quercus rubra		+	+	+		+	+	+	+
Quercus velutina					+[5]				+
Ribes cynosbati					+				
Ribes gracile	+			+	+	+	+	+	
Ribes floridum	+			+	+	+		+	
Ribes missouriense	+								
Rhamnus lanceolata					+	+		+	
Robinia Pseudo-Acacia				+		+		+	
Rosa blanda	+								
Rosa pratincola	+				+	+	+	+	
Rosa Woodsii					+			+	
Rhus glabra	+	+	+	+	+	+	+	+	+
Rhus Toxicodendron	+				+	+	+	+	+
Rubus allegheniensis					+				
Rubus occidentalis					+	+	+	+	
Rubus strigosus	+								
Rubus villosus							+	+	
Salix amygdaloides	+	+		+	+	+			
Salix cordata	+			+	+				
Salix discolor	+	+			+				
Salix fluviatilis	+	+		+	+	+	+	+	
Salix humilis	+				+	+			
Salix missouriensis	+				+				

[3]Cherokee.
[4]Ringgold.
[5]Logan.

Name of Species	Shimek—Lyon & Sioux Counties[17]	Macbride—Osceola & Dickinson Counties[18]	Macbride—Cherokee & Buena Vista Counties	Macbride—Sac & Ida Counties[19]	Shimek—Harrison & Monona Counties[20]	Pammel—Harrison, Monona, Woodbury Counties	Fitzpatrick—Fremont County	Fitzpatrick—Pottawattamie County	Von Bayer—Fremont County
Sambucus canadensis	+	+	+	+	+	+	+	+	
Smilax rotundifolia				+		+	+	+	
Shepherdia argentea						+			
Symphoricarpos occidentalis		+	+	+	+	+	+	+	
Symphoricarpos orbiculatus							+		
Tilia americana	+	+	+	+	+	+	+	+	+
Ulmus americana	+	+	+	+	+	+	+	+	+
Ulmus fulva	+	+	+	+	+	+	+	+	+
Ulmus Thomasii		+			+				
Virburnum Lentago	+	+	+			+			
Viburnum prunifolium				+					
Vitis cinerea							+		
Vitis vulpina	+			+	+	+	+	+	+
Zanthoxylum americana	+	+		+	+	+	+	+	

TOPOGRAPHY OF THE REGION.

The area included in this survey is drained towards the Missouri river and includes the region chiefly between Sioux City, Sioux Rapids on the north and Hamburg and Payne on the south. The ecological distribution of trees was studied more particularly in the counties of Fremont, Harrison, Buena Vista and Woodbury. The topography of the region, especially along the Missouri, is characterized by the wind swept hills or loess bluffs which border the bottom lands of the Missouri. The exposed bluffs contain few trees; towards the east, the hills are less abrupt and wind swept and consequently more trees occur.

The region is traversed by the following streams, Big Sioux, Floyd, Little Sioux, Soldier, Boyer, Nishnabotna and many smaller streams like Pigeon, Mosquito and Keg creeks.

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[17]B. Shimek in the Geology of Lyon and Sioux counties by Frank A. Wilder. Rep. Ia. Geol. Survey *10:* 157-184. Bull. Lab. Nat. Hist. State Univ. of Iowa *5:* 215.

[18]T. H. Macbride. Under the head of forestry notes of Osceola and Dickinson counties. Rep. Ia. Geol. Survey *10:* 228-239.

[19]T. H. Macbride. Geology of Sac and Ida counties. Forestry notes. Op. cit., *16:* 549-562. Part of the trees of these counties belong to the Mississippian flora.

[20]B. Shimek. Geology of Harrison and Monona counties. Botanical Report. Rep. Ia. Geol. Survey *20:* 426-485, pl. *33-39.* Shimek lists the *Celtis occidentalis* as var. *crassifolia.*

SOILS OF WESTERN IOWA.

The Bureau of Soils of the United States Department of Agriculture has made a study of the soil types in Pottawattamie county. The general account of these soils is given in the Bulletin of Bureau of Soils, The Soils of the United States.[21]

There are seven different types of soil of general distribution along western Iowa. On the low bottoms along the Missouri river there are numerous large areas of "Wabash silt clay" which is commonly known as "Gumbo." In the old lake beds there is a good deal of a fine "Sandy loam." Around some of the lakes and on sand-bars of the Missouri river there is a pure "sand." Bordering the "Gumbo" and resembling it to a certain extent but generally on slightly higher ground is found the "Wabash Silt Loam" which is a very dark and heavy soil but is not as sticky as "gumbo." On the second bottoms is found the "LaCrosse silt Loam" which is a chocolate-colored clay. This merges into a lighter colored soil called the Marshall silt Loam and a still lighter colored soil which forms the bulk of the clay bluffs along the Missouri river is the "Knox silt Loam."

Most of the timbered areas are found on the "Marshall silt loam" or the "LaCrosse silt loam." However the "sand" and "fine sandy loam" are generally characterized by a growth of *Salix fluviatilis, Salix nigra* and *Populus deltoides.* These same species are generally found on the gumbo soils with addition of *Salix missouriensis, Salix amygdaloides* and *acer saccharinum.*

The bur oak spreads beyond the usual belt of timber, often growing in clumps of two or three together. The buck brush (*Symphoricarpos occidentalis*) and common sumach usually fringe the borders of woods and often occur in patches on the slopes of hills and ravines. These shrubs undoubtedly precede the growth of trees, making humus. The under growth, especially on the edge of the forest, consists of prickly ash (*Zanthoxylum americanum*), which frequently forms thickets in the drier and more exposed places. The *Symphoricarpos occidentalis* may be common. Here too occurs the common prairie rose (*Rosa pratincola*). In woods, especially near the base of the hills in somewhat more open spaces, there is an abundance of the wild grape (*Vitis vulpina*) and the Virginia creeper (*Psedera vitacea*), while an occasional black haw (*Viburnum lentago*) is

[21]Soils of the United States. Bull. 96, Bureau of Soils, U. S. Dept. of Agriculture. Curtis F. Marbut, Hugh H. Bennett, J. E. Lapham and M. H. Lapham. 791 *f. 13, 1 pl.* 1913.

found among the timber. The poison ivy (*Rhus toxicodendron*) is common in open places in timber. The prickly gooseberry (*Ribes gracile*) is common in woods. The wild black currant (*Ribes floridum*) is common in the ravines. The willows (*Salix humulis* and *S. tristis*) are common in open high places, borders of woods. The herbaceous plants in the rich woods consist of sweet william (*Phlox divaricata*), Dutchman's breeches (*Dicentra cucullaria*), hepatica (*Hepatica acutiloba*), blue violet (*Viola cucullata*), goldenrod (*Solidago ulmifolia*), blood root (*Sanguinaria canadensis*), and blue aster (*Aster sagittifolius*). In open dry bur-oak woods are buck brush (*Symphoricarpos occidentalis*), blue aster (*Aster laevis*), ox-eye (*Heliopsis scabra*), meadow sunflower. (*Helianthus grosseserratus* and *H. Maximiliani*) on border of woods in draws.

ECONOMIC NOTES ON THE TREES.

Fremont County.—Fremont county, occupying the southwest corner of the state, presents a varied topography. On the west side of the county is the Missouri river bottom which varies in width from three to nine miles. Bordering this river bottom land are a number of bluffs which vary in height from 150 to 300 feet. These bluffs are built up largely of Missouri loess. Numerous ravines cut through the bluffs throughout the entire width of the county. The bulk of the native timber is found on the slopes of these ravines. Farther back from the Missouri river, a rolling prairie country is found.

The whole surface of Fremont county is made up of Missouri loess of considerable depth.

Up to the year 1880, both the bottom lands and bluff lands were heavily timbered. A large part of the valuable growth has been cut since this time. The present stand of timber found on the bottom land consists principally of cottonwood. The mills, which are largely dependent on this species for their output, are still in operation. The best stands of timber are found on the slopes of the ravines bordering the bottom lands. The timber consists largely of basswood, hickory, walnut, ash and elm.

The timber reproduces readily both by coppice and seed—more especially the hickory, basswood and red elm—where fires and live stock are kept out. Indications are that the forest in this region would extend itself naturally were it not for the cultivation of the fields close up to the timber. The higher points of land contain stands of bur oak which gradually change in descending the slopes to a mixture of red oak, red and white elm, shellbark hickory, honey locust, Kentucky coffee tree, black walnut, basswood and white ash.

Mills County.—Mills county borders the Missouri river and is in the second tier of counties from the south line of the state. The surface of this county is very similar to that of Fremont county. In general, the Missouri river bottom varies in width from three to seven miles. A large part of this bottom is subject to overflow during high water. As in Fremont county, a border of bluffs extends across the entire county. Back from the bluffs is a fertile, rolling, prairie country which comprises about three-fourths of the area of the county. The best timber on both bottom land and upland has been cut. Scattered areas of cottonwood are still to be found between cultivated areas. The greater part of the timber to be found in the county is in the vicinity of Glenwood. The oaks, elms, basswood, hickory, ash and black walnut are found in abundance. The timber along Nishnabotna river and its tributaries consists of a mixture of soft maple, boxelder, elm, willow, ash, cottonwood and some black walnut. The bur oak and white ash occupy the higher places; the red oak, red elm and shellbark hickory occupy the intermediate slopes; and the walnut, white elm, basswood, cottonwood and Kentucky coffee tree are found on the bottom lands. The cottonwood, green ash and soft maple are the predominating species on the bottom lands. The unrestricted grazing of live stock does a great amount of damage to the standing timber.

Pottawattamie County.—Pottawattamie county borders the Misouri river and is the third county north from the south line of the state. The topography is quite similar to that found in Mills and Fremont counties. The county is well drained by a number of small streams. The virgin stands of oak, elm, hickory, ash, walnut, cottonwood and maple have been replaced by second growth. Practically all of the timber along the Missouri river bottom has been cut. In most of the ravines which cut through the bluffs, there are to be found fine stands of young timber averaging eight to ten inches in diameter. In the neighborhood of Avoca, the principal species in the native stands were bur oak, white elm, red elm and black walnut. On the East and West Nishnabotna rivers the following were the principal species: white elm, red and bur oaks, hickory, basswood, cottonwood, white willow, black walnut, green and white ash, and hackberry.

Harrison County.—The bluff lands bordering the Missouri river in Harrison county are very much broken up by the large rivers flowing in a southwesterly direction into the Missouri river. The area back from the bluffs is an undulating prairie country. The native timber is found adjoining the watercourses and the more important species are the following: black walnut, green ash, soft maple, cottonwood, bur and red oaks, boxelder, hackberry, white willow, black willow, shellbark hickory, bitternut hickory, white and red elms, and basswood. Von Bayer also reports the white oak.

A considerable amount of planted timber is to be found in the county. The soft maple probably has been planted as much as any other species. Other trees which have been planted to a considerable extent and which are doing well, are the black walnut, cottonwood, hardy catalpa, Kentucky coffee tree, boxelder, Norway spruce, Scotch pine and green ash.

Monona County.—Monona county bounds the Missouri river and occupies the position about midway between the north and south boundaries of the state. The flood plain adjacent to the Missouri river occupies about nine per cent of the total area of the county. The remainder consists of bluffs, ridges and rolling country. On the uplands there is a considerable growth of bur oak, sumach and wolfberry. The natural growth of timber between Mapleton and Soldier consists of willow, ash, elm and bur oak. The bur oak covers considerable areas of high land. In general, the timber of the county is confined to the Missouri river and the bluffs of the Little Sioux. The timber along the Missouri is largely cottonwood, the best stands of which have been cut. The newly formed sand-bars of the river are soon covered with a growth of willows and cottonwood. In this section the flood plain is badly cut by the action of the river. A heavy stand of timber does not prevent the meandering of the stream.

In this county the cottonwood has been planted probably more extensively than any other species. Soft maple, honey locust and black walnut plantations are also frequently found.

Woodbury County.—The north part of Woodbury county is very hilly. The soil consists of the Missouri loess. Timber has been planted in the county principally for windbreaks and shelterbelts. The rapid growing species—willow, cottonwood, boxelder and soft maple—predominate. Occasionally the following species are planted: red and white cedar, Scotch pine, white pine, hardy catalpa and white elm.

ECOLOGICAL DISTRIBUTION OF TREES.

The ecological distribution of trees in the vicinity of Council Bluffs was determined on Mosquito and Pony creeks, two small streams near Council Bluffs. The soil area is the Marshall silt loam, Plot I on Mosquito creek south slope, trees from six to ten inches in diameter; Plot II, draw north slope, including a part of the bottom; Plot III, divide between two draws with slope to the west. Unless otherwise stated the area on which the percentage distribution was determined was 100 feet each way.

PERCENTAGE OF TREES, MOSQUITO CREEK, COUNCIL BLUFFS, MARSHALL SILT LOAM.

Name of Species	Plot No. 1 Percentage	Plot No. II Percentage	Plot No. III Percentage
Fraxinus americana	8.1	0	0
Ulmus americana	13.6	4.54	13.28
Ulmus fulva	13.5	9.08	13.28
Quercus rubra	10.8	11.35	4.76
Quercus macrocarpa	24.3	15.87	57.16
Ostrya virginiana	0	24 97	0
Tilia americana	10.8	24.97	0
Juglans nigra	8.1	6.81	0
Celtis occidentalis	2.7	0	0
Carya cordiformis	2.7	0	9.52
Cornus asperifolia	2.7	0	2.
Rhamnus lanceolata	2.7	0	0
Gymnocladus dioica	2.2	2.27	0

The undergrowth here was chiefly goldenrod (*Solidago ulmifolia*), blue grass (*Poa pratensis*), blue violet (*Viola cucullata*), dogwood (*Cornus asperifolia*), buckthorn (*Rhamnus lanceolata*) and some snowberry (*Symphoricarpos occidentalis*).

PERCENTAGE OF TREES, PONY CREEK NEAR COUNCIL BLUFFS, MARSHALL SILT LOAM.

Name of Species	Plot I, N. & E. slope Percentage	Plot II, N. & E. slope near ravine Percentage
Ulmus americana	41.52	15.6
Ulmus fulva	8.98	10.4
Prunus americana	1.49	------
Carya cordiformis	17.15	4.00
Prunus virginiana	16.41	------
Populus deltoides	------	5.00
Cornus asperifolia	4.47	15.6
Gymnocladus dioica	------	0
Ostrya virginiana	------	24.4
Gleditsia triacanthos	------	14.6
Crataegus mollis	1.59	10.4
Acer Negundo	2.96	------
Juglans nigra	3.00	------
Celtis occidentalis	.74	------
Tilia americana	------	------

This grove, comprising about sixty acres, is on the Crossley farm adjacent to Pony creek with a slope north and east. Plot I is on the hill side, Plot II near a draw. It was isolated from all other groves and apparently had no connection with any other forests in that region. The trees were from eight to eighteen inches in diameter. The undergrowth consisted of goldenrod (*Solidago canadensis, Solidago ulmifolia, Solidago latifolia*), buckthorn (*Rhamnus lanceolata*), snowberry (*Symphoricarpos occidentalis*), smooth gooseberry (*Ribes rotundifolium*), prickly ash (*Zanthoxylum americanum*), sunflower (*Helianthus strumosus*), black cap raspberry (*Rubus occidentalis*) undoubtedly introduced, wood thistle (*Cirsium discolor*), stickseed (*Lappula virginiana*) and dutchman's breeches (*Dicentra cucullaria*).

Percentage of Trees, Nishnabotna Valley, Near Hamburg, Iowa-Missouri Line.

Name of Species	Percentage. Plot No. 1, NE. Slope. Areas 1-14	Percentage. Plot No. 11, N. Slope. Areas 23-29	Percentage. Plot No. III, E. Slope. Areas 15-22	Percentage. Plot No. 1, Adjacent to slope, on bottoms
Ostrya virginiana...	21.7	20.99	13.76	0
Carya ovata........	1.55	0	3.50	0
Carya ovalis	5.42	1.55	10.30	0
Carya cordiformis..	6.42	3.82	0	0
Crataegus mollis...	9.52	2.32	3.44	3.9
Ulmus americana...	1.	1.55	13.70	7.7
Ulmus fulva	4.65	.775	3.50	8.5
Platanus occidentalis	0	0	0	20.2
Juglans nigra......	3.10	3.87	0	0
Morus rubra	2.22	2.22	3.40	0
Tilia americana....	5.13	2.32	17.20	0
Quercus acuminata.	4.10	3.10	3.50	0
Quercus rubra	3.10	5.42	3.44	0
Quercus macrocarpa	0	1.55	0	1.3
Fraxinus pennsylvanica var. lanceolata	1.10	0	0	19.5
Fraxinus americana.	5.50	1.55	6.88	0
Asimina triloba....	9.65	43.32	0	0
Gymnocladus dioica.	3.77	.775	0	0
Gleditsia triacanthos	1.55	.755	3.44	7.8
Cornus paniculata ..	0	0	3.55	0
Cercis canadensis...	2.55	1.55	0	0
Celtis occidentalis..	8.97	2.55	3.55	0
Acer saccharinum	0	0	0	2.3
Acer Negundo.......	0	0	0	1.3
Salix missouriensis.	0	0	0	15.6
Salix cordata	0	0	0	5.1
Salix nigra	0	0	0	1.3
Salix amygdaloides..	0	0	0	2.3
Populus deltoides .	0	0	0	3.2

On areas 1 to 14, included under plot I, northeast slope, Missouri loess, Marshall silt loam, from top of hill to bottom, the Asimina formed a thicket near the lower portion of the slope on the bank. Here too the *Carya ovalis* was abundant. In the narrow bottom *Fraxinus pennsylvanica* var. *lanceolata*, *Juglans nigra* and *Gleditsia triacanthos* occurred. In areas 23-29 included under plot II, north slope, down to Nishnabotna bottoms there were a good many thickets of the papaw, while on the slope of the hill the ironwood was one of the dominating plants. There was, however, less of *Carya ovalis* than in plot I and plot III. *Ulmus americana* and *Tilia americana* materially increased in plot III on the east slope. There were found here some old cut-over stumps of red oak. One had 85 annual rings and another 64. The areas in plot IV were taken on the bottom adjacent to the slope. This area is partly under water at times. The sycamore was plentiful and usually occurred in considerable quantities. There was some soft maple, though it was by no means a dominating tree. Adjacent to the slope was some red elm. The green ash was widely scattered over the plot. The undergrowth was mostly blue grass (*Poa pratensis*). There was an abundance of ironweed (*Vernonia fasciculata* and *V. Baldwini*), some sneezeweed (*Helenium autumnale*), morning glory (*Ipomoea hederacea*) and buck brush (*Symphoricarpos orbiculatus*). Wild grape (*Vitis vulpina*) was plentiful and an occasional *Vitis cinerea* was seen and in low places an occasional button brush (*Cephalanthus occidentalis*) was present.

PERCENTAGE OF DISTRIBUTION OF TREES, MISSOURI VALLEY, HARRISON COUNTY.

Name of Species	Plot I. Areas 1-6. Flat, second bottom, sandy	Plot II. Areas 7-10. overflow bank, Missouri river, sandy	Plot III. Rolling timber, areas 1-3, northeast slope	Plot IV. Areas 4-7, S. and E. slope	Plot V. Areas 8-10, N. slope	Plot VI. N. slope	Plot VII. Yellow loess, NW. slope
Ulmus americana	15.10	----	34.8	6.76	18.78	6	1.23
Ulmus fulva	3.02	----	1.09	8.45	26.96	6	1.23
Juglans nigra	1.51	----	15.26	41.59	44.76	2	-----
Fraxinus pennsylvanica	12.08	----	7.63	3.38	----	----	-----
Acer Negundo	3.02	----	----	----	----	----	2.46
Acer saccharinum	3.02	----	----	----	----	----	-----
Cornus asperifolia	22.65	----	----	----	----	----	-----
Gleditsia triacanthos	3.02	----	----	----	----	44	31.98
Carya ovata	3.02	----	1.09	----	----	----	-----
Carya cordiformis	----	----	2.89	----	4.76	2	-----
Crataegus mollis	4.53	----	----	10.14	----	10	2.46
Ostrya virginiana	24.16	----	30.5	10.14	----	----	-----
Celtis occidentalis	1.51	----	1.19	15.13	11.80	----	-----
Gymnocladus dioica	1.51	----	----	----	----	----	-----
Populus deltoides	0	18.6	----	----	----	----	8.61
Salix amygdaloides	0	29	----	----	----	----	-----
Salix missouriensis	0	20	----	----	----	----	-----
Salix fluviatilis	0	32.24	----	----	----	----	1.23
Salix nigra	0	----	----	----	----	----	11.07
Tilia americana	0	----	5.45	----	18.46	8	----
Quercus macrocarpa	0	----	----	11.69	2.38	20	-----
Quercus rubra	0	----	----	----	2.38	2	-----
Eleagnus hortensis var. Songorica	0	----	----	----	----	----	2.46
Prunus americana	0	----	----	----	----	----	36.90

DISTRIBUTION OF TREES IN NORTHERN BUENA VISTA COUNTY.

The following data are based on a study of the forest flora of Buena Vista county by B. L. Bradford. The study concerned itself chiefly with the trees of the Little Sioux, which is in the northern part of the county and forms a part of the Missouri river basin. The geology of this region has been discussed by Macbride.

A part of the drainage of this county is towards the Des Moines and hence towards the Mississippi; the Raccoon river belongs to the Des Moines drainage basin and the Little Sioux to the Missouri. The cutting of the Little Sioux by the enormous amount of water during the glacial times has made a well defined valley and consequently has made possible the growth of trees in the flood plain of this stream and on the hills adjacent to the stream.

There is plenty of drift material in the valley of the Little Sioux between Sioux Rapids and Linn Grove.

PERCENTAGE OF TREES, LITTLE SIOUX, SIOUX RAPIDS, BUENA VISTA COUNTY.

Name of Species	Percentage. Plot No. 1, N. slope	Percentage. Plot No. II, S. slope	Percentage. Plot No. III, E. slope	Percentage. Plot No. IV, W. slope	Percentage. Bottoms, Plot No. V
Quercus macrocarpa ..	33.3	20	23.5	25	1
Quercus rubra.........	7	4	7.5	0	0
Tilia americana	10	6	6	12	0
Acer Negundo.........	5	1	0	0	11
Acer nigrum	0	9	15	0	0
Acer saccharinum	0	0	0	0	10
Prunus americana	0	0	15	------	5
Prunus virginiana	2	0	0	------	0
Crataegus mollis	7.6	0	0	5	4
Ulmus fulva	14.1	10	5	5	4
Ulmus americana	5	15	8	12	5
Ulmus Thomasii	1	0	0	10	0
Juglans nigra	5	0	10	0	12
Salix nigra	0	0	0	0	12
Salix amygdaloides ...	0	0	0	0	11
Gymnocladus dioica ...	0	0	0	0	5
Fraxinus pennsylvanica var. lanceolata...	4	10	0	10	15
Populus deltoides......	0	0	0	0	5
Ostrya virginiana......	3	20	20	16	0
Carya cordiformis	2	5	0	10	0
Pyrus Iowensis	1	0	0	0	0

A study of the distribution of the trees shows that the bur oak (*Quercus macrocarpa*) is a dominant tree in the drier situations and in many cases is distributed with the hard maple (*Acer nigrum*), basswood (*Tilia americana*), elm (*Ulmus americana*) and slippery elm (*Ulmus fulva*). The hard maple occurred in sheltered situations on the south and east slope. The corky bark elm was locally found near the Chicago & North Western railway on a slope of a hill adjacent to the Little Sioux river. It occurs here in considerable quantity. The *Ostrya virginiana* was commonly associated with the hard maple, basswood, slippery elm and red oak.

The American plum (*Prunus americana*) formed thickets and hence the percentage runs high; these thickets occur on the edge of the timber. On the bottoms the black walnut (*Juglans nigra*) is quite unevenly distributed, in some cases making solid blocks of this species alone. The soft maple (*Acer saccharinum*) was mixed with the green ash (*Fraxinus pennsylvanica* var. *lanceolata*) and occurred on the banks of sloughs. On the shores of the stream was an abundance of black willow (*Salix nigra*) and (*Salix amygdaloides*). The more important undergrowth of the bottom consisted of blue grass (*Poa pratensis*), sneezeweed (*Helenium autumnale*), smartweed (*Polygonum lapathifolium* var. *incarnatum*), ironweed (*Vernonia fasciculata*) (*Acnida tuberculata*), northern nut grass (*Cyperus esculentus*) and such weeds as bull thistle (*Cirsium lanceolatum*) and shepherd's purse (*Capsella Bursa-pastoris*).

The distribution of trees in the region is most interesting. The trees are most abundant in the sheltered valleys. The bluffs of this region from which trees are absent are such as are exposed to the west and southwest. The tree growth is often sharply limited where wind and sun have free access. This condition is strikingly shown in figures 1 and 2, plate 33, given by Shimek in his paper on the Geology of Harrison and Monona counties.

It does not, however, follow that all of such protected areas have timber. This has been discussed by Shimek in the paper referred to, in which he says, "It is now necessary to consider the application of these results to our problem. The prairie areas are uniformly so situated that they are fully exposed to the factors which cause rapid evaporation, namely the sun and the wind. During much of the year they may present conditions quite favorable to plant growth, but there are seasons and there are portions of the year, especially in midsummer, when evaporation and consequent desiccation become so extreme that only those plants which are especially adapted to dry regions can survive. The more or less frequent recurrence of such periods which are fatal to the mesophytes of the forest is sufficient to wipe out or rather prevent the development of a forest flora on those surfaces which are most exposed to evaporation. Forest trees are perennial and must exist through all the varying conditions of succeeding seasons. Any period, no matter how short, which is fatal to trees is sufficient to prevent the development of a forest even though the greater part of each season be favorable to tree-growth, and the failure of the trees of course results in the failure of the minor forest flora which in our territory is essentially mesophytic.''[22]

ANNUAL MEAN TEMPERATURE.[23]

Station	County	Years	Degrees Fahrenheit	Altitude, feet
Sioux City	Woodbury	13	47.7	1,165
Onawa	Monona	24	32.07	1,048
Logan	Harrison	37	48.7	928
Council Bluffs	Pottawattamie	6	51.1	990
Glenwood	Mills	15	51.2	891
Thurman	Fremont	6	50.4	-----
Rock Rapids	Lyon	6	28.0	-----

TABLE SHOWING THE MINIMUM TEMPERATURE FOR JANUARY AND FEBRUARY, 1904.

Station	County	Minimum temperature for January	Minimum temperature for February
Little Sioux	Harrison..........	—16	—13
Sioux City	Woodbury	—17	—17
Pacific Junction	Mills..............	—13	— 5
Thurman	Fremont..........	—13	— 8
Le Mars	Plymouth	—19	—17
Logan	Harrison	—17	— 5

Precipitation and temperature are important factors in the growth of trees. The average precipitation as given by Sage and Chappel covering a period of years between 1890 and 1903 is shown in the following table.[24]

[22]B. Shimek. Op. cit., p. 468.

[23]Iowa section of the Climatological Service of the Weather Bureau. Annual summary, December, 1909.

[24]Iowa Weather Crop Service Rep. 1902 with appendix. App. 29.

Annual Precipitation.

Station	County	No. of years	Annual precipitation in inches
Sioux City	Woodbury	14	24.61
Onawa	Monona	24	32.07
Logan	Harrison	37	33.80
Rock Rapids	Lyon	6	23.17
Le Mars	Plymouth	7	28.70
Council Bluffs	Pottawattamie	25	32.25
Glenwood	Mills	17	28.69
Thurman	Fremont	7	40.53

The average precipitations given for the different stations do not approach each other very closely. Sioux City had only a little over twenty-four inches and the county just to the south a little over thirty-two inches, while Plymouth, just to the north, had an average of a little over twenty-eight inches. The averages are based on shorter or longer periods of years. It is probable that an average for a longer series of years would increase the precipitation for Sioux City and would decrease the average precipitation for Fremont county. It is, however, evident that the rainfall is decidedly less in northwestern than in southwestern Iowa. As to temperature Fremont and Mills counties have a higher temperature than Woodbury, Harrison and Monona counties. A difference in temperature of a few degrees during the winter months no doubt influences the distribution of certain species. A few more inches of rainfall as well as sheltered places no doubt determine the distribution of some trees. The lowest temperature reached is a more important factor than the mean. We find the lowest temperature in Fremont county in 1909 was —13°. In Sioux City it was —17° the same year and month, a difference of only 4° Fahrenheit. The records show that lower temperatures are more frequent in Sioux City than in Logan and Thurman. Attention has been called to the native occurrence of the sycamore, red bud and papaw in Fremont county. The sycamore is frequently cultivated in Missouri Valley and Sioux City where the species is perfectly hardy. The red bud is perfectly hardy in Missouri

Valley. The *Quercus acuminata* is hardy as far north as Boone county in central Iowa and Allamakee county in northeastern Iowa. Both of these places have climatic conditions much more severe than has Fremont county.

It is evident that there are other factors which enter into the distribution of trees. What all of these factors are has not been determined.

THE ORIGIN OF THE TREE FLORA.

A discussion of the trees found on the Missouri slope is of interest, especially when we consider their abundance and origin. The family *Aceraceae* contains three species, the soft maple (*Acer saccharinum*), the box elder (*Acer Negundo*) and black maple (*Acer nigrum*). These are common throughout the region. The hard maple is a northern invasion reaching the Spirit Lake and Okoboji district and as far south as Buena Vista county along the Little Sioux. Of the family *Ulmaceae*, the American elm (*Ulmus americana*) and slippery elm (*U. fulva*) are generally distributed. The corky bark elm (*Ulmus Thomasii*) is rare, reported only from the Little Sioux in Buena Vista county by Pammel and again in Harrison county by Shimek. It should occur in intervening counties.

The hackberry (*Celtis occidentalis*) is quite generally distributed. Shimek refers the form in upland woods to var. *crassifolia,* a western form. There are three ashes of the family *Oleaceae* in the region. The common white ash (*Fraxinus americana*) is a southern species which is fairly common in Fremont county but becomes less frequent near Council Bluffs, though reported by Macbride from Osceola, Dickinson, Sac and Ida counties (probably an error). From remarks made by Macbride under the species it is probable that the species recorded by him is *F. pennsylvanica* and the variety *lanceolata,* as they are common in the Spirit Lake and Okoboji region.

Of the rose family (*Rosaceae*) the choke cherry is general in the region from Fremont to Lyon counties. The same is true of the common plum (*P. americana*) or at least what is usually referred to this species by botanists. The rum or black cherry (*P. serotina*) is southern, more common in Fremont and Mills counties than in Pottawattamie. Some of the trees observed were of fairly good size. It is possible, of course, that it is an introduced species. The *P. Chicasa* was observed nowhere wild.

It sometimes is an escape. The service berry (*Amelanchier canadensis*) usually referred to this species is not common, but is reported from South Dakota opposite Woodbury county by Mrs. Taylor and from Lyon county by Shimek. The *A. spicata* occurs in the Okoboji and Spirit Lake region. Probably all of the forms on the shores of the lakes of northern Iowa should be referred to this species rather than to *A. alnifolia* of the west. The most common, if not the only haw in the region, is *Crataegus mollis*. The *C. punctata* is reported from Ida and Sac counties by Macbride. It probably occurred in the Mississippi drainage area. The *C. coccinea* is also reported; its occurrence in the northwest is doubtful. It is not common to the Missouri basin flora. It was found by one of us (Pammel) on the Little Sioux near Sioux Rapids. Of the oak family (*Fagaceae*) six species are recorded. The most common and widely distributed is the bur oak (*Quercus macrocarpa*) which occurs from Fremont to Lyon counties. The var. *olivaeformis* which one of us recorded (Pammel) is probably only a form of *Q. macrocarpa*. The *Q. rubra* occurs from Fremont to Dickinson counties but is nowhere common except southwest. Evidently it is an invasion from the south. The *Q. velutina* recorded by Shimek is very local in Harrison county near Logan. The chestnut oak (*Quercus acuminata*) occurs in Fremont county. It will also be found probably in Mills county. The *Q. imbricaria* though not observed by us, is said to occur in Fremont county. The only tree representative of the family *Betulaceae* is the ironwood (*Ostrya virginiana*) which is fairly common in the region, perhaps more abundant southward than northward. Of the family *Salicaceae* there is only one poplar common, namely the Cottonwood (*Populus deltoides*). The quaking aspen (*P. tremuloides*) is reported from Osceola, Dickinson, Sac and Ida counties. Here the species belongs in part to the Mississippian flora. A part of these counties are drained to the Mississippi and a part to the Missouri. It has been reported from Fremont county by von Bayer, from Ringgold and Union counties by the Fitzpatricks. It also occurs in the Lake Okoboji region though it is not common. These belong to the Missouri basin. Of the willows the *S. amygdaloides* and *S. nigra* and *S. fluviatilis* are common in the region. The *S. amygdaloides* and *S. nigra* belong to the southern flora. The *S. missouriensis* belongs to the west and south. The *S. cordata* and *S. discolor* are northern. The *Tilia* *americana* of the family *Tiliaceae* is common throughout the entire region.

Of the *Leguminosae* there are three native species; the coffee bean (*Gymnocladus dioica*), the honey locust (*Gleditsia triacanthos*) and the red bud (*Cercis canadensis*), the latter of which occurs in Fremont county. The three species are, of course, southern. The black locust (*Robinia pseudacacia*) is widely naturalized. The sycamore (*Platanus occidentalis*) of the family *Platanaceae* is common in Fremont county; but probably does not extend much beyond this county. Of the family *Juglandaceae* the black walnut (*Juglans nigra*) is the most widely distributed, and extends from Fremont to Lyon counties, but is more common in the south than in the north. The pignut (*Carya cordiformis*) is common from Fremont county to the Okoboji and Spirit Lake region. Macbride reports *C. ovata* from Sac and Ida counties. It occurs in Fremont county. There are no localities reported between Fremont, Sac and Ida. Probably it is rare and belongs to the Mississippian flora of those counties. The dogwoods (*Cornaceae*) have been somewhat puzzling. The most widely distributed species is the *C. asperifolia*. This is common everywhere in the loess bluffs. The *C. amomum*, with brownish branches and pale blue fruit, occurs in the region but is rare. *C. stolonifera* is reported from Dickinson and Osceola counties and from Calhoun county by Macbride. One of us has seen it on the shores of Iowa Lake. This locality belongs to the Mississippian flora. It is probably a mistaken identification.

Fitzpatrick expresses considerable doubt as to the occurrence of *Quercus velutina* in western Iowa. We have not seen the species, though it was reported by Shimek from Harrison county. The *Celtis occidentalis* var. *reticulata* we think should be referred to *C. occidentalis*. The variety *pubescens* of *Ceanothus ovatus* we believe is the species. *Prunus chicasa* is certainly not native; it probably is an escape. Boot reports *Carya glabra* and the variety *villosa*. We believe this to be *C. cordiformis*. The occurrence of *Lonicera Sullivantii* reported by Shimek and Fitzpatrick is out of its range, since it does not occur in central Iowa where one would expect to find it with other northern plants. *Rosa woodsii*, reported also by the same observers, is similarly interesting since this is a northern species.

CATALOGUE OF TREES AND SHRUBS.

In the following catalogue we have omitted the localities given by Fitzpatrick, Shimek and Macbride. They are not generally recorded in this list because the localities appear in a separate table.

We have generally used the initials of the collectors as follows: LHP—L. H. Pammel, Rose Schuster Taylor—RST, HBC—H. B. Clark, LHP and HBC—L. H. Pammel and H. B. Clark.

The species listed are generally represented by specimens. We are indebted to Professor C. S. Sargent for verification of some species and to Mr. C. R. Ball for the verification of some of the willows.

GYMNOSPERMÆ.

PINACEÆ Pine Family.

Pinus sylvestris L. Scotch Pine. Sioux City 10 (RST).

Pinus austriaca Höss. Austrian Pine. Commonly cultivated. Sioux City.

Pinus Strobus L. White Pine. Commonly cultivated. Sioux City, Whiting, Missouri Valley.

Larix decidua Nutt. European Larch. Cultivated. Whiting, Sioux City, etc.

Picea Parryana Sarg. Colorado Blue Spruce. Sioux City 20 (RST). Cultivated.

Picea canadensis (Nutt) B. S. P. White Spruce. Cultivated. Whiting.

Picea Abies (L.) Karst. Norway Spruce. Cultivated. Sioux City, Whiting, Missouri Valley.

Abies balsamea (L.) Mill. Balsam Fir. Cultivated. Whiting, etc.

Tsuga canadensis (L.) Carr. Hemlock. Cultivated. Whiting, etc.

Thuja occidentalis Linn. American Arbor Vitae. Cultivated. Whiting, Sioux City.

Juniperus virginiana L. Red Cedar. Native near Sioux City and commonly cultivated there (HBC).

Juniperus horizontalis Moench. Juniper. Cultivated. Whiting.

SALICACEÆ Willow Family.

Salix amygdaloides Anders. Peach leaved Willow. Sioux City 17 (HBC), 2 (RST), Missouri Valley (HBC), Council Bluffs (HBC & LHP), Payne (HBC & LHP), Oto 29 (HBC), Whiting (LHP & HBC). Along streams.

Salix alba L. White Willow. Commonly cultivated in western Iowa. Missouri Valley (HBC), Whiting (LHP & HBC).

Salix babylonica L. Weeping Willow. Cultivated. Sioux City, Whiting, Missouri Valley.

Salix cordata Muhl. Pussy Willow. Hamburg 37 (HBC & LHP), Sioux City (HBC), Whiting 5 (LHP & HBC).

Salix fluviatalis Nutt. Sandbar Willow. Sioux City (HBC), Missouri Valley (HBC), Council Bluffs 51 (LHP & HBC), Oto 29 (HBC), Whiting 36 (LHP & HBC), Payne 69 (HBC & LHP), Hamburg 43 (HBC & LHP). Common along streams and on sandbars.

Salix missouriensis Bebb. Diamond Willow. Sioux City 8 (HBC), 16, 17 (LHP & RST), Payne (LHP & HBC), Council Bluffs 20, 5 (LHP & HBC).

Populus deltoides Marsh. Cottonwood. Sioux City (HBC) 8, 14 (RST), Council Bluffs 52 (LHP & HBC), Missouri Valley (HBC), Whiting 10 (LHP & HBC). The cottonwood is common everywhere from Hawarden to Hamburg, not only in bottoms but in the ravines of the hills and on the bluffs. The *P. Sargentii* which is said to occur in Nebraska has not been found in Iowa. The cottonwood is an extremely variable tree. Near Hawarden on the Big Sioux one of us counted 160 annual rings on a cottonwood. Large trees five feet in diameter occur near Sioux City.

Populus alba L. White Poplar, Abele. Commonly cultivated in western Iowa. Sioux City 16 (RST), Missouri Valley, Hamburg, etc. Commonly spreads from suckers.

Populus nigra Linn. var. *italica* Du Roi. Lombardy Poplar. Commonly cultivated but not entirely hardy. Council Bluffs 53 (LHP & HBC).

Populus tremuloides Michx. Quaking Aspen. Reported from Fremont and Mills counties by Von Bayer. However not represented by specimens in the collection. This species occurs at Lake Okoboji, not, however, common. The Fitzpatricks record it from Ringgold and Union counties.

JUGLANDACEÆ Walnut Family.

Carya ovata (Mill.) K. Koch. Shell bark hickory. Hamburg (LHP & HBC), Payne (LHP & HBC). Not common in Iowa.

Carya ovalis Sargent. Hamburg (HBC), Payne (HBC & LHP).

Carya cordiformis (Wang.) K. Koch. Pignut. Payne (LHP & HBC), Council Bluffs 41 (LHP & HBC), Missouri Valley (HBC), Oto 42 (HBC), Hamburg 22 (LHP & HBC), Sioux City 5 (HBC). This species is distributed much farther north than the shellbark hickory. It is reported from Sioux Rapids on the Little Sioux by L. H. Pammel.

Juglans nigra L. Black Walnut. Oto 31 (HBC), Sioux City 24, 3, 23 (HBC), Council Bluffs (HBC & LHP), Payne (LHP & HBC), Sioux Rapids (LHP). Common in bottoms.

Juglans cinerea L. Butternut. Cultivated. Missouri Valley (HBC).

BETULACEÆ. Birch Family.

Corylus americana Walt. Hazelnut. Oto 10 (HBC), Sioux City 7 (HBC), Missouri Valley (HBC), Council Bluffs (LHP & HBC), Payne (LHP & HBC). The hazelnut is more common in southwestern Iowa than northward.

Ostrya virginiana (Mill.) K. Koch. Hop Hornbean. Oto 46 (HBC), Sioux City 6 (HBC), Hamburg 28 (LHP & HBC), Logan (LHP), Council Bluffs 55 (LHP & HBC), Missouri Valley (HBC), Payne (LHP & HBC), Sioux Rapids (LHP). More common southward than northward. In protected ravines.

Betula alba L. White Birch. Commonly cultivated. Sioux City, Whiting, Missouri Valley.

Castanea dentata (Marsh) Borkh. Chestnut. Cultivated. Whiting, scarcely hardy here. Also cultivated southwestern Iowa and hardy.

FAGACEÆ Oak Family.

Quercus macrocarpa Michx. Bur Oak. Sioux City 11 (RST & LHP), Hitchcock (LHP), Oto 36, 22, 40 (HBC), Payne (LHP & HBC), Missouri Valley 21, 73 (HBC), Council Bluffs 82 (LHP & HBC), Hawarden (LHP).

Quercus alba L. White Oak. Frank C. Pellett reports it from Cass county. Specimens have not been seen by us. This is also reported from Harrison county by Von Bayer.

Quercus acuminata Houba. Chestnut Oak. Equals Q. *Muhlenbergii* Engelm. Gray's Manual 7th Ed., p. 341, *f. 676*. Hamburg 1 (HBC), 7, 8, 11 (LHP & HBC), Payne (LHP & HBC). The leaves of this species are extremely variable, some quite narrow lanceolate to oblong. In No. 8 the leaves are obovate, suggesting the *Q. Michauxii.* The specimen with broad leaves comes from a tree all of which had broad leaves. The *Q. Michauxii* occurs in Missouri and southward. The chestnut oak occurs on the low hillside or even on the banks of small streams of the small valleys.

Quercus rubra L. Red Oak. Oto 44 (HBC), Sioux City 4 (HBC), Hamburg 10 (LHP & HBC), Payne (LHP & HBC), Sioux Rapids (LHP), Council Bluffs 81 (LHP & HBC), Missouri Valley (HBC). The red oak is not common in western Iowa, more common southwest than northward. There are some nice groves on the shady slopes near Council Bluffs.

Quercus velutina Lam. Black Oak. Quercitron oak. Logan. Reported by Shimek. We have not seen it. This species occurs in Story county but is a rare tree. The occurrence here is of great interest.

Quercus imbricaria Michx. Shingle Oak. This is reported near Sidney but we have not seen specimens.

ULMACEÆ Elm Family.

Ulmus Americana L. American Elm. Sioux Rapids (HBC), Oto 26 (HBC), Sioux City (LHP), Whiting (LHP & HBC), Payne (LHP & HBC), Hamburg 34 (LHP & HBC), Missouri Valley 9, 70, 78 (HBC), Sioux Rapids (LHP), Council Bluffs 27 (LHP & HBC). The most common elm along the Missouri.

Ulmus fulva Michx. Red Elm. Missouri Valley 7, 19, 78 (HBC), Hamburg, Payne, Sioux City (LHP & HBC), 15 (LHP & RST), Sioux Rapids (LHP), Council Bluffs 28 & 44 (LHP & HBC). On the loess bluffs.

Ulmus racemosa Thomas. Cork or Rock Elm, Sioux Rapids (LHP). A small grove near Sioux Rapids on a bluff near the C. & N. W. Ry. east of the city. It is apparently not common anywhere in the region. Also reported by Prof. Shimek from Harrison county, and Frank Pellett states it is reported in Cass county. This locality is not based on specimens.

Celtis occidentalis L. Hackberry. Oto 45 (HBC), Hamburg (LHP & HBC), Payne (LHP & HBC), Sioux City (HBC), Sioux Rapids (LHP), Council Bluffs 39, 58 (LHP & HBC), Missouri Valley (HBC). Common in ravines and on the slopes of loess bluffs.

Maclura pomifera (Raf.) Schneider. Osage Orange. Hamburg, an escape. Commonly cultivated. Not entirely hardy northward.

Morus rubra L. Red Mulberry. Hamburg (LHP & HBC), Council Bluffs 45 (LHP & HBC), Payne (LHP & HBC). Not common. In ravines.

Morus alba L. var. *tatarica* Loudon. Russian Mulberry. Hamburg 14 (LHP & HBC). Council Bluffs 21 (LHP & HBC). Escaped from cultivation. Not common in western Iowa.

MAGNOLIACEÆ Magnolia Family.

Magnolia acuminata L. Cucumber Tree. Occasionally cultivated southward.

Liriodendron tulipifera L. Tulip Tree. Occasionally cultivated.

CALYCANTHACEÆ Strawberry Bush Family.

Calycanthus laevigatus Willd. Strawberry Bush or Sweet Scented Shrub. Occasionally cultivated southward.

ANONACEÆ Papaw Family.

Asimina triloba Dunal. Common papaw. Hamburg 6 (LHP & HBC), Payne 25 (LHP & HBC). The papaw is common in edge of thickets, loess bluffs, usually up in the ravines.

MENISPERMACEÆ Moonseed Family.

Menispermum canadense L. Moonseed. Hamburg (LHP & HBC), Sioux City (Bandusia Wakefield).

BERBERIDACEÆ Barberry Family.

Berberis vulgaris L. Common Barberry. Hamburg, Payne, Sioux City (LHP & HBC). Occasionally an escape. Red tinted leaved form also cultivated.

Berberis Thunbergii DC. Red Fruited Barberry. Commonly cultivated.

SAXIFRAGACEÆ Gooseberry Family.

Philadelphus coronarius L. Common Mock Orange. Commonly cultivated. Sioux City, Whiting, Council Bluffs, Hamburg.

Ribes gracile Michx. Gooseberry. Missouri Valley (LHP), 11 (HBC), Sioux Rapids (LHP).

Ribes Grossularia L. European Gooseberry. Commonly cultivated.

Ribes floridum L'Her. Wild Black Currant. Sioux City (LHP), Sioux Rapids (LHP).

Ribes rubrum L. Garden Currant. Commonly cultivated.

Ribes aureum Pursh. Golden Currant. Commonly cultivated for ornamental purposes, also an escape. Hamburg, Council Bluffs, Logan, Payne.

PLATANACEÆ Sycamore Family.

Platanus occidentalis L. Sycamore. Sioux City 21 (RST) cultivated, Hamburg 40 (LHP & HBC), Payne (LHP & HBC). Low alluvial bottoms; some large trees on the bottom lands near Hamburg, also on the banks of the Missouri near Payne. The species apparently does not extend much north of Fremont county.

ROSACEÆ. Rose Family.

Physocarpus opulifolius (L.) Maxim. Nine-bark. Cultivated. Whiting, Council Bluffs.

Spiraea trilobata L. Bridal Wreath. Cultivated. Known as *S. Van Houttei*.

Spiraea Thunbergii Sieb. Bridal Wreath, Spiraea. Commonly cultivated. Sioux City, Hamburg, Missouri Valley, Sioux Rapids, etc.

Spiraea Japonica L. Cultivated. Whiting.

Pyrus communis L. Pear. Cultivated. Council Bluffs, Hamburg, Payne, etc.

Pyrus baccata L. Siberian Crab. Commonly cultivated.

Pyrus prunifolia Willd. Crab. A variable group of hybrids. The so-called crab apples. Commonly cultivated.

Pyrus ioensis (Wood) Bailey. Wild Crab. Not common in western Iowa, Hamburg, Sioux Rapids (LHP).

Pyrus malus L. Apple. Commonly cultivated. Also a hybrid group, in all probability.

Pyrus Aucuparia L. Ehrh. European Mountain Ash. Commonly cultivated for ornamental purposes, Sioux City, Missouri Valley.

Amelanchier spicata (Lam.) C. Koch. This occurs in the lake region but we have not seen it southward.

Amelanchier canadensis (L.) Medic. Mrs. Rose Schuster Taylor reports it on the Big Sioux in South Dakota near Sioux City.

Crataegus mollis (T. G.) Scheele. Sioux City 11 (HBC), 9 (RST), Oto 28 (HBC), Missouri Valley 5, 18 (HBC), Hamburg 21 (HBC & LHP), Sioux City (LHP), Crescent 3411 (D. B. Baker), Turin (LHP), Sioux Rapids (LHP), Council Bluffs 29 (LHP & HBC), Payne (LHP & HBC). This species is common in the region and apparently the only haw found here.

Rubus idaeus L. var. *aculeatissimus* (C. A. Mey.) Regel & Tiling. Commonly cultivated.

Rubus neglectus Peck. Shaffer. Raspberry. This is a hybrid between the red and black cap raspberries. Commonly cultivated.

Rubus occidentalis L. Black cap Raspberry or Thimbleberry. Sioux City (Bandusia Wakefield), Council Bluffs 50 (LHP & HBC), Missouri Valley 10 (HBC), Sioux Rapids (LHP). Apparently native. Commonly cultivated.

Rubus villosus Ait. High Bush Blackberry. Commonly cultivated and an escape. Hamburg, Sioux City. Sometimes creeping.

Rosa setigera Michx. Prairie Queen Rose. Cultivated.

Rosa rubiginosa L. Sweet Brier. Commonly cultivated.

Rosa centifolia L. Cabbage Moss Rose. Cultivated.

Rosa sulphurea Ait. Yellow Rose. Cultivated.

Rosa rugosa Thumb. Japanese Rose. Cultivated.

Rosa pratincola Greene. Wild Rose. Sioux City (LHP & Bandusia Wakefield), Hamburg, Sioux Rapids (LHP), Missouri Valley (LHP), 12 (HBC). Common. The state flower.

Prunus serotina Ehrh. Wild Black or Rum Cherry. Payne (LHP & HBC). Some small trees apparently indigenous. Hamburg 20 (LHP & HBC). Apparently indigenous. Small trees. Council Bluffs 22, 49 (LHP & HBC), Missouri Valley (HBC). Small trees in woods. None of the trees observed were more than four inches in diameter.

Prunus virginiana L. Choke Cherry. Sioux City 20 (HBC), (LHP), Hamburg (LHP & HBC), Oto, Missouri Valley 20 (HBC), Payne (HBC & LHP), Council Bluffs (LHP & HBC). Common in all of the ravines.

Prunus Padus L. May Day Tree. Cultivated. The earliest of the blooming choke cherries of Europe. Sometimes escaped, most closely allied to the Wild Choke Cherry. So called in Europe because blooming about the first of May.

Prunus hortulana Bailey. Wild Goose Plum. Commonly cultivated and an escape.

Prunus Chicasa Michx. Chickasaw Plum. Commonly cultivated.

Prunus pumila L. Sand cherry. Council Bluffs (LHP), 18 (LHP & HBC), Payne (LHP & HBC), Sioux City (LHP) on sand bars.

Prunus Cerasus L. Sour Cherry. Commonly cultivated from Hawarden to Hamburg. Frequent escape.

Prunus Avium L. Sweet Cherry. Cultivated. Scarcely hardy northward.

Prunus Americana Marsh. Wild Plum. Oto 35 (HBC), Hamburg 2 (LHP & HBC), Sioux City (HBC), Hawarden (LHP), Council Bluffs (LHP & HBC), Sioux Rapids (LHP), Missouri Valley (HBC), Payne (LHP & HBC). Thickets in ravines.

Prunus triflora Roxb. Japan Plum. Cultivated southward.

Prunus domestica L. European Plum. Commonly cultivated.

Prunus persica L. Stokes. Peach. Cultivated southward. Hamburg, Payne, etc.

Prunus armeniaca L. Common Apricot. Cultivated southward.

Prunus japonica Thunb. Japan Flowering Almond. Commonly cultivated.

LEGUMINOSÆ Pea Family.

Gymnocladus dioica (L.) Koch. Coffee Bean. Sioux City 15 (HBC), 12 (RST), Oto 38 (HBC), Missouri Valley 824 (HBC), Hamburg 32 (LHP & HBC), Sioux Rapids (LHP), Payne (LHP & HBC), Council Bluffs 26 (LHP & HBC). Common bottoms of streams.

Gleditsia triacanthos L. Honey Locust. Hamburg (LHP & HBC), Payne (LHP & HBC), Sioux City (Bandusia Wakefield), Council Bluffs 25 (LHP & HBC), Missouri Valley 6 (HBC). Two forms, one with young pods pubescent and the other with smooth pods.

Amorpha fruticosa L. False Indigo. Hawarden (LHP). Swamp.

Amorpha canescens Nutt. Lead Plant. Hamburg 18 (LHP & HBC). Common loess bluffs.

Cersis canadensis L. Redbud. Hamburg 31, Payne (LHP & HBC). Side slope of hills, border of thickets. Cultivated. Council Bluffs (LHP & HBC).

Robinia Pseudacacia L. Black Locust. Sioux City 16 (HBC), 19 (RST), Missouri Valley 71 (HBC).

Wisteria frutescens (L.) Poir. Wisteria. This handsome woody climber is frequently cultivated.

Caragana arborescens Lam. Siberian Pea Tree. Occasionally cultivated.

RUTACEÆ Rue Family.

Zanthoxylum americanum Mill. Prickly Ash. Oto 34 (HBC), Sioux City 23 (HBC), Payne (HBC & LHP), Missouri Valley 79 (HBC), Council Bluffs 57 (LHP & HBC), Hamburg 30 (LHP & HBC), Sioux City. Thickets in ravines. Common.

SIMARUBACEÆ Quassia Family.

Ailanthus glandulosa Desf. Tree of Heaven. Occasionally cultivated but an undesirable tree. Council Bluffs.

ANACARDIACEÆ Sumach Family.

Rhus glabra L. Smooth Sumach. Sioux City 5, 13 (HBC), Oto 41 (HBC), Missouri Valley (HBC), Council Bluffs 54 (LHP & HBC). Abundant in loess bluffs.

Rhus Toxicodendron L. Poison Ivy. Poison Oak. Common everywhere in thickets from Lyon to Fremont counties.

CELASTRACEÆ Staff Tree Family.

Evonymus atropurpureus Jacq. Wahoo. Burning Bush. Sioux City (LHP) (HBC), Plymouth county, Payne (LHP & HBC), Missouri Valley (HBC) (Olive F. Brown). Common in ravines.

Celastrus scandens L. Climbing Bitter-sweet. Sioux City (LHP), Hamburg 15 (LHP & HBC). Common in thickets.

STAPHYLEACEÆ Bladder Nut Family.

Staphylea trifolia L. American Bladder Nut. Sioux City (Bandusia Wakefield). Not common. In ravines.

ACERACEÆ Maple Family.

Acer nigrum Michx. Black Hard Maple. Cultivated in Sioux City, Whiting, Missouri Valley, Hamburg, and other places in western Iowa. The species is native about Sioux Rapids and Lake Okoboji (LHP).

Acer platanoides L. Norway Maple. Frequently cultivated.

Acer saccharinum L. Soft Maple. Sioux City 5, 8 (HBC), 6 (RST), Oto 27 (HBC), Hamburg 13, 35 (LHP & HBC), Missouri Valley (HBC), Payne (LHP & HBC), Council Bluffs 48 (LHP & HBC).

Acer Negundo L. Box Elder. Sioux City 7, 8 (HBC), 20 (RST), Hamburg 24, 32 (HBC & LHP), Sioux Rapids (LHP), Payne (LHP & HBC), Council Bluffs 9, 53 (LHP & HBC), Missouri Valley (HBC). Common everywhere. Its area is greatly extended because of the abundance of seed and ease with which it germinates. The form with purplish branches is common.

SAPINDACEÆ Buckeye Family.

Aesculus glabra Willd. Ohio Buckeye. It is rather strange that the Ohio buckeye is not native along the Missouri, since it occurs in central Iowa. Occasionally cultivated.

Aesculus Hippocastanum L. Common Horse-chestnut. Frequently cultivated. Missouri Valley, Council Bluffs, Hamburg.

RHAMNACEÆ Buckthorn Family.

Rhamnus lanceolata Pursh. Wild Buckthorn. Sioux City 4 (HBC), Sioux City (Bandusia Wakefield), Council Bluffs 47 (LHP & HBC).

Rhamnus cathartica L. Common Buckthorn. Cultivated as a hedge plant. Council Bluffs and Hamburg.

Ceanothus americanus L. New Jersey Tea. Turin (LHP), Sioux City (Bandusia Wakefield). Common over the loess bluffs.

Ceanothus ovatus Desf. Red Root. Council Bluffs (LHP), Turin, Missouri Valley (LHP), Hamburg (LHP & HBC).

VITACEÆ Grape Family.

Psedera quinquefolia (L.) Greene. Virginia Creeper. Woodbine. Hamburg, Payne, Missouri Valley (LHP & HBC), Turin, Whiting (LHP), Sioux City (Bandusia Wakefield). Common everywhere in western Iowa. With adhesive disks.

Psedera quinquefolia (L.) Greene var. *hirsuta* (Donn.) Rehder. This form has pubescent leaflets and tendrils, at least when young, and also aerial rootlets. Hamburg (LHP & HBC).

Psedera vitacea (Knerr) Greene. Virginia Creeper. This form rarely has adhesive disks, tendrils with twining branches. Payne (LHP & HBC), Sioux Rapids (LHP).

Vitis cinerea Engelm. Sweet Winter Grape. Hamburg 1 (LHP & HBC). Iowa-Missouri line. This was found abundantly on the flat at the base of one of the little hills. It has evidently reached its northern distribution at this point.

Vitis labrusca L. Northern Fox Grape. Cultivated only. The Concord, Worden, etc. Hamburg, Payne, Council Bluffs, Turin, Whiting, Sioux City.

Vitis vulpina L. Wild Grape. Frost Grape. Hamburg, Payne, Whiting (LHP & HBC), Missouri Valley (HBC), Sioux City, Turin (LHP), Sioux Rapids (LHP), Council Bluffs 51 (LHP & HBC).

Vitis vulpina L. var. *praecox* Bailey. Early Wild Grape. Hamburg 5 (LHP & HBC), Iowa-Missouri line. The grapes were turning color on July 5, 1914.

TILIACEÆ Basswood Family.

Tilia americana L. Basswood. Sioux City 12 (HBC) 13 (RST) 11 (LHP & RST), Oto 8, 11 (HBC), Hamburg 23 (LHP & HBC), Payne (LHP & HBC), Missouri Valley (HBC), Council Bluffs 56 (LHP & HBC), Sioux Rapids (LHP). The basswood is common in all of the ravines.

ELEAGNACEÆ Oleaster Family.

Eleagnus hortensis Bieb. var. *Songorica* Bernh. Russian Olive. Oleaster. Commonly planted. Whiting, Sioux City (LHP & HBC), Missouri Valley 3 (HBC).

Shepherdia argentea Nutt. Buffalo Berry. Sioux City 15 (RST) 13 (LHP & RST). Big Sioux and Missouri river bottoms.

CORNACEÆ Dogwood Family.

Cornus asperifolia Michx. Dogwood. Sioux City 4 (RST) 4 (HBC), Oto 8 (HBC), Sioux City (LHP), Little Rock (C. R. Ball), Missouri Valley (HBC), Council Bluffs 46 (LHP & HBC), Payne (LHP & HBC), Whiting 2 (LHP & HBC). Common on the loess bluffs, ravines, border of thickets.

Cornus Amomum Mill. Dogwood. Nebraska City, Nebraska, in grove, Arbor Loge. It was not observed on the Iowa side, probably introduced.

Cornus sanguinea L. Dogwood. Occasionally cultivated.

OLEACEÆ Ash Family.

Fraxinus pennsylvanica Marsh. Red Ash. Sioux City 1 (RST) (HBC), Little Rock (C. R. Ball), Payne, Hamburg (LHP & HBC)), Missouri Valley 50, 80 (HBC).

Fraxinus pennsylvanica Marsh var. *lanceolata* (Borkh.) Sarg. Green Ash. Sioux City 2, 9 (HBC) 12 (LHP & RST), Hamburg 36 (RST) (LHP & HBC), Oto 32 (HBC), Sioux City, Turin, Sioux Rapids (LHP), Whiting, Payne (LHP & HBC), Missouri Valley (HBC), Council Bluffs (LHP & HBC). Common throughout this region.

Fraxinus americana L. White Ash. Hamburg 26 (LHP & HBC), Council Bluffs 24 (LHP & HBC), Payne (LHP & HBC). This ash is much more common near Hamburg than near Council Bluffs.

Forsythia viridissima Lindl. Forsythia. Occasionally cultivated.

Syringa vulgaris L. Common Lilac. Commonly cultivated.

Syringa persica L. Persian Lilac. Occasionally cultivated. Council Bluffs (LHP & HBC).

Ligustrum vulgare L. Privet. Cultivated in southwestern Iowa.

SOLANACEÆ Nightshade Family.

Lycium halimifolium Mill. Matrimony Vine. Cultivated and hardy. Council Bluffs, Missouri Valley. Occasionally escaped from cultivation in Missouri Valley, Hamburg, etc.

BIGNONIACEÆ Catalpa Family.

Tecoma radicans (L.) Juss. Trumpet Creeper. Apparently not native; occasionally cultivated in southwestern Iowa.

Catalpa speciosa Warder. Hardy Catalpa. Commonly cultivated in western Iowa. Sioux City 17 (RST), Hamburg (LHP & HBC), Missouri Valley (HBC).

Catalpa Kaempferi Sieb and Zucc. Japanese Catalpa. Cultivated. Sioux City.

RUBIACEÆ. Madder Family.

Cephalanthus occidentalis L. Button Bush. Hamburg (HBC & LHP), Payne (LHP & HBC). Lowlands subject to overflow.

CAPRIFOLIACEÆ Honey Suckle Family.

Lonicera tatarica L. Tartarian Honey Suckle. Commonly cultivated from Hamburg to Sioux City, also an escape.

Lonicera sempervirens L. Trumpet Honey Suckle. Commonly cultivated.

Lonicera Sullivantii Gray. Yellow Honey Suckle. Reported from Fremont county (Fitzpatrick) and Harrison county (Shimek).

Symphoricarpos occidentalis Hook. Snow Berry. Oto 37 (HBC), Sioux City (LHP), Missouri Valley (HBC), Hawarden (LHP), Turin (LHP), Woodbury county 3896, 4170 (Olive F. Brown), Hamburg 17 (LHP & HBC), Sioux Rapids (LHP), Council Bluffs 40 (LHP & HBC). Common everywhere in western Iowa.

Symphoricarpos orbiculatus Moench. Buck Brush. Coral-berry. Indian Hemp. Hamburg 12 (LHP & HBC), Payne (LHP & HBC), Council Bluffs 54 (LHP & HBC). Common everywhere in southwestern Iowa.

Viburnum Opulus L. Snowball. Commonly cultivated.

Viburnum Lentago L. Sheepberry. Wild Raisin. Council Bluffs 19 (LHP & HBC).

Sambucus canadensis L. Common elder. From Fremont to Lyon counties, Sioux City (HBC).

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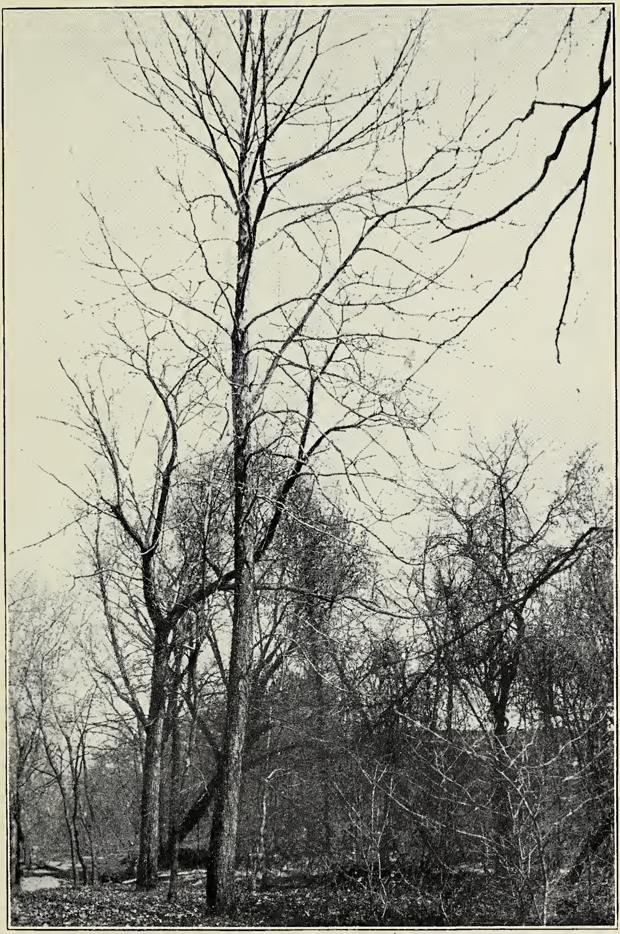
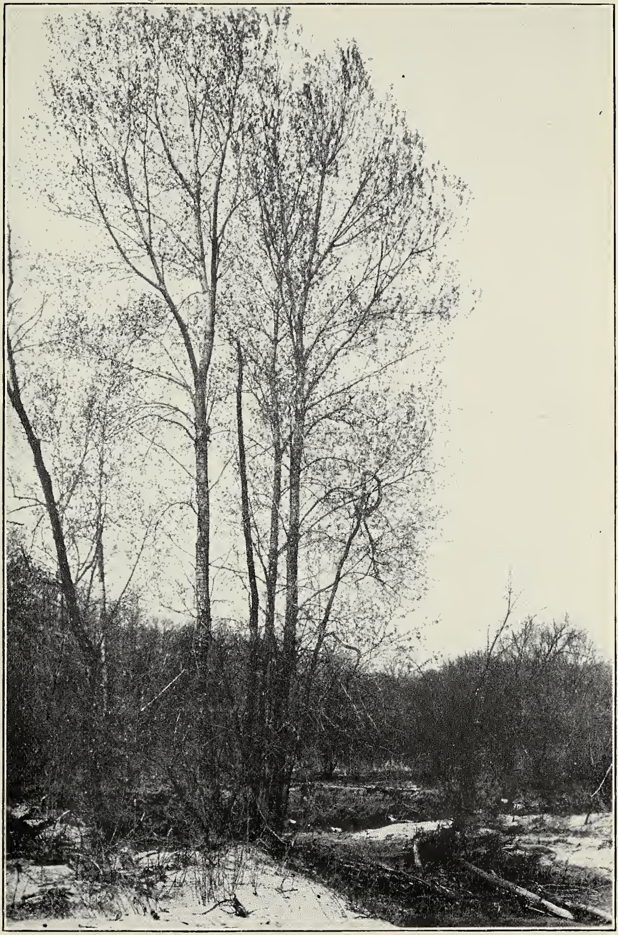
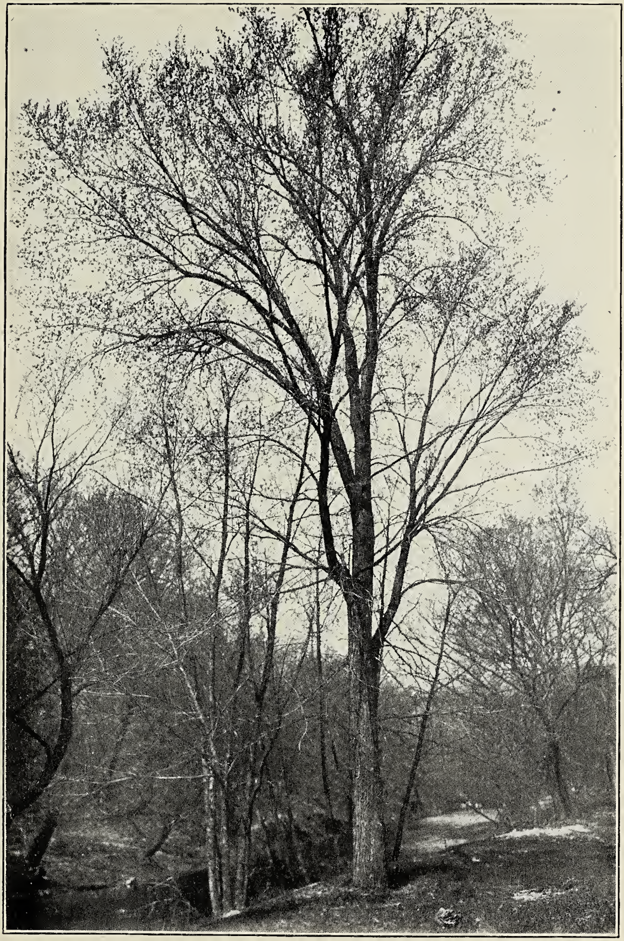


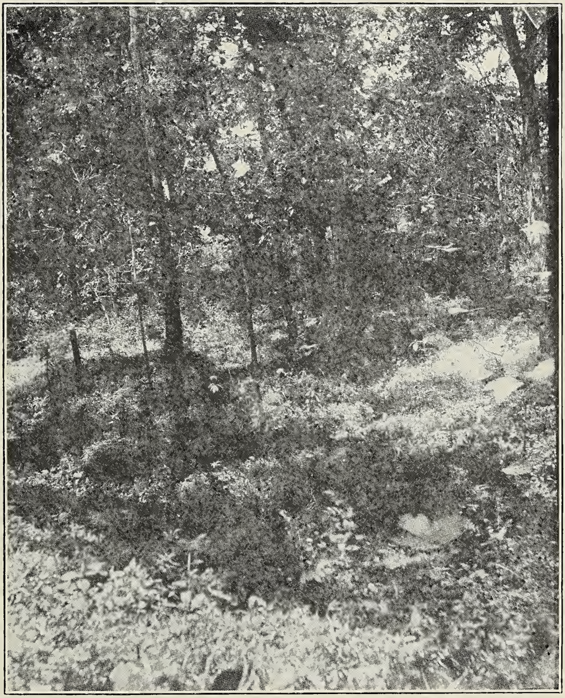
Sycamore (*Platanus occidentalis*). Photographed G. B. MacDonald.



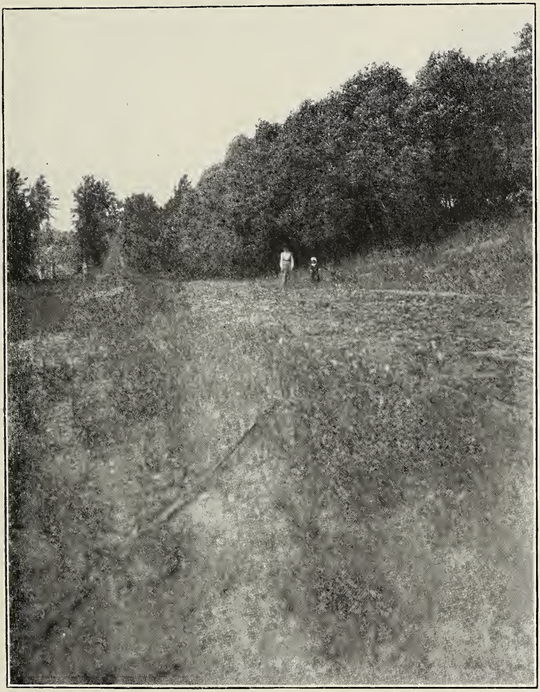
Cottonwood (*Populus deltoides*). Photographed, G. B. MacDonald.



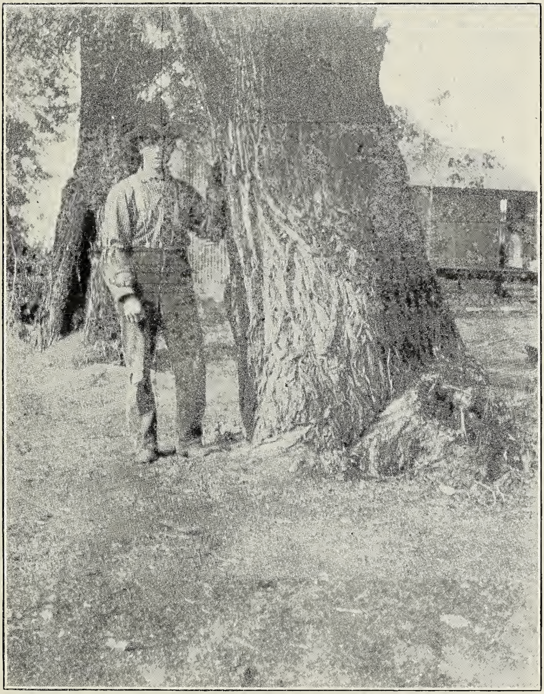
American Elm (*Ulmus americana*). Photographed,
G. B. MacDonald.



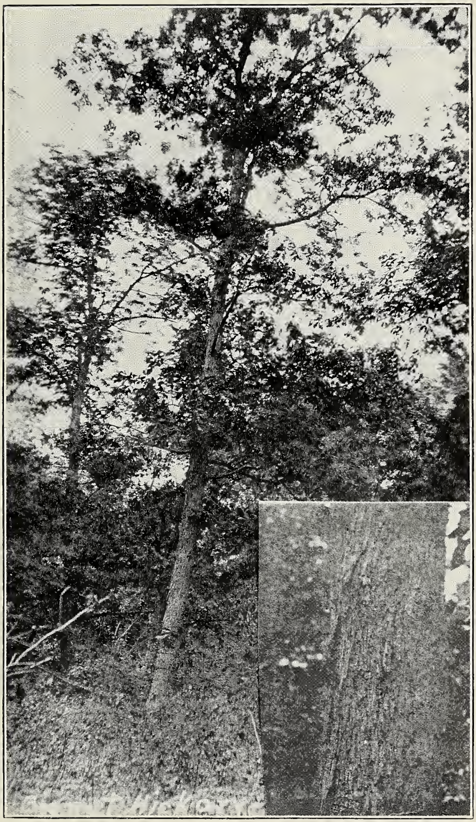
Bur Oak (*Quercus macrocarpa*), Missouri Valley, Iowa.
Photographed, L. H. Pammel.



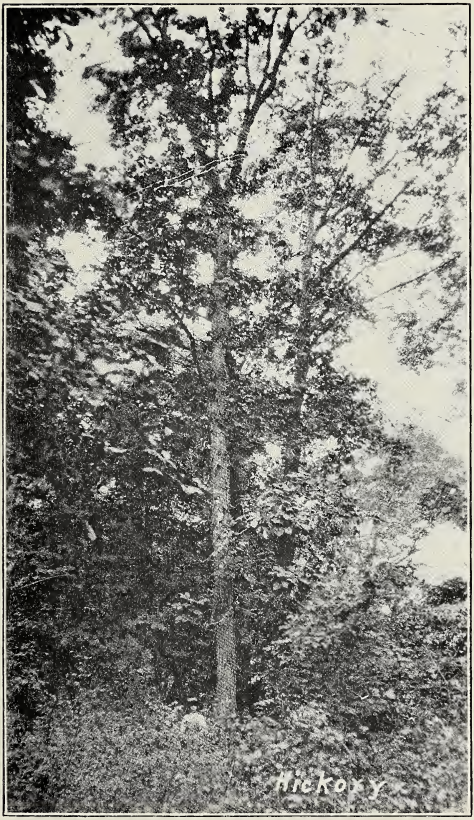
White Willow hedge (*Salix alba*). Photographed, L. H. Pammel.



Bark of White Willow (*Salix alba*), Missouri Valley.
Photographed, L. H. Pammel.

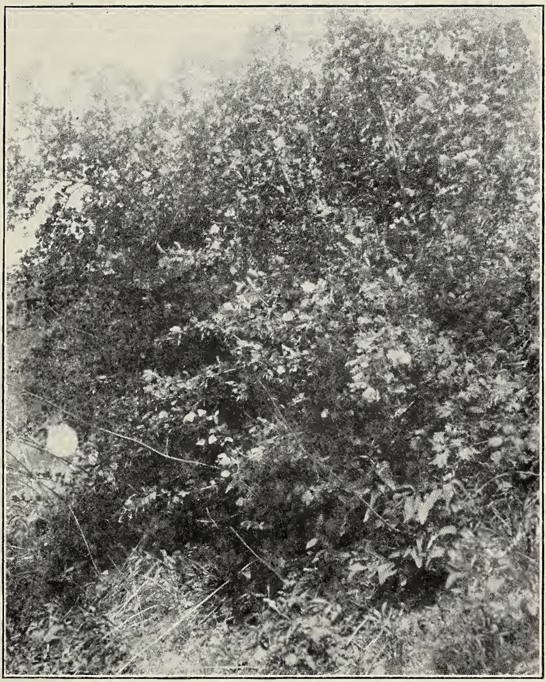


Bignut Hickory (*Carya ovalis*). Photographed, H. B. Clark.
To the right, bark characters.

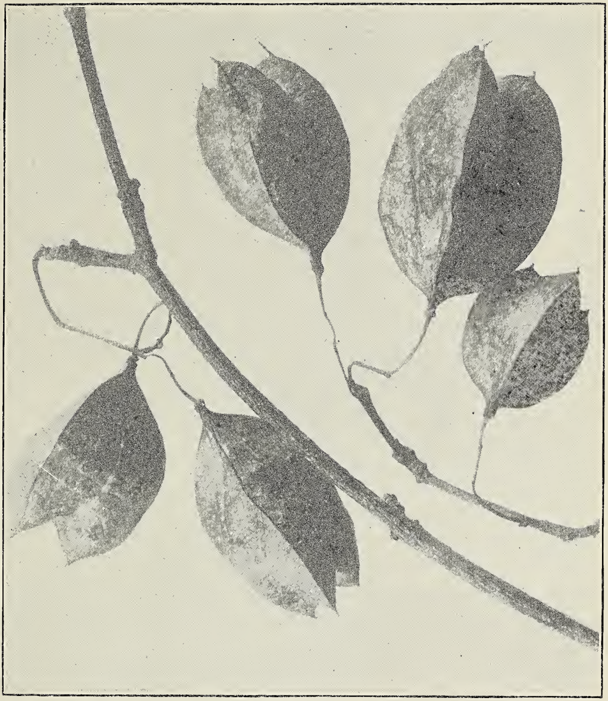


Shell Bark Hickory (*Carya ovata*). Photographed, H. B. Clark.

Wild Grape (*Vitis vulpina*). Photographed, Charlotte M. King.



Gooseberry (*Ribes gracile*). Photographed, L. H. Pammel.



Bladder Nut (*Staphylea trifolia*). Photographed, Charlotte M. King.

Wild Indigo (*Amorpha fruticosa*). Photographed, Charlotte M. King.

A COMPARATIVE STUDY OF THE WEEDS OF CENTRAL IOWA, NORTHERN MINNESOTA AND WISCONSIN.

L. H. PAMMEL.

During a short trip made by the writer in northern Minnesota from Cass Lake to Duluth in Minnesota, St. Croix, Wisconsin, and Taylors Falls, Minnesota, some observations were made on the introduced plants. The route covered was over the Northern Pacific from Minneapolis to Walker and Cass Lake; from Cass Lake over the Great Northern Railway to Duluth, and via the Northern Pacific to St. Croix Falls, Wisconsin.

The weeds of the region have been given by Upham[1] in his Catalogue of the Flora of Minnesota.

The plants of the St. Croix region were listed by Dr. C. C. Parry.[2]

The plants listed here are based on observation at various stations, although collections of plants were made in Cass Lake, Star and Cedar Islands and the vicinity. Collections were also made in Duluth, St. Croix Falls and Taylors Falls.

In order to list these plants in a convenient form I am arranging the plants in the form of a table.

Name of Plant	Ames, Iowa	St. Paul, Minn.	Brainerd, Minn.	Cass Lake, Minn.	Duluth, Minn.	St. Croix Falls, Wis.
Amaranthus retroflexus	+	+	+	+		
Ambrosia artemisiæfolia	+	+			+	+
Ambrosia trifida	+	+			+	+
Artemisia biennis	+	+			+	+
Achillea Millefolium	+	+	+	+	+	+
Anthemis Cotula	+	+	+		+	+
Arctium major	+	+	+		+	+
Agropyron repens	+	+	+	+	+	+
Agropyron Smithii	+	+	+	+	+	+
Brassica arvensis	+	+	+	+	+	+
Brassica nigra	+	+			+	+
Bidens frondosa	+	+	+		+	+
Agrostemma Githago		+	+	+	+	+
Asclepias syriaca	+	+				

[1]Geol. and Nat. Hist. Survey of Minn. Pt. VI, Progress Rep. 1883. 1 Map.
[2]David Dale Owen. Rep. Geol. Survey, Wis., Ia. and Minn., 606-622. Philadelphia, 1852.

Name of Plant	Ames, Iowa	St. Paul, Minn.	Brainerd, Minn.	Cass Lake, Minn.	Duluth, Minn.	St. Croix Falls, Wis.
Cannabis sativa	+	+				
Chenopodium album	+	+				+
Cirsium discolor	+	+				+
Eragrostis pilosa	+	+	+			+
Epilobium spicatum				+	+	
Helianthus annuus	+	+				+
Linaria vulgaris	+	+	+			
Lophanthus anisatus		+		+	+	
Melilotus alba	+	+	+			
Melilotus officinalis	+	+				
Oxybaphus nyctagineus	+	+		+		
Portulaca oleracea	+	+	+	+	+	+
Cirsium arvense	+	+	+	+	+	+
Cirsium lanceolata	+	+	+	+	+	+
Daucus Carota	+	+	+			
Erigeron canadense	+	+	+	+	+	+
Euphorbia corollata	+	+	+			
Grindelia squarrosa	+	+	+	+	+	+
Hordeum jubatum	+	+	+	+	+	+
Helianthus petiolaris		+			+	
Helianthus Maximiliani		+	+		+	
Iva xanthifolia	+	+	+	+	+	+
Lactuca pulchella		+	+	+	+	
Lactuca Scariola var. integrata	+	+			+	+
Lepidium apetalum	+	+	+	+	+	
Nepeta Cataria	+	+	+			
Oenothera biennis	+	+	+		+	+
Panicum sanguinale	+	+				
Panicum crus-galli	+	+	+		+	+
Polygonum erectum	+	+			+	+
Polygonum aviculare	+	+	+	+	+	+
Polygonum convolvulus	+	+	+	+	+	+
Pastinaca sativa	+	+			+	+
Plantago major		+	+	+	+	+
Ranunculus acris					+	
Ranunculus septentrionalis	+	+		+		
Rumex acetosella	+	+	+			+
Rumex crispus	+	+			+	+
Rumex altissimus	+	+			+	+
Silene stellata	+	+				+
Sisymbrium altissimum	+	+	+	+	+	+
Solidago canadensis	+	+	+	+	+	+
Sonchus arvensis		+				
Saponaria officinalis	+	+				
Setaria viridis	+	+	+		+	+
Setaria glauca	+	+	+			
Setaria verticillata	+					
Taraxacum officinale	+	+	+	+	+	+
Urtica gracilis	+	+			+	+
Verbena stricta	+	+	+			
Verbena hastata	+	+	+			
Verbena urticaefolia	+	+	+			+
Vicia sativa		+	+	+	+	+

The striking differences occur in a few of the common weeds of central Iowa and northern Minnesota. The boreal weeds like the European Crowfoot (*Ranunculus acris*), fireweed (*Epilobium angustifolium*), the Canada thistle (*Cirsium arvense*), *Lophanthus anisatens* become increasingly common in the north. The absence of the *Ranunculus acris,* fireweed, and *Lophanthus* in our flora is of interest. The abundance of corn cockle and tumbling mustard vetch (*Vicia sativa*) in the north can be accounted for easily because of the shipment of grain from western Minnesota and Dakota.

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THE FLORA OF THE RAINY RIVER REGION.

HARRIETTE S. KELLOGG.

There is no evidence accessible to the writer that a critical study of the flora of this region has ever been made, although several of the early explorers must have passed over this part of Minnesota.

Mr. Warren Upham[1] mentions the work of Mr. Thomas Say who was with Long's expedition. Keating noted in 1823, that Say had collected from the vicinity of the Lake of the Woods and along Rainy Lake as far as the Lake Superior region, thirty of his plants being from the Minnesota side.

The report of the British North American Boundary Commission submitted by Mr. George Dawson and published in 1875 includes flora from the Lake of the Woods to the Red River and lists 289 plants from Minnesota. Both of these reports would necessarily include many plants indigenous to the Rainy river country.

Mr. John Macoun later surveyed the whole of the Dawson route, his work being recorded in the "Catalogue of Canadian Plants" published in 1883 under the Geological and Natural History Survey of Canada.

Conway Macmillan's "Metaspermae of the Minnesota Valley" covers the southern part of Koochiching county, then a part of Itasca county.

The "Observations on Distribution of Plants along the Shores of the Lake of the Woods", by the same author, has been helpful as a means of comparison with the notes made in the collecting tour described in the present paper.

The territory to which reference is made in the following study lies below Koochiching or International Falls on the south bank of the Rainy river, and on both sides of the "Old Dock" in the city of International Falls, Minnesota. Plants were collected from an area extending about forty feet east of the dock in the timbered belt only, but west of the dock, the survey ex-

[1]Warren Upham. Catalogue of Flora of Minnesota. Part VI of the Annual Report of Progress, 1883. Geological and Natural History Survey of Minnesota.

tended not only through the timbered belt but also into the cleared land lying back of this and not more than three hundred feet from the river.

The wooded bank slopes rather abruptly to the river and the clearing lies on higher, rather level ground.

The river itself is a part of the Hudson Bay drainage system, the divide between the Mississippi river and the Bay being situated a short distance southwest of this place. The ''Old Dock'' was built for a river boat plying on the Minnesota side of the river. Before the coming of the railroad nearly all of the traffic down the river was by boat; freight, including grain, was transported by this means, and in this fact lies the explanation of the exceedingly frequent appearance of tame clover and grasses near the landing.

The river flows in a rocky channel, and many boulders and rocks line the shores; there is a short strip of sandy beach, but partly because of nearness to the falls, the current of the river is rapid and there is very little characteristic strand vegetation, the only exceptions occurring in a covelike inlet east of the dock where the water is more sluggish. Here were found Carex and Juncus.

Geologically, the region lies within the boundaries of Lake Agassiz which disappeared rather abruptly more than seven thousand years ago, leaving the field open to plant immigration from the south. The icy barrier which extended along the eastern shores of Lake Tecamamisuan or Rainy Lake as it is now called, precluded a similar immigration from the east; hence the marked similarity of the flora of this region to that of southern Minnesota on the one hand, and the evident unlikeness to that of the northeastern part of the state on the other.

For the same reason the flora of the Lake of the Woods bears close relation to that of the Minnesota Valley and the Rainy river region.[2] The soil is extremely fertile, consisting of a subsoil of modified drift overlaid with a rich humus. Maples, boxelders, cedar, spruces, white birch and willows are the prevailing trees. The two latter are especially characteristic of regions that have been swept by fire.

The forest growth of this region differs markedly from that of the Rainy Lake region, a mile east. In the latter district,

[2]MacMillan, Conway. Observations on Distribution of Plants along the Shores of Lake of the Woods. Minn. Bot. Studies. Bull. 9, p. 954. Also Metaspermae of the Minnesota Valley, 826 p., 1892. Geological and Natural History Survey of Minn. Reports of Survey. Botanical Series 1.

conifers, as spruce, pine, and tamarack abound, while along the river, especially where the timber is largely second growth, the trees are deciduous.

Of the shrubs, hazel, dogwood, low willow, and high-bush cranberry are prominent; herbs do not differ materially from those of southern Minnesota, except, possibly, in their greater luxuriance of growth, due to the high percentage of humidity of the region and to the long periods of sunshine and daylight through the summer months.

The timber extends to the water's edge, while the shrubs lie back from the river.

Opposite the collecting ground are two islands, apparently rocky ledges that have been uplifted in some earlier geological disturbance. Seeds carried by birds, wind, or water have lodged in crevices of rocks, and thus, white pines, birches, and cottonwoods have become established.

The collection, except where otherwise noted, was made between August 14 and August 25, 1914. Vernal plants had practically disappeared, although each day some belated spring blossom was discovered. Thus solitary Aquilegias, Clintonias, and Violas, long past their usual blooming period, displayed flowers. Where locality is not noted, International Falls is understood.

A few specimens are included that were collected near Rainy Lake and others from the Canadian side of the river; also a few from the west bank of the Winnipeg river near Minaki, and one from Hibbing, Minnesota.

To the list referred to, collected by the writer, are added other plants collected in April by Miss Annette Miller at Littlefork, Minnesota, and by Dr. Mary C. Ghostley in 1915 at International Falls, to whom my thanks are due.

It is noticeable that plants from "cleared ground" are largely of a weedy nature, and are introduced plants probably brought in by immigrants.

It is also interesting to note that certain species common in our locality are replaced by other similar species in the more northern habitat; thus, *Polygonum cilinode* is as common around fences and in similar locations in northern Minnesota as its more vigorous representative, *P. Convolvulus* in Iowa. The former is more slender in appearance and its leaves are slightly reddish. It is rather ornamental in character.

Several plants collected by the writer are not numbered since they are not in the collection at Ames. Owing to accident in drying they were discarded.

The willows were identified by Mr. C. R. Ball of the U. S. Department of Agriculture. To him and to members of the Department of Botany who have aided me in identification of specimens, I wish to express my thanks.

CATALOGUE.

HEPATICÆ.

225. *Marchantia polymorpha* L. River bank. June, 1915.

MUSCI.

263. *Funaria hygrometrica* (L.) Sibth. Cord Moss. Moist places. June, 1915.
192. *Pohlia nutans* (Schreb.) Lindb. Nodding Bryum. River bank. May, 1915.
136. *Mnium cuspidatum* (L.) Leyss. Reindeer Moss. River bank. April, 1915.
134. *Amblystegium adnatum* (Hedw.) J. & S. River bank. April, 1915.
133. *Polytrichum commune* L. Common Hairy Cap Moss. River bank. April, 1915.
187. *Sphagnum* sp. Sphagnum Moss. Bog. May, 1915.

LICHENES.

124. *Usnea barbata plicata* (L.) Fr. Common on trees along Winnipeg river at Minaki, Ontario.
131. *Cladonia rangeriferina* (L.) Webb. Reindeer Moss. River bank. April, 1915.
188. *Cladonia bacillaris* (Del.) Wyl. River bank. May, 1915.
189. *Cladonia cristatella* Tuck. Crested Cladonia. River bank. May, 1915.
190. *Cladonia fimbriata prolifera* (Retz.) Mass. River bank. May, 1915.
208. *Peltigera aphthosa* (L.) Willd. River bank. June, 1915.

FILICES.

180. *Polypodium vulgare* L. Polypody. River bank. May, 1915.
181. *Phegopteris polypodioides* Fée. Beech Fern. River bank. May, 1915.

78. *Phegopteris dryopteris* (L.) Fée. Oak Fern. Moist places on river bank.

31. *Pteris aquilina* L. Common Brake. Eight to ten inches high. Not abundant.

Aspidium noveboracense (L.) Sw. Wood Fern. River bank.

34. *Aspidium spinulosum* (O. F. Müller) Sw. Wood Fern. River bank.

OPHIOGLOSSACEÆ.

200. *Botrychium virginianum* (L.) Sw. Rattlesnake Fern. River bank. May, 1915.

EQUISETACEÆ.

23. *Equisetum arvense* L. Horsetail. On cleared ground. Infrequent.

132. *Equisetum hyemale* L. Scouring Rush. River bank. April, 1915.

207, 70, 95. *Equisetum sylvaticum* L. Wood Horsetail. On cleared ground. Abundant.

LYCOPODIACEÆ.

163. *Lycopodium annotinum* L. Club Moss. River bank. May, 1915.

54. *Lycopodium obscurum* v. *dendroideum* Gray. Club Moss. Along Winnipeg river at Minaki, Ontario.

169. *Lycopodium obscurum* v. *dendroideum* Gray. Club Moss. River bank. May, 1915.

139. *Lycopodium complanatum flabelliforme* Fernald. Ground Pine. Littlefork, Minnesota (Annette Miller).

191. *Lycopodium complanatum flabelliforme* Fernald. Ground Pine. River bank. April, 1915.

PINACEÆ.

Pinus Strobus L. White Pine. Observed on rocky island opposite collecting ground.

36. *Pinus Strobus* L. White Pine. River bank. Mainland. May, 1915.

84. *Pinus resinosa* Ait. Red Pine. Not seen in this locality. Hibbing, Minnesota.

193, 5. *Larix laricina* (Du Roi) Koch. Tamarack. Near river, farther east.

157. *Picea* sp. Spruce. Young specimen. River bank. May, 1915.

164. *Picea canadensis* (Mill.) BSP. White Spruce. River bank. May, 1915.

24. *Picea canadensis* (Mill.) BSP. White Spruce. Near Rainy Lake.

55. *Abies balsamea* (L.) Mill. Balsam Fir. Rainy Lake.

165. *Abies balsamea* (L.) Mill. Balsam Fir. River bank. May, 1915.

118, 162. *Thuja occidentalis* L. Arbor Vitae. River bank.

Juniperus communis L. Juniper. On river bank. Common.

TYPHACEÆ.

Typha latifolia L. Cat-tail. On Canadian bank.

ALISMACEÆ.

Sagittaria latifolia Willd. Arrow-head. Canadian bank.

GRAMINEÆ.

77. *Panicum capillare* L. Old-witch Grass. Cleared ground.

69. *Echinochloa crusgalli* (L.) Beauv. Barnyard Grass. Cleared ground.

79. *Phleum pratense* L. Timothy. East of dock.

Calamagrostis inexpansa Gray. Reed Bent-Grass. River bank.

66. *Cinna arundinacea* L. Wood Reed Grass. River bank.

Cinna latifolia (Trev.) Griseb. Wood Reed Grass. River bank.

29. *Agropyron repens* (L.) Beauv. Quack Grass. Cleared ground. Infrequent.

Poa Annua L. East of dock.

49. *Glyceria* sp. Manna Grass. Cleared ground.

72. *Hordeum jubatum* L. Squirrel-tail Grass. Cleared ground. Common.

CYPERACEÆ.

41. *Carex Grayi* Carey. Sedge. River bank. Not abundant.

ARACEÆ.

Arisaema triphyllum (L.) Schott. Indian Turnip. River bank. Observed.

Arisaema Dracontium (L.) Schott. Dragon Root. Observed.

JUNCACEÆ.

219. *Luzula saltuensis* Fernald. Wood Rush. River bank. June, 1915.

LILIACEÆ.

179. *Uvularia perfoliata* L. Bellwort. River bank. May 1915.

18. *Clintonia borealis* (Ait.) Raf. Northern Lily. River bank. Frequent.

Smilacina racemosa (L.) Desv. Wild Spikenard. River bank.

175. *Smilacina stellata* (L.) Desv. False Solomon's Seal. River bank. May, 1915.

179. *Smilacina trifolia* (L.) Desv. Three-leaved Solomon's Seal. River bank. May, 1915.

205. *Streptopus amplexifolius* (L.) DC. Clasping-leaved Twisted Stalk. River bank. June, 1915.

122. *Trillium grandiflorum* (Mx.) Salisb. Large-flowered Trillium. River bank.

206. *Trillium cernuum* L. Nodding Trillium. River bank. June, 1915.

220. *Trillium erectum* L. Erect Trillium. River bank. June, 1915.

IRIDACEÆ.

262. *Iris* sp. Bogs.

ORCHIDACEÆ.

141. *Calypso bulbosa* (L.) Oakes. Bog Orchid. Bogs. May, 1915.

227. *Cypripedium acaule* Ait. Stemless Lady Slipper. Woods. June, 1915.

253. *Cypripedium hirsutum* Mill. Showy Lady Slipper. Bogs. July, 1915.

SALICACEÆ.

160. *Salix* sp. Willow. River bank. April, 1915.

160. *Salix* sp. Willow. River bank. April, 1915.

191. *Salix longifolia* Muhl. Sand-bar Willow. River bank.

105, 106. *Salix syrticola* Fernald. Bog Willow. River bank. May, 1915.

203. *Salix pedicellaris* Pursh. Myrtle-leaved Willow. River bank. May, 1915.

143. *Salix discolor* Muhl. Glaucus Willow. River bank. April, 1915.
195. *Salix petiolaris* Sm. Slender Willow. River bank.
144. *Salix humilis* Marsh. Prairie Willow. River bank. April, 1915.
91. *Populus tremuloides* Michx. American Aspen. River bank. Common.
90. *Populus balsamifera* L. Tacamahac. River bank. Very common.
170. *Populus candicans.* Ait. Balm-of-Gilead. River bank. May, 1915.

BETULACEÆ.

68, 69. *Corylus rostrata* Ait. Beaked Hazel-nut. River bank.
158. *Ostrya.* American Hop Hornbeam. Ironwood. River bank. May, 1915.
174. *Betula alba* v. *papyrifera* (Marsh) Spach. River bank. Common. May, 1915.

FAGACEÆ.

196. *Quercus macrocarpa* Michx. Bur Oak. River bank. May, 1915.

URTICACEÆ.

199. *Ulmus americana* L. White Elm. River bank. May, 1915.

ARISTOLOCHIACEÆ.

62. *Asarum canadense* L. Wild Ginger. River bank. Common
150. *Asarum canadense* L. Wild Ginger. May, 1915.

POLYGONACEÆ.

103. *Rumex mexicana* Meissn. Dock. Cleared ground. Rather common.
88. *Polygonum Muhlenbergii* (Meissn.) Wats. Knotweed. Cleared ground.
86. *Polygonum acre* HBK. Water Smartweed. On Canadian bank.
89. *Polygonum Persicaria* L. Lady's Thumb. Cleared ground.
235. *Polygonum convolvulus* L. Black Bindweed. Cleared ground—climbing on fences. June, 1915.
87. *Polygonum cilinode* Michx. Black Bindweed. Cleared ground. Employed as an ornamental vine for covering fences.

CHENOPODIACEÆ.

65. *Chenopodium hybridum* L. Maple-leaved Goosefoot. Cleared ground.

60. *Amaranthus retroflexus* L. Pigweed. Cleared ground. Common.

CARYOPHYLLACEÆ.

248. *Sagina procumbens* L. Procumbent Pearlwort. Moist places on river bank. June, 1915.

111. *Silene noctiflora* L. Night-flowering Catchfly. Cleared ground.

246. *Cerastium vulgatum* L. Larger Mouse-ear, Chickweed. Woods. June, 1915.

RANUNCULACEÆ.

182. *Ranunculus abortivus* L. Small-flowered Crowfoot. River bank. May, 1915.

101. *Ranunculus pennsylvanicus* L. f. Bristly Crowfoot. River bank.

Hepatica triloba Chaix. Hepatica. River bank.

166. *Anemone caroliniana* Walt. Carolina Anemone. River bank. May, 1915.

Anemone canadensis L. Round-leaved Anemone. River bank.

149. *Anemone quinquefolia* L. Wind Flower. River bank. May, 1915.

37. *Caltha palustris* L. Marsh Marigold. River bank near spring.

218. *Coptis trifolia* (L.) Salisb. Goldthread. Swampy land. June, 1915.

19. *Aquilegia canadensis* L. Columbine. River bank.

Actaea alba (Ait.) Willd. White Baneberry. River bank.

12, 28. *Actaea rubra* (Ait.) Willd. Red Baneberry. Blue Cohosh. River bank.

MENISPERMACEÆ.

Menispermum canadense L. Moonseed. River bank. Grows with great luxuriance. Employed as an ornamental climber.

FUMARIACEÆ.

Dicentra canadensis (Goldie) Walp. Squirrel Corn. River bank.

41. *Corydalis sempervirens* (L). Pers. Pale Corydalis. Three inches to three feet tall. Recent clearings. Very beautiful.

210. *Corydalis aurea Willd.* Golden Corydalis. Rocky bank. May, 1915.

CRUCIFERÆ.

249. *Thlaspi arvense* L. Field Penny-cress. A troublesome weed in the northwest. June, 1915.

38. *Capsella bursa-pastoris* (L.) Medic. Shepherd's Purse. Cleared ground.

36. *Brassica arvensis* (L.) Ktze. Charlock. Cleared ground. Introduced.

250. *Conringia orientalis* (L.) Dumort. Hare's-ear Mustard. Waste ground. June, 1915.

251. *Sisymbrium incisum* Engelm. Cut-leaved Hedge Mustard. Waste places. June, 1915.

259. *Sisymbrium altissimum* L. Tumble Mustard. Edge of woods. July, 1915.

101. *Radicula palustris* (L.) Moench. Marsh Cress. River bank.

SAXIFRAGACEÆ.

230. *Heuchera hispida* Pursh. Alum Root. River bank. June, 1915.

75. *Mitella nuda* L. Bishop's Cap. Shady bank near spring.

178. *Ribes oxyacanthoides* L. Northern Gooseberry. River bank. May, 1915.

204. *Ribes floridum* L'Her. Wild Black Currant. River bank. May, 1915.

106. *Ribes triste* Pall. Swamp Red Currant. Moist places on river bank.

154. *Ribes triste* Pall. Swamp Red Currant. River bank. May, 1915.

ROSACEÆ.

115. *Spiraea salicifolia* L. Meadow Sweet. Moist ground near river.

97. *Pyrus americana* (Marsh) DC. American Mountain Ash. Woods.

177. *Amelanchier canadensis* (L.) Medic. Service Berry. River bank.

138. *Amelanchier spicata* (Lam.) C. Koch. Juneberry. River bank.

172. *Amelanchier spicata* (Lam.) C. Koch. Juneberry. River bank. May, 1915.
201. *Crataegus* sp. Hawthorn. River bank. May, 1915.
197. *Crataegus Crus-galli* L. Cockspur Thorn. River bank. May, 1915.
3. *Fragaria vesca* v. *americana* Porter. Wild Strawberry. Woods.
159. *Fragaria virginiana* v. *illinoiensis* (Prince) Gray. Wild Strawberry. River bank. May, 1915.
93. *Potentilla anserina* L. Silver Weed. Near Minaki, Ontario.
202. *Potentilla anserina* L. Silver Weed. River bank. May, 1915.
94. *Potentilla anserina* L. Silver Weed. On Canadian bank.
48, 71. *Geum macrophyllum* Willd. Avens. Woods.
152. *Rubus* sp. River bank. May, 1915.
25. *Rubus strigosus* Michx. Wild Red Raspberry. Thickets on river bank.
243. *Rubus idaeus* L. v. *aculeatissimus* (C. A. Mey.) Regel & Tiling. Wild Red Raspberry. Thickets on bank. June, 1915.
20, 59. *Agrimonia gryposepala* Wallr. Agrimony. River bank.
4. *Rosa acicularis* Lindl. Rose. Thickets.
99. *Rosa Woodsii* Lindl. Rose. Dry open places in woods.
95. *Prunus pennsylvanica* L. f. Pin or Bird Cherry. Thickets.
156. *Prunus virginiana* L. Choke Cherry. River bank. May, 1915.

LEGUMINOSÆ.

119. *Trifolium hybridum* L. Alsike Clover.
120. *Trifolium pratense* L. Red Clover.
121. *Trifolium repens* L. White Clover.

These clovers were growing with great luxuriance on the river bank nearest the town and close to the road leading to the "Old Dock", indicating that the seed probably had been scattered from loads of grain in the days of transportation by the river.

123. *Vicia americana* Muhl. Vetch. Open ground.
240. *Vicia tetrasperma* (L.) Moench. Slender Vetch. Clearings. June, 1915.

255. *Vicia hirsuta* (L.) S. F. Gray. Edge of woods. July, 1915.

161. *Lathyrus ochroleucus* Hook. Vetchling. River bank. May, 1915.

256. *Lathyrus venosus* Muhl. Veiny Pea. River bank. July, 1915.

Petalostemum purpureum (Vent.) Rydb. Prairie Clover. Open ground, edge of woods.

ANACARDIACEÆ.

184. *Rhus glabra* L. Smooth Sumac. River bank. May, 1915.

GERANIACEÆ.

9. *Geranium Robertianum* L. Herb Robert. River bank. Very common.

ACERACEÆ.

26, 58. *Acer Negundo* L. Box Elder. River bank.

27. *Acer spicatum.* Lam. Mountain Maple. River bank.

176. *Acer spicatum* Lam. Mountain Maple. May, 1915.

137. *Acer rubrum* L. Swamp Maple. River bank. May, 1915.

126. *Acer rubrum* L. Swamp Maple. Littlefork. Annette Miller.

BALSAMINACEÆ.

8. *Impatiens fulva* Walt. Jewel Weed. Eighteen inches to four feet high. Moist places. A beautiful plant.

RHAMNACEÆ.

17. *Ceanothus americanus* L. New Jersey Tea. River bank.

VITACEÆ.

Psedera quinquefolia (L.) Greene. Virginia Creeper. Thickets. Rather common. An ornamental climber.

Vitis vulpina L. Frost Grape. Thickets.

TILIACEÆ.

198. *Tilia americana* L. Basswood. River bank. May, 1915.

VIOLACEÆ.

194. *Viola sororia* Willd. Woolly Blue Violet. River bank. May, 1915.

142. *Viola blanda* Willd. Wild Sweet Violet. River bank. May, 1915.

226. *Viola hastata* Michv. Halberd-leaved Violet. Woods, June, 1915.

Viola canadensis L. Canada Violet.

195. *Viola pubescens* Ait. Downy Yellow Violet. River bank. May, 1915.

155. *Viola labradorica* Schrenk. American Dog Violet. River bank. May, 1915.

ONAGRACEÆ.

80. *Epilobium angustifolium* L. Great Willow-herb. Clearings.

49. *Epilobium coloratum* Muhl. Fireweed. In clearings swept by forest fires.

76. *Oenothera biennis* L. Evening Primrose. Clearings.

ARALIACEÆ.

183. *Aralia nudicaulis* L. Wild Sarsaparilla. River bank. May, 1915.

UMBELLIFERÆ.

107. *Sanicula canadensis* L. Black Snakeroot. River bank.

10. *Hydrocotyle americana* L. Water Pennywort. River bank.

Hydrocotyle americana L. Water Pennywort. May, 1915.

140. *Carum Carvi* L. Caraway. Cleared ground. April, 1915.

112. *Sium cicutaefolium* L. Schrank. Water Parsnip. River bank.

37. *Pastinaca sativa* L. Wild Parsnip. River bank.

16. *Daucus Carota* L. Wild Carrot. Growing with *Impatiens fulva.*

CORNACEÆ.

8. *Cornus canadensis* L. Bunchberry. In damp woods. Common.

40. *Cornus stolonifera* Michx. Red Osier. Dogwood. Moist woods.

ERICACEÆ.

14. *Pyrola asarifolia* var. *incarnata* (Fisch.) Fernald. Shin Leaf. Moist places.

163. *Pyrola elliptica* Nutt. Shin Leaf. River bank. May, 1915.

135. *Ledum groenlandicum* Oeder. Labrador Tea. River bank. April, 1915.

202. *Kalmia polifolia* Wang. Pale Laurel, Swamp Laurel. River bank. May, 1915.

127. *Epigaea repens* L. Trailing Arbutus. Littlefork, Annette Miller. April, 1915.

130. *Gaultheria procumbens* L. Wintergreen. Littlefork, Annette Miller. April, 1915.

33. *Arctostaphylos Uva-ursi* (L.) Sprengel. Bearberry. River bank. April, 1915.

129. *Arctostaphylos Uva-ursi* (L). Sprengel. Bearberry. Littlefork. Annette Miller, April, 1915.

46. *Gaylussacia baccata* Wang. L. Koch. Huckleberry. Sandy slope.

173. *Vaccinium pennsylvanicum* Lam. Blueberry. Dry sandy places. May, 1915.

Vaccinium canadense Kalm. Blueberry. Moist places.

PRIMULACEÆ.

222. *Trientalis americana* (Pers.) Pursh. Chickweed Wintergreen. Woods. June, 1915.

OLEACEÆ.

95. *Fraxinus nigra* Marsh. Black Ash. River bank.

GENTIANACEÆ.

47. *Gentiana amarella* L. Northern Gentian. Rocky bank.

APOCYNACEÆ.

13, 61. *Apocynum androsaemifolium* L. Spreading Dogbane. River bank.

BORAGINACEÆ.

211. *Mertensia paniculata* (Ait.) G. Don. River bank. June, 1915.

229. *Lithospermum canescens* (Michx.) Lehm. Hoary Puccoon. Sandy soil. June, 1915.

LABIATÆ.

108. *Scutellaria laterifolia* L. Mad-dog Skull-cap. River bank.

238. *Dracocephalum parviflorum* Nutt. Dragon Head. Rocky bank. June, 1915.

83. *Physostegia virginiana* (L.) Benth. False Dragon-head. River bank.

116. *Stachys* sp. River bank.

74. *Mentha arvensis* L. var. *canadensis* (L.) Briquet. Mint. River bank.

SOLANACEÆ.

52. *Physalis grandiflora* Hook. Ground Cherry. River bank.

SCROPHULARIACEÆ.

228. *Castilleja coccinea* (L.). Spreng. Scarlet Painted cup. Sandy soil. Woods. June, 1915.

PLANTAGINACEÆ.

12. *Plantago major* L. Dooryard Plantain. Cleared ground.
85. *Plantago Rugelii* Dcne. Rugel's Plantain. In clearings.

RUBIACEÆ.

1. *Galium triflorum* Michx. Sweet-scented Bedstraw. River bank.
234. *Galium boreale* L. Northern Bedstraw. Rocky bank. June, 1915.
6. *Mitchella repens* L. Partridge Berry. Moist places on bank.

CAPRIFOLIACEÆ.

43. *Diervilla Lonicera* Mill. Bush Honeysuckle. River bank.
145. *Lonicera canadensis* Marsh. American Fly-Honeysuckle. River bank. May, 1915.
53. *Lonicera hirsuta* Eat. Hairy Honeysuckle. River bank.
73. *Linnaea borealis* v. *americana* (Forbes) Rehder. Twin-flower. River bank.
167. *Linnaea borealis* v. *americana* (Forbes) Rehder. Twin-flower. May, 1915.
245. *Viburnum pauciflorum* Raf. Squashberry. Woods. June, 1915.
81. *Viburnum Opulus* L. v. *americana* (Mill.) Ait. High-bush Cranberry. Canadian bank. Fruit used as a substitute for cranberries.

COMPOSITÆ.

113. *Solidago serotina* Ait. Goldenrod. Cleared ground.
64. *Boltonia asteroides* (L.) L'Her. Cleared ground.
125. *Aster Drummondii* Lindl. Aster. Cleared ground.
63. *Aster umbellatus* Mill. Aster. Cleared ground.
185. *Antennaria canadensis* Greene. Everlasting. River bank. May, 1915.
180, 31. *Anaphalis margaritacea* B. & H. Pearly Everlasting. River bank.
Erigeron philadelphicus L. Fleabane. Moist bank.
30. *Ambrosia trifida* L. Great Ragweed. Cleared ground.
7. *Xanthium canadense* Mill. Cocklebur. Cleared ground.

35. *Bidens frondosa* L. Beggar-ticks. Cleared ground.

50. *Helenium autumnale* L. Sneezeweed. Cleared ground.

148. *Petasites sagittatus* (Pursh.) Gray. Sweet Coltsfoot. River bank.

11. *Achillea Millefolium* L. Common Yarrow. Cleared ground.

258. *Chrysanthemum Leucanthemum* L. Ox-eye Daisy. Woods. July, 1915.

223. *Senecio vulgaris* L. Groundsel. Cleared ground.

261. *Senecio Jacobaea* L. Stinking Willie. Woods. July, 1915.

67. *Cirsium arvense* (L.) Scop. Canada Thistle. Cleared ground.

39. *Cirsium lanceolatum* (L.) Hill. Scotch Thistle. Cleared ground.

117. *Taraxacum officinale* Weber. Dandelion. Cleared ground. Not over-abundant.

114. *Sonchus arvensis* L. Sow Thistle. Cleared ground.

52. *Lactuca pulchella* (Pursh.) DC. Blue Thistle. Cleared ground.

2. *Prenanthes alba* L. Rattlesnake Root. Woods. Common.

51. *Hieracium canadense* Michx. Woods.

Botanical Laboratory,
Iowa State College.

FIG. 1.—Island opposite collecting ground on which are white pine, cottonwoods, spruces and willows.

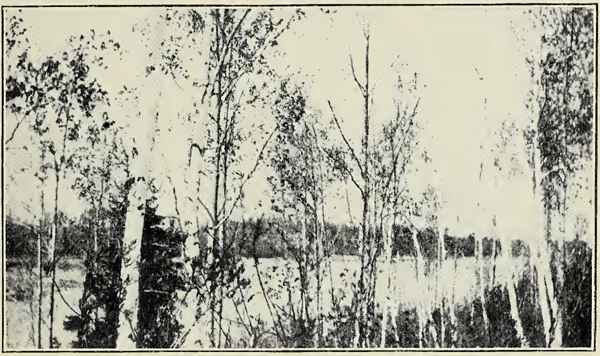

FIG. 2.—Birches along Rainy River.

FIG. 3.—North of dock. Trees are cottonwoods, birches, maples and poplars.

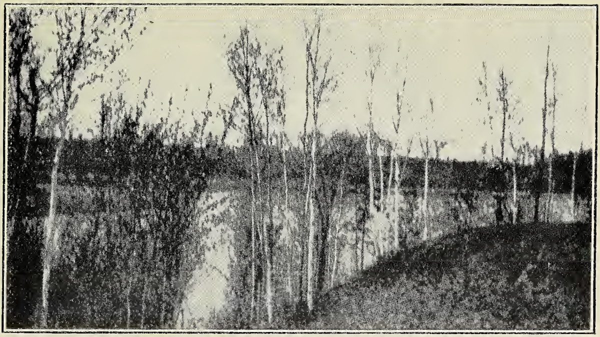

FIG. 1. Rocky bank of Rainy River. Poplars and birches.

FIG. 2.—1. Blueberry (*Vaccinium canadense*).
2. Swamp Laurel (*Kalmia polifolio*).
3. Labrador Tea (*Ledum groenlandicum*).

THE FLORA OF THE LEDGES REGION OF BOONE COUNTY, IOWA.

WILLIAM W. DIEHL.

INTRODUCTION.

In the south-central part of Boone county is an area that possesses characteristic plants as well as peculiar geological and topographic features. This is located four miles directly south of Boone and extends for about two miles south toward and along the Des Moines river. Its name ''The Ledges'' is appropriate because of striking sandstone cliffs from ten to over forty feet in height, extending beyond the perpendicular in some cases as much as twelve feet. This ledge rock here comprises an island of younger massive sandstone surrounded unconformably by somewhat older Carboniferous layers, which are of different structure.[1] The conditions peculiar to this restricted locality give the flora a distinctive character.

The region has been of special interest at various times to students of plant life. Plants from ''The Ledges'' have been collected and studied chiefly by students from Ames. Thus the herbarium of the Department of Botany of Iowa State College possesses much material from that source. Hitchcock probably made use of some material from ''The Ledges'' in his Anthophyta and Pteridophyta of Ames, Iowa. L. H. Pammel in ''The Character and Distribution of Forest Trees and Shrubs of Boone County, Iowa ''[4] gives a list which was based largely upon collections and observations made at ''The Ledges.'' Bruce Fink collected lichens at The Ledges in 1903[3]. Collections preserved in the herbarium of the Department of Botany have been made at various times by L. H. Pammel, R. E. Buchanan, C. M. King, Robert Combs, C. R. Ball, J. P. Anderson, J. V. Ellis, and others.

THE SCOPE OF THE WORK.

The scope of this paper is to list the Pteridophytes and Spermatophytes of ''The Ledges'' with an account of the plant characters of the region as revealed by a detailed study of a strip across a characteristic location.

The area from which this collection was taken includes practically all that region, originally part of the forest belt adjacent to the Des Moines river, which is drained by the ravines that converge among the ledge outcrops. The more restricted area, represented on the map (fig. 1) by the shaded part, is

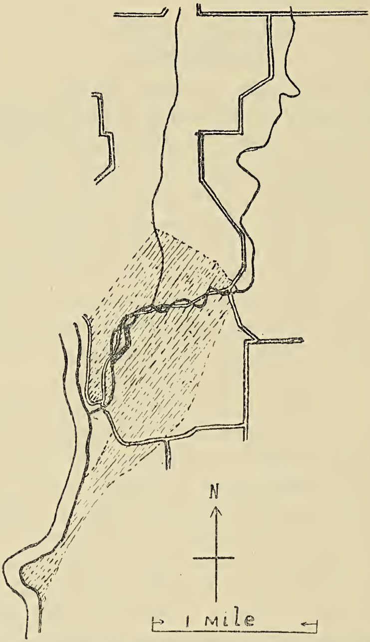

FIG. 1.—Map of the "Ledges" region. The shaded part indicates the area characterized by the sandstone outcrops.

characterized by outcropping native sandstone rock. All of the plants listed as collected by the writer were obtained within this area at various times from September, 1914, until June, 1915. Those specimens which are listed as collections by others may have been obtained within the boundaries of the unshaded part of the map. All the plants in the catalogue are represented by specimens in the herbarium of the Department of Botany of the Iowa State College at Ames. The arrangement followed is that of Engler and Prantl as used in Gray's Manual, seventh edition,[7] and the nomenclature of this manual has been used throughout. This list is incomplete in some respects, due to the limitations of the season when this study was undertaken.

THE CHARACTER OF THE FLORA.

It is evident from the appended catalogue that this area possesses a flora typical of a forested region or of a region until recently covered with woodland. Originally all or nearly all of this area was wooded. It would seem that the northern limit of the unshaded part of the map represents approximately the northern extension of the former encroaching forest belt. Along the roadside just north of this line are some remnants of such prairie grasses as *Spartina Michauxii* Hitch, which have not been found within the area in question. That the forest once extended to this line is shown by the presence of tree stumps over much of the area. The stump of a bur oak growing near a clump in this vicinity showed sixty-one annual rings. Residents of the district also attest that practically all this land was once wooded. Of course the wooded area is now confined to the rough land near the river and along the steep slopes of the ravines adjacent.

The catalogue indicates the somewhat anomalous character of the vegetation of the region. For instance, *Morus rubra* L. and *Viburnum Lentago* L., which are plentiful just outside the tract to the westward, have not yet been found within "The Ledges." *Aesculus glabra* var. *arguta* (Buckley) Robinson, while plentiful at Frazer near Boone, and along Honey creek about three miles to the northwest where conditions are somewhat similar, has not been found at "The Ledges." *Anemonella thalictroides* L. is abundant on the bluffs along the Skunk river in Story county, but it has not been collected at "The Ledges." *Caltha palustris* L. covers the marshy southern bank of the Des Moines river to the west of "The Ledges," but the writer has been unable to find it within the area in question.

"The Ledges" may be said to be characterized by the presence of *Cladonia sylvatica, Polytrichum commune, Camptosorus rhizophyllus, Polypodium vulgare, Woodsia obtusa, Trillium nivale, Mitella diphylla, Juniperus virginiana, Dirca palustris, Lathyrus ochroleucus, Physocarpus opulifolius, Prunus pennsylvanica,* and *Rhamnus lanceolata.*

THE BELT TRANSECT.

An idea of the character of the region is best indicated perhaps by a detailed study of a belt transect or strip across some part of the area representative of the diverse conditions which give "The Ledges" their peculiarity. The belt chosen extends toward the southeast from the bank of Pease creek, up the north-facing hillside, over the ridge or hogback and down the south-facing slope to Pease creek. The belt is represented on the map (fig. 1) as a black block.

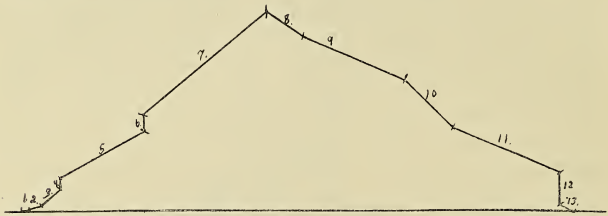

FIG. 2.—Diagram showing the relative location of the various plots in the strip survey.

The strip is six feet in width. The north and south slopes are designated "A" and "B" respectively. Each has been subdivided into separate plats because of their somewhat individual characters.

PART A.

Plat 1 is two yards long. It is the area directly along the stream bank, and is made up of plants growing a part of the time partly submerged.

Plat 2, three yards in length, extends from the edge of plat 1 to the base of the hill; it has many characters in common with 1.

Plat 3 extends up the talus slope for six yards to the first vertical cliff or rock exposure. Here, as on much of the hillside above, the extreme mesophytic conditions are reflected in the type of plants found.

Plat 4 is the part of the belt which extends up the cliff at this point. In one respect this location is not typical of the ledges in that here is found the Moosewood, *Dirca palustris*, which is nowhere else in this region.

Plat 5 extends for twenty-three yards up the slope to the base of the next cliff, and goes up most of the way in a rock-strewn ravine.

Plat 6 is the twelve foot cliff, which is bare of any vascular plants.

Plat 7 lies from the top of the cliff to the watershed of the hogback, a distance of thirty-eight yards.

At this point, where the sun's rays strike the hilltop, the vegetation is immediately of a different character, even approaching a prairie type. But the woody plants are becoming established in places, giving shade sufficient to protect those plants more commonly found on the north slope.

PART B.

Plat 8 extends ten yards down the hillside. The plat is covered chiefly by *Antennaria plantaginifolia* (L.) Richards.

Plat 9 is a tract twenty-six yards long, covered by a shrubby growth.

Plat 10, sixteen yards long, is rather open clay and dry exposed rock, with scant plant-cover.

Plat 11 is a twenty-eight yard strip covered with a fairly dense growth of shrubs and young trees.

From this point there is a sheer drop of twenty-four feet down a bare sandstone cliff, plat 12, to plat 13, which is a talus and alluvial bank nine feet across, reaching to the edge of the stream.

The appended tables give the data upon a comparative percentage basis with the number of plants in the average square yard, rated at 100 per cent.

THE PERCENTAGE DISTRIBUTION OF PLANTS ON THE NORTH SLOPE (A).

Species	Percentage to Each Plat						
	1	2	3	4	5	6	7
Adiantum pedatum........	----	----	----	2.6	9.2	----	-----
*Camptosorus rhizophyllus	----	----	----	—	----	----	-----
Cystopteris fragilis........	----	----	172.8	----	----	----	-----
Woodsia obtusa...........	----	----	----	.4	0.9	----	----
Equisetum arvense........	----	+	—	----	----	----	-----
Equisetum hyemale var. robustum...............	----	—	—	----	----	----	-----
Muhlenbergia Sp..........	----	+	—	----	----	----	-----
Cinna arundinacea........	—	+	----	----	----	----	-----
Poa pratensis.............	----	----	—	----	----	----	-----
Glyceria aquatica	+	+	----	----	----	----	----
Eleocharis palustris.......	+	----	----	----	----	----	-----

*NOTE—For such plants not easily counted the relative abundance is indicated by + or —; these are not taken into consideration otherwise.

PERCENTAGE DISTRIBUTION, NORTH SLOPE (A)—Continued

Species	Percentage to Each Plat						
	1	2	3	4	5	6	7
Carex pennsylvanica......	----	----	----	----	—	----	—
Carex sp.................	—	—	—	----	—	----	—
Carex sp.................	----	----	—	----	—	----	—
Arisaema triphyllum......	—	----	8.7	2.2	----	----	----
Polygonatum commutatum	----	----	0.8	----	----	----	----
Salix longifolia	19.4	3.5	----	2.2	----	----	----
Populus grandidentata....	----	----	----	----	----	----	0.1
Corylus americana........	----	----	----	----	----	----	0.5
Ostrya virginiana	----	----	----	0.4	1.8	----	3.4
Carpinus caroliniana......	----	----	9.6	0.8	1.8	----	----
Quercus alba.............	----	----	----	----	----	----	0.2
Quercus rubra............	----	----	----	----	----	----	1.1
Ulmus fulva..............	----	----	0.8	----	0.2	----	----
Asarum canadense........	----	----	2.6	----	0.9	----	----
Thalictrum dioicum	----	----	15.7	6.6	9.2	----	8.7
Hepatica acutiloba........	----	----	4.3	3.5	10.6	----	12.9
Anemone virginiana.......	----	----	1.7	----	----	----	----
Anemone quinquefolia.....	----	----	7.8	----	0.2	----	0.6
Isopyrum biternatum.....	----	----	----	1.7	----	----	0.6
Aquilegia canadensis......	----	----	9.6	----	----	----	0.1
Sanguinaria canadensis...	----	----	----	1.7	----	----	----
Draba caroliniana........	----	----	----	----	0.2	----	----
Mitella diphylla...........	----	----	13.2	6.4	1.8	----	----
Ribes cynosbati...........	----	----	0.8	----	0.4	----	0.2
Amelanchier canadensis...	----	----	----	----	----	----	1.6
Rubus occidentalis........	----	----	0.8	0.4	0.2	----	----
Rosa pratincola...........	----	----	----	----	----	----	0.2
Prunus virginiana........	----	----	----	----	----	----	1.7
Astragalus canadensis.....	----	----	----	0.4	----	----	----
Desmodium grandiflorum..	----	----	8.7	----	----	----	1.1
Rhus Toxicodendron......	----	----	----	1.7	0.9	----	0.2
Evonymus atropurpureus..	----	----	2.6	----	----	----	----
Celastris scandens........	----	----	0.8	----	----	----	1.7
Acer saccharum...........	----	----	0.8	----	----	----	0.2
Impatiens pallida.........	----	----	1.7	----	----	----	----
Psedera quinquefolia......	----	----	----	0.4	----	----	0.6
Vitis vulpina.............	----	----	1.7	----	----	----	0.6
Tilia americana..........	----	----	0.8	----	----	----	0.1
Dirca palustris...........	----	----	----	0.8	----	----	----
Aralia racemosa..........	----	----	0.8	0.8	0.4	----	----
Aralia nudicaulis.........	----	----	----	----	----	----	2.0
Osmorhiza Claytoni.......	----	----	1.7	0.4	----	----	----
Cornus circinata..........	----	----	----	----	----	----	0.2
Cornus asperifolia........	----	----	----	----	----	----	2.5
Cornus alternifolia........	----	----	----	----	0.4	----	----
Fraxinus americana.......	----	----	----	----	----	----	0.4
Fraxinus nigra...........	----	----	----	----	0.2	----	----
Hydrophyllum appendiculatum..................	----	----	----	----	1.3	----	----
Teucrium canadense......	----	----	0.8	----	----	----	----
Prunella vulgaris.........	----	5.9	----	----	----	----	----
Monarda fistulosa.........	----	10.6	13.0	2.6	----	----	----
Pedicularis canadensis....	----	10.6	13.0	2.6	----	----	----
Galium aparine...........	----	----	----	----	+	----	+

PERCENTAGE DISTRIBUTION, NORTH SLOPE (A)—Continued

Species	Percentage to Each Plat						
	1	2	3	4	5	6	7
Galium circaezans.......	----	----	----	----	----	----	+
Galium boreale...........	----	----	----	----	+	----	+
Galium trifidum..........	----	----	—	----	+	----	+
Lonicera dioica..........	----	----	0.8	1.3	0.2	----	0.8
Viburnum pubescens......	----	----	----	----	----	----	2.2
Vernonia altissima.......	----	----	0.8	2.2	0.9	----	-----
Solidago latifolia.........	----	----	17.5	----	33.4	----	3.6
Solidago canadense.......	----	122.6	31.4	----	----	----	-----
Aster sagittifolius........	----	----	0.8	----	108.1	----	20.3
Erigeron philadelphicus..	----	----	1.7	----	----	----	10.7
Ambrosia trifida..........	----	----	----	0.4	----	----	-----
Heliopsis scabra.........	----	7.0	----	----	----	----	1.9
Rudbeckia laciniata......	----	17.6	14.8	1.3	----	----	0.1
Prenanthes alba..........	----	----	----	1.3	----	----	-----

THE PERCENTAGE DISTRIBUTION OF PLANTS ON THE SOUTH SLOPE (B).

Species	Percentage of Plants to Each Plat					
	8	9	10	11	12	13
Adiantum pedatum	----	----	----	0.1	----	-----
Equisetum arvense.............	----	----	----	----	----	+
Equisetum hyemale var. robusta	----	----	----	----	----	+
Panicum lanuginosum..........	----	----	—	----	----	-----
Muhlenbergia tenuiflora........	----	----	—	—	----	+
Elymus robustus...............	----	—	----	+	----	-----
Carex sp.......................	+	—	—	—	----	----
Hypoxis hirsuta................	0.3	3.6	----	----	----	-----
Populus grandidentata..........	----	----	----	0.1	----	-----
Corylus americana.............	----	----	----	2.3	----	-----
Ostrya virginiana..............	----	2.3	2.9	1.2	----	----
Carpinus caroliniana...........	----	----	----	0.9	----	-----
Quercus alba..................	----	0.1	------	----	----	-----
Quercus rubra..................	0.9	0.7	----	0.2	----	-----
Ulmus fulva....................	----	----	0.3	1.1	----	1.0
Ulmus racemosa................	----	----	3.5	----	----	-----
Thalictrum dioicum	31.5	3.5	----	0.2	----	-----
Hepatica acutiloba.............	----	----	1.1	6.2	----	-----
Anemone virginiana............	----	0.4	----	0.3	----	-----
Anemone quinquefolia..........	----	----	1.9	----	----	----
Menispermum canadense........	----	----	----	----	----	8.4
Amelanchier canadensis........	----	1.3	----	0.1	----	-----
Fragaria virginiana var. illinoisensis........................	----	----	1.3	2.0	----	-----
Potentilla argentea	----	0.1	----	----	----	-----
Rubus occidentalis.............	----	----	0.5	0.4	----	-----
Rosa pratincola................	----	----	----	0.6	----	-----
Prunus virginiana..............	----	----	----	1.0	----	-----
Melilotus alba.................	----	----	----	----	----	5.5
Amorpha canescens.............	1.4	3.9	----	----	----	-----
Astragalus canadensis..........	1.2	----	----	1.0	----	-----

THE PERCENTAGE DISTRIBUTION OF PLANTS ON THE SOUTH SLOPE (B).

Species	Percentage of Plants to Each Plat					
	8	9	10	11	12	13
Lespedeza capitata	----	----	----	1.3	----	----
Vicia americana	----	----	----	0.4	----	----
Lathyrus ochroleucus	----	0.6	----	0.5	----	----
Zanthoxylum americanum	----	----	----	0.2	----	----
Oxalis corniculata	----	----	----	0.5	----	4.2
Polygala Senega	----	----	----	1.3	----	----
Rhus glabra	----	----	3.5	----	----	----
Rhus Toxicodendron	----	0.1	----	0.7	----	----
Vitis vulpina	----	----	----	0.3	----	----
Tilia americana	----	----	----	0.1	----	----
Aralia nudicaulis	0.9	0.4	0.1	0.9	----	----
Zizia aurea	----	0.4	----	0.7	----	----
Cornus asperifolia	----	3.4	1.3	6.9	----	----
Fraxinus americana	----	----	----	----	----	1.0
Apocynum androsaemifolium	----	0.1	----	0.1	----	----
Phlox pilosa	----	3.0	----	0.5	----	----
Phlox divaricata	----	----	0.1	0.1	----	----
Teucrium canadense	----	----	----	----	----	3.1
Monarda fistulosa	----	----	2.5	0.1	----	15.8
Pedicularis canadensis	----	.03	----	----	----	----
Galium circaezans	----	—	+	+	----	----
Galium boreale	----	----	----	+	----	----
Galium sp	----	----	----	+	----	----
Lonicera dioica	0.6	0.4	----	----	----	----
Viburnum pubescens	----	5.2	----	1.2	----	----
Solidago latifolia (?)	----	0.3	----	7.6	----	----
Solidago ulmifolia (?)	----	----	----	2.9	----	----
Solidago canadensis (?)	0.3	0.6	----	----	----	----
Aster sagittifolia	----	----	0.9	6.1	----	----
Aster sp	4.3	2.0	----	3.9	----	----
Erigeron philadelphicus	----	----	40.5	7.3	----	----
Heliopsis scabra	13.0	----	0.7	6.3	----	----
Prenanthes alba	0.3	0.3	----	----	----	----

CATALOGUE OF THE PLANTS OF "THE LEDGES."

PTERIDOPHYTA.

FILICALES.

Polypodiaceæ.

Polypodium vulgare L. L. H. P., 96; 296, L. H. P., R. E. B., C. M. K., 03; 1, W. W. D., 14. Common on sandstone exposures.

Adiantum pedatum L. R. E. B., 02; 3938, L. H. P., R. E. B., C. M. K., 03; 2, W. W. D. Common in rich woods.

Asplenium Filix-femina (L.) Bernh. 3926, L. H. P., R. E. B., C. M. K., 03. (No collection of this plant has since been made.)

Camptosorus rhizophyllus (L.) Link. 3974, L. H. P., R. E. B., C. M. K., 03; 3, W. W. D. On damp sandstone exposures.

Cystopteris fragilis (L.) Bernh. L. H. P., 98; 3892, L. H. P., R. E. B., C. M. K., 03; L. H. P., 13; 3, J. V. Ellis, 14; 4, W. W. D. Common on woody slopes.

Woodsia obtusa (Spreng.) Torr. L. H. P., 96; L. H. P. & R. C., 97; 3903, L. H. P., R. E. B., C. M. K.,03; 5, W. W. D., 15. On shaded, rocky banks.

Ophioglossaceæ.

Botrychium virginianum (L.) Sw. L. H. P. & R. C., 97; R. E. B., 02; 32, J. V. E., 14; 6, W. W. D., 15. Common in rich woods.

EQUISETALES.

Equisetaceæ.

Equisetum arvense L. E. Bissell, L. H. P., 10; 36, V. E. 14; 7, W. W. D., 15. Common in sandy alluvium.

Equisetum hyemale L. var. *robustum* (A. Br.) A. A. Eaton. R. E. B., 02; 3979, L. H. P., R. E. B., C. M. K., 03; 33, J. V. E., 14; 8, W. W. D., 14.

SPERMATOPHYTA.

GYMNOSPERMÆ.

CONIFERALES.

Pinaceæ.

Juniperus virginiana L. L. H. P., 98, 99, 13; 3935, C. M. K., 03; 9, W. W. D., 14. On exposed hillsides, rare.

ANGIOSPERMÆ.

MONOCOTYLEDONÆ.

PANDANALES.

Typhaceæ.

Typha latifolia L. 62, J. V. E.; 10, W. W. D., 15. In artificial swamp on upland.

NAJADALES.

Alismaceæ.

Sagittaria latifolia Willd. 11, W. W. D., 15. On flood plain of the Des Moines river.

Alisma Plantago-aquatica L. L. H. P., 14.

GRAMINALES.

Gramineæ

Andropogon furcatus Muhl. R. E. B., 02; 12, W. W. D., 15. Roadsides.

Sorghastrum nutans (L.) Nash. R. E. B., 02.

Digitaria humifusa Pers. L. H. P., 91.

Digitaria sanguinalis (L.) Scop. L. H. P., 91; 13, W. W. D., 15. Upland fields.

Panicum capillare L. L. H. P., 96; R. E. B., 02; 14, W. W. D., 14. Common in fields.

Panicum virgatum L. 287, W. W. D., 15.

Panicum lanuginosum Ell. 15, W. W. D., 15. Dry exposed hillside.

Panicum latifolium L. L. H. P., R. E. B., C. M. K., 03; W. W. D, 14. Upland woods.

Panicum villosissimum Nash. 3879, L. H. P., R. E. B., C. M. K., 03.

Echinochloa crusgalli (L.) Beauv. 17, W. W. D., 14. Upland fields.

Setaria glauca (L.) Beauv. 18, W. W. D., 14. Upland fields.

Setaria viridis (L.) Beauv. 65, J. V. E., 14; 19, W. W. D., 14. Upland fields.

Cenchrus carolinianus Walt. 20, W. W. D., 15. Sandy alluvium.

Leersia virginica Michx. L. H. P., 96.

Leersia oryzoides (L.) Sw. L. H. P., 15.

Muhlenbergia tenuiflora (Willd.) B. S. P., 21, W. W. D., 15. Exposed, rocky hillsides.

Muhlenbergia racemosa (Michx.) B. S. P., L. H. P., 96; 22, W. W. D., 15. Moist banks of Pease creek.

Muhlenbergia Mexicana (L.) Trin. L. H. P., 15.

Phleum pratense L. 28, J. V. E., 14.

Agrostis alba L. 3940, L. H. P., R. E. B., C. M. K., 03; L. H. P., 13; 68, J. V. E., 14.

Agrostis hyemalis (Walt.) B. S. P. 3942, L. H. P., R. E. B., C. M. K., 03.

Agrostis perennans (Walt.) Tuckerm. 3688, L. H. P., R. E. B., C. M. K., 03.

Cinna arundinacea L. 3930, L. H. P., R. E. B., C. M. K., 03; 23, W. W. D., 15. Moist shaded banks of Pease creek.

Sphenopholis obtusata (Michx.) Scribn. L. H. P., 15. Hill-sides.

Danthonia spicata (L.) Beauv. 3951, R. E. B., L. H. P., C. M. K., 03; 24, W. W. D., 15. Exposed hillsides.

Eragrostis hypnoides (Lam.) B. S. P. 108, L. H. P., C. R. B., 96.

Eragrostis capillaris (L.) Nees. L. H. P., 96; C. R. B., L. H. P., 96.

Eragrostis Frankii (Fisch. May. & Lall.) Steud. C. R. B., L. H. P., 96.

Eragrostis pilosa (L.) Beauv. L. H. P., 15.

Eragrostis Megastachya (Koeler.) Link. 183, W. W. D.

Poa pratensis L. 109, W. W. D., 15. Woods and pastures, common.

Glyceria nervata (Willd.) Trin. L. H. P., 96; 110, W. W. D., 15. Banks of Pease creek and of Des Moines river.

Bromus purgans L. 3908, L. H. P., R. E. B., C. M. K., 03.

Elymus virginicus L. 3924, L. H. P., R. E. B., C. M. K., 03.

E. robustus Scribn. & J. G. Sm. 3925, L. H. P., R. E. B., C. M. K., 02; 111, W. W. D., 14.

Hystrix patula Moench. L. H. P., 91; 3902, L. H. P., R. E. B., C. M. K., 03; L. H. P., J. V. E., 13.

Cyperaceæ.

Cyperus esculentus L. 291, W. W. D., 15. Roadside.

Eleocharis palustris (L.) R. & S. 112, W. W. D., 15. Partly submerged, along Pease creek.

Scirpus validus Vahl. 67, J. V. E., 14.

Carex rosea Schkuhr.? 197, W. W. D., 15. Rich shaded hillside.

Carex gravida Bailey. 462, L. H. P., R. H. C., 97; L. H. P., 98.

Carex pennsylvanica Lam. 113, W. W. D., 15. Common on hillsides.

Carex panicea L. var. *Meadii* (Dewey) Bailey. 193, W. W. D.

Carex eburnea Boot.? 305, W. W. D., 15.

Carex laxiflora Lam. L. H. P., R. H. C., 97.

Carex laxiflora Lam. var. *latifolia* Boot. 114, W. W. D., 15. Rich wooded hillsides, frequent.

Carex oligocarpa Schkuhr. L. H. P., C. R. B., 97; L. H. P., 13.

Carex grisea Wahlenb.? Too young. 194, W. W. D., 15.

Carex Crawei Dewey.? Too young. 195, W. W. D., 15.

Carex Assiniboinensis W. Boot.? 196, W. W. D., 15.

ARALES.

Araceæ

Arisaema triphyllum (L.) Schott. L. H. P., R. H. C., 97; L. H. P., 14; 115, W. W. D. Woods, common.

Arisaema Dracontium (L.) Schott. L. H. P., 97, 13; L. H. P., R. H. C., 97; L. H. P., C. R. B., 98.

XYRIDALES.

Commelinaceæ

Tradescantia reflexa Raf. 315, W. W. D., 15.

LILIALES.

Liliaceæ

Uvularia grandiflora Sm. 116, W. W. D., 15. Woods, common.

Erythronium albidum Nutt. 117, W. W. D., 15. Woods, not uncommon.

Allium canadense L. L. H. P., R. H. C., 97.

Lilium philadelphicum L. L. H. P., 15.

Smilacina racemosa (L.) Desf. R. E. B., 02.

Polygonatum commutatum (R. & S.) Dietr. 118, W. W. D., 15. Woods, common.

Trillium nivale Riddell. E. Bissell, L. H. P., 10; 119, W. W. D., 15. Common.

Smilax herbacea L. 120, W. W. D., 15. Edge of upland wood.

Smilax ecirrhata (Engelm.) Wats. 121, W. W. D., 15.

Smilax hispida Muhl. L. H. P., 98; 45, J. V. E., 14; 122, W. W. D., 15.

Amaryllidaceæ

Hypoxis hirsuta (L.) Coville. 123, W. W. D., 15. With moss on hilltop.

ORCHIDALES.

Orchidaceæ

Cypripedium candidum Muhl. Edith Cairns, 97.
Cypripedium hirsutum Mill. Edith Cairns, 03.
Orchis spectabilis L. L. H. P., 15.
Habenaria bracteata (Willd.) R. Br.

DICOTYLEDONÆ.

Archiclamydeae.

SALICALES.

Salicaceæ

Salix nigra Marsh. L. H. P., 13; 124, W. W. D., 15. Along Pease creek and Des Moines river.

Salix amygdaloides Anders. 3473, W. D. Fitzgerald, R. F. M., 01; 3876, L. H. P., R. E. B., C. M. K., 03; 125, W. W. D., 15. Along Pease creek and in wet places on upland.

Salix longifolia Muhl. 3870, L. H. P., R. E. B., C. M. K., 03; H. S. Kellogg, 06; 125, W. W. D., 15. Valley of Pease creek and Des Moines river, abundant.

Salix discolor Muhl. L. H. P., 98.

Salix humilis Marsh. 3873, L. H. P., R. E. B., C. M. K., 03.

Populus tremuloides Michx. 126, W. W. D., 15. Exposed hilltops and level upland.

Populus grandidentata Michx. L. H. P., 02; 3898, L. H. P., R. E. B., C. M. K., 03; L. H. P., 13; 127, W. W. D. Dry slopes.

Populus deltoides Marsh. L. H. P., A. F. M., 12; 128, W. W. D. Valley of Pease creek and of Des Moines river.

JUGLANDALES.

Juglandaceæ

Juglans cinerea L. 129, W. W. D., 14. Wooded slopes, common.
Juglans nigra L. 130, W. W. D., 14. Common.
Carya ovata (Mill.) K. Koch. 131, W. W. D., 15. Frequent.
Carya cordiformis (Wang.) K. Koch. 132, W. W. D., 14. Hillsides.

FAGALAS.

Betulaceæ.

Corylus americana Walt. 133, W. W. D., 14. Dry hillsides, abundant.

Ostrya virginiana (Mill.) K. Koch. R. E. B., 02; L. H. P., 13; J. P. A., L. H. P., 13; 134, W. W. D., 15. Hillside, abundant.

Carpinus caroliniana Walt. L. H. P., 98; R. E. B., 02; 135, W. W. D., 14. Shaded hillsides, common.

Fagaceæ.

Quercus alba L. 3897, L. H. P., R. E. B., C. M. K., 03; 136, W. W. D., 15. Hillside and upland, common.

Quercus macrocarpa Michx. R. E. B., 02; 154, J. V. E., 98; 137, W. W. D., 14. Common.

Quercus Muhlenbergii Engelm. L. H. P., C. R. B., 98; 3906, L. H. P., R. E. B., C. M. K., 03; 138, W. W. D., 15. Upland and dry hillsides, not uncommon.

Quercus rubra L. 139, W. W. D., 15. Common.

URTICALES.

Urticaceæ.

Ulmus fulva Michx. L. H. P., C. R. B., 98; L. H. P., 98; 3943, L. H. P., R. E. B., C. M. K., 03; 18, J. V. E., 14; 140, W. W. D., 15. Common.

Ulmus americana L. 141, W. W. D., 15. Ravines and valleys.

Ulmus racemosa Thomas. 142, W. W. D., 15. Dry, rocky hillsides, and along Pease creek, rare.

Celtis occidentalis L. 143, W. W. D., 15. Valley of Des Moines river.

Cannabis sativa L. 144, W. W. D., 15. Pasture, east end of "Ledges".

Humulus lupulus L. 145, W. W. D., 15. Valley of Pease creek.

Morus rubra L. L. H. P., 98. (Probably just outside the mapped area.)

Laportea canadensis (L.) Gaud. 3927, L. H. P., R. E. B., C. M. K., 03; 42, J. V. E., 14; 146, W. W. D., 15. Woods, common.

Pilea pumila (L.) Gray. 147, W. W. D., 15. Low woods, common.

SANTALALES.

Santalaceæ.

Comandra umbellata (L.) Nutt. L. H. P., 92, 02, 12, 13; 3897, L. H. P., R. E. B., C. M. K., 03; 148, W. W. D. Dry exposed south slope.

ARISTOLOCHIALES.

Aristolochiaceæ.

Asarum canadense L. 3936, L. H. P., R. E. B., C. M. K., 03; L. H. P., '10; 149, W. W. D., 15. Damp shaded locations, common.

POLYGONALES.

Polygonaceæ.

Rumex crispus L. 150, W. W. D., 15. Fields.

Rumex altissimus Wood. 151, W. W. D., 15. Fields in valley of Des Moines river.

Rumex acetosella L. L. H. P., 15.

Polygonum aviculare L. 152, W. W. D., 15. Common weed.

Polygonum convolvulus L. 300, W. W. D., 15. Field, common.

Polygonum virginianum L. L. H. P., R. F. M., 12.

Fagopyrum esculentum Moench. L. H. P., 02.

CHENOPODIALES.

Chenopodiaceæ.

Chenopodium album L. 153, W. W. D., 15. Common weed.

Salsola Kali L. var. *tenuifolia* G. F. W. Mey. 154, W. W. D., 15. Weed, rare.

Amaranthaceæ.

Amaranthus retroflexus L. 155, W. W. D., 15. Common weed.

Amaranthus graecizans L. 156, W. W. D., 15.

CARYOPHYLLALES.

Caryophyllaceæ.

Silene stellata (L.) Ait. 3863, L. H. P., R. E. B., C. M. K., 03; 51, J. V. E., 14; 158, W. W. D., 15.

Silene nivea (Nutt.) Otth. 3954, L. H. P., R. E. B., C. M. K., 03.

Saponaria officinalis L. 159, W. W. D., 15. Roadside.

Claytonia virginica L. 160, W. W. D., 15. Common in woods.

RANUNCULALES.

Portulacaceæ.

Ranunculus aquatalis L. var. *capillaceous* DC. L. H. P., 9.

Ranunculus rhomboideus Goldie. L. H. P., 98.

Ranunculus abortivus L. 161, W. W. D., 15. Damp hillsides, common.

Ranunculus septentrionalis Poir. 162, W. W. D., 15. Wooded hillsides, common.

Thalictrum dioicum L. L. H. P., 98, 13; R. E. B., 03; 163, W. W. D., 15. Hillsides, common.

Hepatica acutiloba DC. 164, W. W. D., 15. Shaded hillside, common.

Anemone virginiana L. R. E. B., 02; 3884, L. H. P., R. E. B., C. M. K., 03; L. H. P., 13; 165, W. W. D., 15. Hillsides, frequent.

Anemone quinquefolia L. 294, W. W. D., 15. Woods, common.

Clematis virginiana L. 30, J. V. E., 14.

Isopyrum biternatum (Raf.) L. & G. 166, W. W. D., 15. Hillsides, common.

Aquilegia canadensis L. L. H. P., 98; 167, W. W. D., 15. Hillsides, common.

Actaea rubra (Ait.) Willd. 3917, L. H. P., R. E. B., C. M. K., 03; 168, W. W. D., 14. Shaded hillsides.

Menispermaceæ.

Menispermum canadense L. 6, J. V. E., 14; 169, W. W. D., 14. Common.

Berberidaceæ.

Podophyllum peltatum L. 170, W. W. D., 15. Common in woods.

PAPAVERALES.

Papaveraceæ.

Sanguinaria canadensis L. 171, W. W. D., 15. Open woods, frequent.

Fumariaceæ.

Dicentra cucullaria (L.) Bernh. 172, W. W. D., 15.

Cruciferæ.

Draba verna L. 173, W. W. D., 15. Roadsides, fields.

Draba caroliniana Walt. 174, W. W. D., 15. Woods and fields.

Lepidium virginicum L. 175, W. W. D., 15. Fields and roadsides, common.

Lepidium apetalum Willd. L. H. P., 15.

Capsella bursa-pastoris (L.) Medic. 176, W. W. D., 15. Fields and roadsides, common.

Brassica nigra (L.) Koch. R. E. B., 02.

Sisymbrium canescens Nutt. L. H. P., 98; L. H. P., C. R. B., 98.

Sisymbrium officinale (L.) Scop. 301, W. W. D., 15. Fields.

Erysimum cheiranthoides L. 3869, L. H. P., R. E. B., C. M. K., 03.

Radicula palustris (L.) Moench. 3954, L. H. P., R. E. B., C. M. K., 03.

Dentaria laciniata Muhl. 177, W. W. D., 15. Hillside, common.

Cardamine bulbosa (Schreb.) B. S. P. L. H. P., C. J. Griffiths, R. H. C., 97; 157, W. W. D., 15. Roadside ditch.

Cardamine hirsuta L. 3928, 3975, L. H. P., R. E. B., C. M. K., 03.

Arabis laevigata (Muhl) Poir. 3870, L. H. P., R. E. B., C. M. K., 03.

Arabis canadensis L. R. E. B., 03.

ROSALES.

Saxifragaceæ.

Heuchera villosa Michx. L. H. P., 02.

Mitella diphylla L. L. H. P., C. R. B., 98; 162, L. H. P., R. E. B., C. M. K., 03; 180, W. W. D., 15. Damp shaded hillsides.

Ribes Cynosbati L. L. H. P., 96, 02, 13; 8, J. V. E., 14; 181, W. W. D., 15. Common.

Ribes floridum L'Her. L. H. P., 15.

Ribes gracile Michx. 182, W. W. D., 15. Common.

Rosaceæ.

Physocarpus opulifolius (L.) Maxim. L. H. P., 13; 184, W. W D., 15. Wooded slopes.

Pyrus ioensis (Wood.) Bailey. L. H. P., R. H. C., 97; L. H. P., 06; 185, W. W. D., 15. Frequent.

Amelanchier canadensis (L.) Medic. L. H. P., 02, 13; 186, W. W. D., 15.

Crataegus punctata Jacq. L. H. P., 98; 3427, L. H. P., R. E. B., C. M. K., 03; 187, W. W. D., 15. Frequent.

Crataegus tomentosa L. R. E. B., 02.

Crataegus mollis (T. & G.) Scheele. L. H. P., 98; 188, W. W. D., 15. Common.

Fragaria virginiana Duchesne var. *illinoisensis* (Prince) Gray. 189, W. W. D., 15. Common.

Fragaria vesca L. var. *americana* Porter. L. H. P., 98; 3964, L. H. P., R. E. B., C. M. K., 03; 190, W. W. D., 15. On rocky hillside.

Potentilla arguta Pursh. R. E. B., 02.

Potentilla monspeliensis L. 292, W. W. D., 15. Fields.
Potentilla canadensis L. L. H. P., 02.
Rubus idaeus var. *aculeatissimus* (C. A. Mey.) Regel & Tiling. L. H. P., 98.
Rubus occidentalis L. 191, W. W. D., 15. Frequent.
Rubus villosus Ait. 192, W. W. D., 15. Frequent.
Agrimonia striata Michx. 3956, L. H. P., R. E. B., C. M. K., 03.
Rosa pratincola Greene. L. H. P., 98; 193, W. W. D., 15. Frequent.
Rosa blanda Ait. L. H. P., 98.
Prunus serotina Ehrh. L. H. P., C. R. B., 98; 194, W. W. D., 15. Not uncommon.
Prunus virginiana L. 3923, L. H. P., R. E. B., C. M. K., 03; 195, W. W. D., 15. Common.
Prunus pennsylvanica L. L. H. P., 14. Rare.
Prunus americana Marsh. L. H. P., 97; 3881, L. H. P., R. E. B., C. M. K., 03; 196, W. W. D., 15. Common.

Leguminosæ.

Gymnocladus dioica (L.) Koch. 197, W. W .D., 15. Rare.
Gleditsia triacanthos L. L. H. P., 00; 197, W. W. D., 15. Frequent.
Baptisia bracteata (Muhl.) Ell. 135, J. V. E., 14.
Trifolium pratense L. 198, W. W. D., 14. Escaped to fence rows.
Melilotus officinalis (L.) Lam. 199, W. W. D., 14. Roadsides.
Melilotus alba Desr. 200, W. W. D., 15. Roadsides and old fields.
Medicago sativa L. 201, W. W. D., 15. Old field.
Amorpha canescens Pursh. 3991, L. H. P., R. E. B., C. M. K., 03; 202, W. W. D., 15.
Petalostemum purpureum (Vent.) Rydb. R. E. B., 02.
Petalostemum candidum Michx. 3865, L. H. P., R. E. B., C. M. K., 03.
Robinia pseudo-acacia L. 3901, L. H. P., R. E. B., C. M. K., 03.
Astragalus caryocarpus Ker. L. H. P., 00.
Astragalus canadensis L. R. E. B., 02; 3918, L. H. P., R. E. B., C. M. K., 03; 203, W. W. D., 15. Exposed hillside.
Desmodium grandiflorum (Michx.) DC. R. E. B., 02; 204, W. W. D., 15. Rich woods.
Desmodium Dillenii Darl. R. E. B., 02.

Desmodium canadense (L.) DC. 52, J. V. E., 14.

Lespedeza capitata Michx. R. E. B., 02; 205, W. W. D., 15. Dry exposed slopes.

Vicia caroliniana Walt. L. H. P., R. H. C., 97.

Vicia americana Muhl. L. H. P., 13; 206, W. W. D., 15. In woods, common.

Lathyrus ochroleucus Hook. L. H. P., C. R. B., 98; L. H. P., 99; L. H. P., R. F. M., 12; 207, W. W. D., 15. Dry slopes.

Strophostyles helvola (L.) Britton. L. H. P., 15.

Amphicarpa monoica (L.) Ell. 56, J. V. E., 14.

GERANIALES.

Oxalidaceæ.

Oxalis corniculata L. R. E. B., 02; 3871, L. H. P., R. E. B., C. M. K., 03. Common.

Oxalis violacea L. L. H. P., 15.

Geraniaceæ.

Geranium maculatum L. 208, W. W. D., 15. Common.

Rutaceæ.

Zanthoxylum americanum Mill. 209, W. W. D., 15. Frequent.

Polygalaceæ.

Polygala senega L. L. H. P., C. R. B., 98; L. H. P., 02; 210, W. W. D., 15. Dry slopes.

Polygala sanguinea L. R. E. B., 02; 3957, L. H. P., R. E. B., C. M. K., 03.

Polygala verticillata L. 3855, L. H. P., R. E. B., C. M. K., 03.

Euphorbiaceæ.

Acalypha virginica L. 211, W. W. D., 15. Fields, common.

Euphorbia Preslii Guss. R. E. B., 02; 212, W. W. D., 15. Fields.

Euphorbia corollata L. 3668, L. H. P., R. E. B., C. M. K., 03.

SAPINDALES.

Anacardiaceæ.

Rhus glabra L. R. E. B., 02; 213, W. W. D., 15. Common on dry slopes.

Rhus toxicodendron L. 22, J. V. E., 14; 214, W. W. D., 14. Frequent.

Celastraceæ.

Evonymus atropurpureus Jacq. R. E. B., 02; 215, W. W. D., 14. Common.

Celastrus scandens L. R. E. B., 02; J. P. A., 13; 216, W. W. D., 14. On wooded slopes.

Staphylaceæ.

Staphylea trifolia L. 2900, L. H. P., R. E. B., C. M. K., 03; 217, W. W. D., 15. On damp shaded slopes.

Aceraceæ.

Acer saccharum Marsh. var. *nigrum* (Michx. f.) Britton. L. H. P., 98; R. E. B., 02; 218, W. W. D., 14. Common on slopes and in upland woods.

Acer saccharinum L. 9, J. V. E., 14; 219, W. W. D., 15. Valley of Des Moines river.

Acer negundo L. 3885, R. E. B., 02; 220, W. W. D., 15. Along Pease creek and Des Moines river.

Balsaminaceæ.

Impatiens pallida Nutt. 3939, L. H. P., R. E. B., C. M. K., 03; 221, W. W. D., 15. In damp shaded locations.

Impatiens biflora Walt. 61, J. V. E., 14.

RHAMNALES.

Rhamnaceæ.

Rhamnus lanceolata Pursh. L. H. P., C. R. B., 98.

Ceanothus americanus L. R. E. B., 02; 35, J. V. E., 14; 222, W. W. D., 15.

Vitaceæ.

Psedera quinquefolia L. 223, W. W. D., 15. Common.

Vitis vulpina L. L. H. P., 98; R. E. B., 02; 26, J. V. E., 14; 224, W. W. D., 15.

MALVALES.

Tiliaceæ.

Tilia americana L. 225, W. W. D., 15. Frequent in fields.

Abutilon Theophrasti Medic. 226, W. W. D., 15. Fields.

VIOLALES.

Cistaceæ.

Lechea villosa Ell. 3952, L. H. P., R. E. B., C. M. K., 03.

Violaceæ.

Viola cucullata Ait. 3946, L. H. P., R. E. B., C. M. K., 03; 308, W. W. D., 15. Common.

Viola pubescens Ait. L. H. P., R. H. C., 97; 309, W. W. D., 15. Common.

MYRTALES.

Thymelæaceæ.

Dirca palustris L. 4020, R. E. B., 02; 310, W. W. D., 15. On damp shaded ledge; one station only.

Onagraceæ.

Oenothera biennis L. 3868, L. H. P., R. E. B., C. M. K., 03; 311, W. W. D., 15. Fields.

UMBELLALES.

Araliaceæ.

Aralia racemosa L. R. E. B., 02; 2976, 2933, L. H. P., R. E. B., C. M. K., 03; 312, W. W. D., 15. Damp woods.

Aralia nudicaulis L. L. H. P., 13; 313, W. W. D., 15. Woods, common.

Panax quinquefolium L. 314, W. W. D., 15. Very rare.

Umbelliferæ.

Sanicula marilandica L. L. H. P., C. R. B., 98; L. H. P., 13.

Chaerophyllum procumbens (L.) Crantz. L. H. P., 98, 00.

Osmorhiza Claytoni (Michx.) Clarke. L. H. P., R. E. B., C. M. K., 03; 227, W. W. D., 15. In woods, frequent.

Osmorhiza longistylis (Torr.) DC. 228, W. W. D., 15. In damp woods, infrequent.

Cicuta maculata L. 3944, L. H. P., R. E. B., C. M. K., 03; 229, W. W. D., 14. Valley of Des Moines river.

Cryptotaenia canadensis (L.) DC. L. H. P., 98; 3932, L. H. P., R. E. B., C. M. K., 03.

Zizia aurea (L.) Koch. L. H. P., 98; 23, J. V. E., 14; 230, W. W. D., 15.

Zizia cordata (Walt.) DC. R. E. B., 02.

Taenidia integerrima (L.) Drude. L. H. P., R. H. C., 97; L. H. P., 98; 3898, L. H. P., R. E. B., C. M. K., 03.

Pastinaca sativa L. 231, W. W. D., 15. Roadside.

Heracleum lanatum Michx. L. H. P., 13; 70, J. V. E., 14; 316, W. W. D., 15.

Cornaceæ.

Cornus circinata L'Her. 3968, L. H. P., R. E. B., C. M. K., 03; 232, W. W. D., 15. Rocky hillsides, infrequent.

Cornus asperifolia Michx. 3886, L. H. P., R. E. B., C. M. K., 03; 233, W. W. D., 15. Hillsides.

Cornus amomum Mill. R. E. B., 02; 3932, L. H. P., R. E. B., C. M. K., 03; 234, W. W. D., 15.

Cornus alternifolia L. f. 3961, L. H. P., R. E. B., C. M. K., 03; L. H. P., J. P. A., 13; 235, W. W. D., 15. Frequent.

ERICALES.

Ericaceæ.

Monotropa uniflora L. L. H. P., 15.

PRIMULALES.

Primulaceæ.

Steironema ciliatum (L.) Raf. 3907, L. H. P., R. E. B., C. M. K., 03.

GENTIANALES.

Oleaceæ.

Fraxinus americana L. 236, W. W. D., 15. Uplands and wooded hillsides, common.

Fraxinus pennsylvanica Marsh. 37, J. V. E., 15; 237, W. W. D., 15. Infrequent.

Fraxinus pennsylvanica Marsh. var. *lanceolata* (Borkh.) Sarg. L. H. P., 15.

Fraxinus nigra Marsh. L. H. P., 98; 3895, L. H. P., R. E. B., C. M. K., 03; L. H. P., 13; 238, W. W. D., 15. Frequent in ravines and in valley of Pease creek.

Apocynaceæ.

Apocynum androsaemifolium L. 239, W. W. D., 15. On dry wooded hillsides.

Apocynum cannabinum L. L. H. P., 14.

Asclepiadaceæ.

Asclepias incarnata L. 69, J. V. E., 14.

Asclepias syriaca L. 240, W. W. D., 15.

Asclepias verticillata L. L. H. P., 15.

POLEMONIALES.

Convolvulaceæ.

Convolvulus sepium L. 241, W. W. D., 15. In fields along Des Moines river.

Ipomoea hederacea Jacq. L. H. P., 15.

Polemoniaceæ.

Phlox divaricata L. J. V. E., 14; 242, W. W. D., 15. Common in woods.

Phlox pilosa L. L. H. P., 00; 243, W. W. D., 15. On dry slopes, frequent.

Hydrophyllaceæ.

Hydrophyllum appendiculatum Michx. 3885, L. H. P., R. E. B., C. M. K., 03.

Hydrophyllum virginianum L. 244, W. W. D., 15. Common in woods.

Ellisia nyctelea L. 245, W. W. D., 15. Damp woods, common.

Boraginaceæ.

Cynoglossum officinale L. L. H. P., 15.

Cynoglossum boreale Fernald. L. H. P., 15.

Luppula virginiana (L.) Greene. 3921, L. H. P., R. E. B., C. M. K., 03; 246, W. W. D., 15. Woods, common.

Symphytum officinale L. L. H. P., 15. Near mouth of Pease creek.

Mertensia virginica (L.) Link. L. H. P., E. Bissel; 247, W. W. D., 15. Valley of Pease creek.

Lithospermum latifolium Michx. 3859, L. H. P., R. E. B., C. M. K., 03.

Lithospermum canescens (Michx.) Lehm. 19, J. V. E., 14.

Onosmodium occidentale Mackenzie. 299, W. W. D., 15. Exposed hillsides.

Verbenaceæ.

Verbena urticaefolia L. 3920, L. H. P., R. E. B., C. M. K., 03.

Verbena hastata L. 3872, L. H. P., R. E. B., C. M. K., 03; 155, J. V. E., 14.

Verbena stricta Vent. 290, W. W. D., 15. Pastures.

Verbena bracteosa Michx. 3882, L. H. P., R. E. B., C. M. K., 03; 317, W. W. D., 15.

Lippia lanceolata Michx. L. H. P., 13.

Labiatæ.

Teucrium canadense L. 3971, L. H. P., R. E. B., C. M. K., 03; L. H. P., J. P. A.; 39, J. V. E., 14; 248, W. W. D., 15. Shaded hillsides.

Agastache nepetoides (L.) Ktze. 249, W. W. D., 15. Common in valley of Pease creek.

Nepeta cataria L. 3893, L. H. P., R. E. B., C. M. K., 03; 250, W. W. D., 15. About abandoned dwellings.

Nepeta hederacea (L.) Trevisan. L. H. P., 13; 288, W. W. D., 15. In pastured ravine.

Prunella vulgaris L. 3862, L. H. P., R. E. B., C. M. K., 03; 251 W. W. D., 15.

Stachys palustris L. L. H. P., 98; 3931, L. H. P., R. E. B., C. M. K., 03.

Monarda fistulosa L. R. E. B., 02; 252, W. W. D., 14. Common along Pease creek.

Hedeoma hispida Pursh. L. H. P., 99, 00.

Pycnanthemum virginianum (L.) Durand & Jackson. L. H. P., 15.

Mentha spicata L. 253, W. W. D., 15.

Solanaceæ.

Solanum carolinense L. L. H. P., C. R. B., 97.

Solanum nigrum L. L. H. P., C. R. B., '97; 270, W. W. D., 14.

Physalis subglabrata (L.) Mackenzie & Bush. R. E. B., 97.

Physalis pruinosa L. 306, W. W. D., 15. Des Moines river valley.

Lycium halimifolium Mill. 254, W. W. D., 15. Escaped from door-yard.

Datura stramonium L. R. E. B., 02; 271, W. W. D., 14.

Scrophulariaceæ.

Verbascum thapsus L. L. H. P., 02; 13, J. V. E., 14.

Scrophularia leporella Bicknell. 296, W. W. D., 14. Woods, frequent.

Chelone glabra L. L. H. P., 15.

Mimulus ringens L. 3875, L. H. P., R. E. B., C. M. K., 03.

Veronica peregrina L. 295, W. W. D., 15.

Pedicularis canadensis L. L. H. P., 95; J. V. E., 14; 293, W. W. D., 15. Rocky hillsides, etc.

Phrymaceæ.

Phryma leptostachya L. L. H. P., R. E. B., C. M. K., 03.

Plantaginaceæ.

Plantago major L. J. V. E., 14; 255, W. W. D., 15.

Rubiaceæ.

Galium aparine L. 3947, L. H. P., R. E. B., C. M. K., 03; 272, W. W. D., 15.

Galium circaezans Michx. 24, J V E., 14; 273, W. W. D., 15.

Galium boreale L. 3969, L. H. P., R. E. B., C. M. K., 03; L. H. P., 13; 274, W. W. D., 15.

Galium boreale L. 3969, L. H. P., R. E. B., C. M. K., 03; L. H. P., 13; 275, W. W. D., 15.

Galium trifidum L. 3916, L. H. P., R. E. B., C. M. K., 03; 276, W. W. D., 15.

Caprifoliaceæ.

Lonicera diocica L. L. H. P., R. H. C., 97; 277, W. W. D., 15.

Viburnum pubescens (Ait.) Pursh. L. H. P., 98; 3965, R. E. B., 02; 25, J. V. E., 14; 278, W. W. D., 14.

Sambucus canadensis L. J. P. A., L. H. P., 13; 279, W. W. D., 15.

CAMPANULALES.

Cucurbitaceæ.

Sicyos angulatus L. 26, L. H. P., C. R. B., 96; 256, W. W. D., 15. Des Moines valley, common.

Campanula americana L. 3950, L. H. P., R. E. B., C. M. K., 03.

Lobeliaceæ.

Lobelia spicata Lam. 3880, L. H. P., R. E. B., C. M. K., 03; 21, J. V. E., 14.

Lobelia siphilitica L. R. E. B., 02.

Compositæ.

Vernonia fasciculata Michx. 257, W. W. D., 15. In open upland woods.

Eupatorium urticaefolium Reichard. L. H. P., 15. In woods, common.

Eupatorium perfoliatum L. L. H. P., 15. Along Pease creek.

Eupatorium purpureum L. var. *maculatum* (L.) Darl. L. H. P., 15. In damp woods.

Kuhnia eupatoroides L. 258, W. W. D., 14. Dry, exposed hillsides.

Liatris pycnostachya Michx. L. H. P., 15. Dry hillside.

Solidago latifolia L. 28, 29, J. V. E., 14; 259, W. W. D., 14.

Solidago ulmifolia Muhl. R. E. B., 02; 3894, L. H. P., R. E. B., C. M. K., 03; 260, W. W. D., 14. Dry slopes.

Solidago radula Nutt. R. E. B., 02.

Solidago canadensis L. 261, W. W. D., 15. Wooded hillsides.

Solidago altissima L. 262, W. W. D., 15. Wooded slopes.

Solidago rigida L. R. E. B., 02.

Boltonia asteroides (L.) L'Her. L. H. P., 15.

Aster cordifolius L. 48, L. H. P., C. R. B., 96; 263, W. W. D., 14. Wooded slopes.

Aster sagittifolius Wedemeyer. R. E. B., 02; 3967, L. H. P., R. E. B., C. M. K., 03; 264, W. W. D., 15.

Erigeron philadelphicus L. L. H. P., 02; 12, J. V. E., 14; 265, W. W. D., 15. Common.

Erigeron annuus (L.) Pers. L. H. P., R. H. C., 97; 3864, L. H. P., R. E. B., C. M. K., 03; 307, W. W. D., 15. Fields and exposed slopes.

Erigeron canadensis L. L. H. P., 02; 12, J. V. E., 14.

Antennaria plantaginifolia (L.) Richards. 266, W. W. D., 15. Common on hillsides.

Silphium perfoliatum L. 3910, L. H. P., R. E. B., C. M. K., 03.

Silphium laciniatum L. 298, W. W. D. Dry exposed hillsides. Infrequent.

Ambrosia trifida L. 267, W. W. D., 14. River valley, etc., common.

Ambrosia artemisiifolia L. 267, W. W. D., 14. Upland fields, common.

Ambrosia psilostachya DC. L. H. P., 15.

Xanthium canadense Mill. R. E. B., 02; 268, W. W. D., 15. Fields, common.

Heliopsis scabra Dunal. 3913, L. H. P., R. E. B., C. M. K., 03; 268, W. W. D., 15. Frequent.

Rudbeckia hirta L. 3948, L. H. P., R. E. B., C. M. K., 03; 269, W. W. D., 15.

Helianthus grosseseratus Martens. L. H. P., 15.

Helianthus strumosus L. L. H. P., 15.

Helianthus tuberosus L. L. H. P., C. R. B., 96; R. E. B., 02; 49, J. V. E., 14; 270, W. W. D., 15.

Coreopsis palmata Nutt. 3866, L. H. P., R. E. B., C. M. K., 03; L. H. P., 13.

Bidens discoidea (T. & G.) Britton. L. H. P., 15.

Bidens frondosa L. L. H. P., 15.

Bidens cernum L. L. H. P., C. R. B., 98; 280, W. W. D., 15. Valley of Pease creek.

Helenium autumnale L. L. H. P., 15.

Dyssodia papposa (Vent.) Hitchc. L. H. P., 15.

Achillea Millefolium L. L. H. P., 13; 281, W. W. D., 15. Valley of Pease creek.

Matricaria suaveolens (Pursh.) Buchenau. L. H. P., 15. About dwelling at head of Pease creek.

Tanacetum vulgare L. L. H. P., J. P. A., 13.

Cacalia tuberosa Nutt. L. H. P., 15. Fields and open spaces.

Senecio balsamifera Muhl. L. H. P., 15. Hillsides and open spaces.

Arctium minor Bernh. 63, J. V. E., 14; 282, W. W. D., 15. Roadsides.

Cirsium discolor (Muhl.) Spreng. R. E. B., 02.

Cirsium lanceolatum (L.) Hill. L. H. P., 15. Along Pease creek.

Cirsium ioense (Pammel) Fernald. L. H. P., 15. In open places.

Taraxacum officinale Weber. 283, W. W. D., 15. Pastures and roadsides, common.

Sonchus oleraceus L. 284, W. W. D., 15. Roadsides and pastures.

Lactuca canadensis L. 43, J. V. E., 14.

Lactuca scariola L. L. H. P., 15. Along Pease creek.

Lactuca floridana (Lam.) Hitch. 297, W. W. D., 15. Woods, frequent.

Prenanthes alba L. R. E. B., 02; 47, J. V. E., 14; 285, W. W. D., 14. Common on wooded hillsides.

Key to initials used in the Catalogue:

J. P. A. ....J. P. Anderson
C. R. B. ....C. R. Ball
R. E. B. ....R. E. Buchanan
R. H. C. ....R. H. Combs
W. W. D. ....W. W. Diehl
J. V. E. ....J. V. Ellis
C. M. K. ....Miss C. M. King
R. F. M. ....R. F. Miller
L. H. P. ....L. H. Pammel

Acknowledgment is gratefully made to Dr. L. H. Pammel, under whose direction this study was made, for aid and advice in the work and for help in determining many of the plants. Thanks are due also to the members of the staff of the Department of Botany of Iowa State College for many suggestions in effecting the work. Acknowledgment is made to Mr. R. I. Cratty of Armstrong, Iowa, for determining the various species of Carex.

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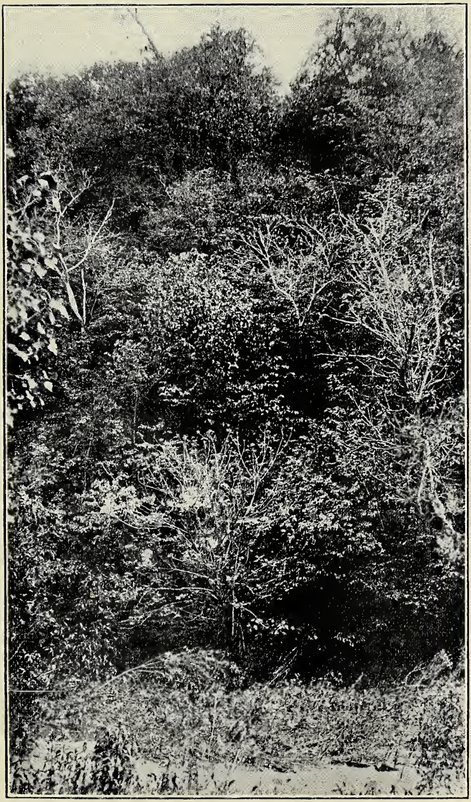
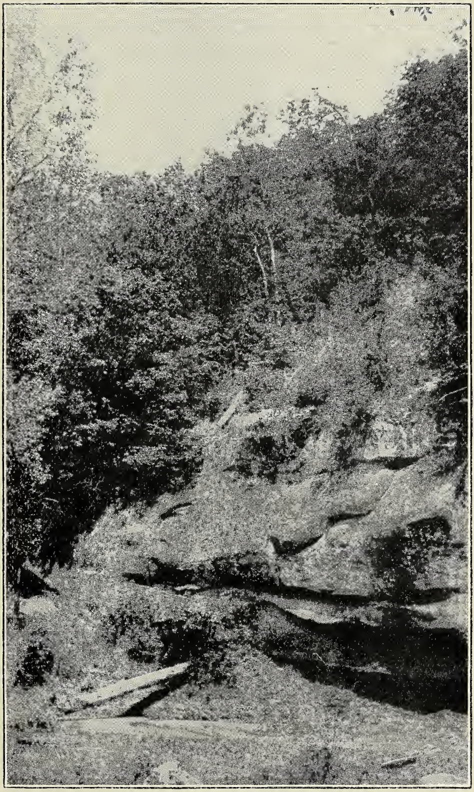


North slope of the strip survey.

PLATE XIX.



South slope of the strip survey.

EARLY IOWA LOCALITY RECORDS.

B. SHIMEK.

Students of plant and animal distribution are naturally interested in exact geographic designation, and they frequently suffer inconvenience from the inaccuracy or misconception of locality names. Confusion in our western records sometimes arises because the earlier explorers worked in an unsettled wilderness in which accurate geographic designation was difficult or impossible, and again from the fact that names were often at first applied to larger areas than those to which the name is at present restricted.

Some such cases have come under the writer's notice recently in his effort to secure full records of Iowa plants and mollusks. The locality which attracted special attention is that which is designated as "Council Bluff," or "Council Bluffs," in various reports on plants, mollusks, insects, etc. This is the locality made memorable by the visit of Thomas Say, who spent parts of the years 1819 and 1820 at the Engineer Cantonment near Council Bluff, and who reported and described many species of mollusks, insects and vertebrates from this locality. Later, in 1839, the Nicollet Expedition visited the same locality and collected numerous plants which were submitted for determination to Dr. Torrey.

Say's "Council Bluff" is generally considered the same as the Council Bluffs, Iowa, of today, but this is clearly not correct. The present city of Council Bluffs, Iowa, is located on the east side of the Missouri river, and about twenty-two miles above the mouth of the Platte river in Nebraska. Naturally the references to Council Bluff or Council Bluffs would suggest the Iowa locality, but there can be no question that the locality to which Say and others refer is on the western, or Nebraska, side of the Missouri river, and more than twenty miles above the present city of Council Bluffs.

The name "Council Bluff" was originally applied to a locality at which Lewis and Clark held a council with the Ottoe and Missouri Indians, August 3, 1804.[1]

[1]See Original Journals of the Lewis and Clark Expedition, 1804-1806. (In full and exactly as written.) Edited by Reuben Gold Thwaites LL. D., 1904. Vol. I, p. 98. Coues' edition, Vol. I, p. 66, 1893.

Referring to this locality in his valuable edition of these Journals, Thwaites makes the following statement:[2]

"This is the origin of the name now applied to a city in Iowa opposite Omaha, Neb.; but Coues thinks . . . that the place of this council was higher up the river, on what was later the site of Ft. Calhoun, in the present Washington County, Nebraska. He also calls attention to the well known uncertainty and constant shifting of the Missouri's channels, rendering it difficult to identify historic points."

This cautious statement might give the impression that it is not quite certain that Coues' conclusion was right. But the evidence that this point is some distance above the city of Council Bluffs, and that it is on the Nebraska side of the Missouri river, is clear and the place may be readily identified from the early descriptions of Lewis and Clark and those who followed them later. This evidence may be briefly stated as follows:

In the acount of the journey up the Missouri river the Clark Journal states[3] that Camp No. 9 was located 10 miles above the "Platt River," and that in ascending the Missouri river from this point the party traveled 15 miles on July 27th (p. 91); 10¾ miles on July 28th (p. 93); 10 miles on July 29th (pp. 93, 94); and 3¼ miles on July 30th,—to Council Bluff,—making a total of 49 miles. This carries "Council Bluff" about 27 miles beyond the city of Council Bluffs (i.e., to the north). Some discrepancies occur in the distances reported in different parts of the Journals, but these do not materially affect the result. Thus in the Original Journal of Private Joseph Whitehouse[4] the distance from "the Great River Platt" to the first camp above (Camp 9) is given as 12 miles (p. 44); and the subsequent distances are given respectively as 15 miles (p. 46), 10 miles (p. 46), 11½ miles (p. 46), and 4 miles (p. 47),—making a total of 52½ miles. However, in his "Distances and Latitudes," p. 189, Whitehouse gives the distance along the river to the "Mouth of Plate River" as 632 miles, and to "Council Bluffs" as 682 miles, making the distance between these points 50 miles. The distances as given on the return trip, September 5th to 8th,

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[2]See volume I, p. 98—footnote.

[3]See the Thwaites edition, volume I. Unless otherwise stated the quotations from the Lewis and Clark Journals are taken from the Thwaites edition as this is an exact copy. The editor of the Coues' edition took greater liberties with the original Journals, and that edition is therefore less reliable.

[4]Volume VII of the Original Journals.

1806,[5] will give 49½ miles as this distance if the "5th" is substituted for the "4th" of August (a manifest error) on page 379. As noted these slight variations do not affect the general conclusion, and it is evident that the Council Bluff was not located near the present city of Council Bluffs.

No fluctuations in the course of the Missouri could account for the great difference in distance, and moreover, the Lewis and Clark record of courses and distances has made it possible to retrace the old course of the river, and this further confirms the conclusion that in that part of the Missouri river here under discussion the changes have not been sufficient to account for the difference between the distance from Council Bluffs Iowa, to the Platte river, and that from Council Bluff to the same point as recorded by Lewis and Clark.

Further corroboration is found in the fact that it is noted in the Original Journals[6] that on the 29th of July it was observed that on the S. S. (i.e., the starboard side, here the east side) of the Missouri "a creek comes in called Boyers R.," and on the following page it is noted that at 1¼ miles from that day's starting point the party "passed Bowyers R."[7] This is the Boyer river of today, and it now empties into the Missouri at a point about twelve miles above the city of Council Bluffs, but the Lewis and Clark record shows that the Boyer was then thirty-seven miles from the Platte, hence beyond the site of Council Bluffs, Iowa, and that Council Bluff was about twelve miles still farther north. It is thus certain that the Council Bluff of Lewis and Clark is north of the Boyer, whereas Council Bluffs, Iowa, is several miles south of that stream. The subsequent changes in the course of the Missouri have brought the mouth of the Boyer somewhat nearer to Council Bluffs, Iowa, but it is still clearly between the two points under discussion.

Another point of special importance in this connection is the record in the Clark Journal[8] that the landing place (at Council Bluff) was at "the lower part of a Bluff & High Prairie on L. S." "L. S." here means larboard side, as is clearly shown in many places in the Journals, "S. S.," which is also frequently used, meaning starboard side. The larboard side of a boat going

[5]See Original Journals, volume V, 376-380.

[6]Volume I, p. 93.

[7]This stream is also called Boyers River in the Original Journal of Sergeant Charles Floyd, Original Journals, Vol. VII, p. 22.

[8]Original Journals, Vol. I, p. 94.

north is the west side, hence the landing and camp at Council Bluff must have been on the west, or Nebraska, side of the Missouri river, whereas Council Bluffs, Iowa, is on the east side.

The distance of Council Bluff from the Platte, its distance and direction from the mouth of the Boyer, and its location on the west bank of the Missouri river seem to be sufficient to prove that the Council Bluff of Lewis and Clark was in Nebraska.

It is also evident that the Council Bluff of Lewis and Clark is the same as that of Say and Nicollet. Thirteen years after Lewis and Clark's return voyage, on which Council Bluff was again visited,[9] the Long Expedition established a winter camp "near the quarters of the troops at Council Bluffs (Camp Missouri)."[10]

A military expedition, under the command of Col. Henry Atkinson, had preceded the scientific expedition under Maj. Long, and established Camp Missouri at Council Bluff in September, 1819. On the 19th of September of the same year the Long party, which had ascended the Missouri river in the steamer "Western Engineer," established a winter cantonment "on the west bank of the Missouri, about half a mile above Fort Lisa, five miles below Council Bluff, and three miles above the mouth of Boyer's river."[11]

This camp was named "Engineer Cantonment," and Say refers to it frequently in his papers under that name, or simply as "Cantonment." It is in Nebraska.

It is further stated (p. 222) that "cliffs of sparry limestone rise in the rear of the site we had selected, to an elevation of near three hundred feet. At times of low water strata of horizontal sandstone are disclosed in the bed of the Missouri. These pass under and support the limestone."

And still further it is stated (p. 229) that "the Council Bluff, so called by Lewis and Clark, from a council with the Otoes and Missouries held there on the 3d of August, 1804, is a remarkable bank rising abruptly from the brink of the river, to an elevation of about one hundred and fifty feet."

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[9]Original Journals, volume V, p. 379.

[10]Account of an expedition from Pittsburgh to the Rocky Mountains performed in the years 1819, 1820—under the command of Major S. H. Long. Compiled from the notes of Major Long, Mr. T. Say, and other gentlemen of the party by Edwin James, botanist and geologist to the expedition. Published 1823. The original London edition, published in three volumes, was consulted by the writer, but the references herein given are to the Thwaites edition in four volumes published in 1905, as this is more accessible. The words quoted above appear in Vol. I, p. 12.

[11]This very full designation of the locality appears on p. 221, Vol. I, of the Thwaites edition of Long, and on p. 137 of the London edition.

These descriptions of topography and geologic formations are of especial interest because they do not at all apply to any part of the vicinity of Council Bluffs, Iowa, as any one familiar with the region under discussion will at once perceive.

It is evident that Long's party found the river and bluff at Council Bluff much as Lewis and Clark had described them. Long's map shows the great bend of the Missouri near Council Bluff, evidently about as it had appeared thirteen years before, and it also clearly shows the relative position of Boyer's River (so named on the map), Engineer Cantonment and Council Bluff.

The great bend of the Missouri river was still in existence in 1839 when Nicollet visited Council Bluff, and his map, compiled by Lieut. W. H. Emory,[12] shows the same relative position of Boyer River, Engineer Cantonment and Council Bluff as that indicated on Long's map. A great change, however, took place soon after as is shown by Nicollet's report, which, it should be remembered, was prepared two years after his observations at Council Bluff were made, and was not published until two more years had elapsed. Referring to the unstable character of the Missouri channel he says (p. 22): "Thus we could not recognize many of the bends described by Lewis and Clark; and most probably those determined by us in 1839, and laid down upon my map, will ere long have disappeared; such is the unsettled course of the river. Already have I been informed, in fact, that the great bend opposite Council Bluffs has disappeared since our visit; and that the Missouri, which then flowed at the foot of the bluff, is now further removed by several miles to the east of it." The extent of this change is indicated on the map of Harrison county, Iowa, published in the Reports of the Iowa Geological Survey, opposite p. 380, in Vol. XX, 1910. In this map the writer published the results of the Lewis and Clark survey, 1804, the U. S. survey, 1853, and the Wattles survey, 1898. Council Bluff was a little south of the south line of Harrison county, and on the opposite side of the Missouri river. If the change reported by Nicollet brought the river to the position indicated by the U. S. survey of 1853, which is not materially

[12]This map accompanies the report intended to illustrate A Map of the Hydrographic Basin of the Upper Mississippi River.—I. N. Nicollet.—1843. Submitted Feb. 16, 1841. Published as a Senate Document, 26th Congress, 2d Session.

different at this point from that shown by the Wattles survey of 1898, the shift eastward amounted to nearly five miles.[13]

The foregoing facts make it clear that the name Council Bluff was applied to the same locality by Lewis and Clark, Long and Nicollet, and that this locality is situated on the Nebraska side of the Missouri river more than 20 miles above the city of Council Bluffs, Iowa. The evidence is especially clear so far as it concerns the location of the Council Bluff of Say and Nicollet, and this is of greatest interest to students of distribution, for the reports of Say and Nicollet contain many references to this locality.

The term Council Bluffs was probably first publicly applied, at least in scientific literature, to hills on the Iowa side by D. D. Owen,[14] who refers to "Council Bluffs" on p. 132 of the Report, and marks the hills on the Iowa side, which extend from opposite the mouth of the Platte to northwestern Missouri, as "Council Bluffs."

It is evident from the foregoing discussion that the Council Bluff of Say's and Nicolet's reports, and all others based upon them, is a Nebraska locality, and this is also true of the "Engineer Cantonment," or "Cantonment." Where reference is made to "Bowyer's Creek," "Boyers River," or Boyer river, the locality is on the Iowa side. It is not probable that Say made many excursions to the Iowa side of the Missouri river, the broad prairie bottom-lands of that side being less inviting than the wooded bluffs of the Nebraska side, and the difficulty of crossing the Missouri probably adding an obstacle. His journal, copied by James, shows that he did occasionally cross to the Iowa side, and a longer trip was taken along the Boyer to the present site of Logan, Iowa.[15]

It may seem that the exact location of Council Bluff is not a matter of serious moment, but this locality is cited in many scientific papers and is therefore of interest to students of plant and animal distribution. In addition to the general desirability of accuracy there are two reasons for correcting the impression

[13]The old channel of the Missouri, indicated by dotted lines on the map of Pottawattamie county opposite p. 266 in Vol XI, Iowa Geological Survey, 1901, was probably determined by the U. S. survey of 1853, though the report does not state this. Pottawattamie county lies just south of Harrison county.

[14]Report of a geological survey of Wisconsin, Iowa and Minnesota, etc., 1852. Also map in "Illustrations" in same—the one marked "Sections on the Missouri River from no. 20 M., to no. 40 M."

[15]Thwaites' edition of Long, Vol. II, pp. 136-138; the London edition, Vol. II, pp. 67-69. See also the writer's brief discussion in Iowa Geological Survey, Vol. XX., p. 278.

that the Council Bluff of the earlier reports is Council Bluffs, Iowa. The two localities are on opposite sides of the Missouri river, and hence in different states, and the difference of about twenty-seven miles between them is sufficiently great to be of interest in connection with the preparation of state lists. Say invariably wrote the name *Council Bluff,* and most of the authors who subsequently copied his record used the same form. But in some cases, particularly those of more recent date, an effort was made to supply the name of the state or territory, and an error has resulted. Thus Frank C. Baker, in a recent work,[16] cites "Council Bluffs, Iowa," as the type locality for *Lymnaea umbrosa* Say, a form of *Galba elodes* (p. 324), and among the localities for *Galba elodes* appears the following: "*Iowa:* Missouri River, in the vicinity of Council Bluffs, Pottawattamie county (Say)." Say's original record mentions neither county nor state. The only accurate reference of Council Bluff to Nebraska which the writer has seen in locality citations of this kind appears in W. G. Binney's report on Land Shells in Warren's Explorations in Nebraska, to which subsequent reference will be made in this paper. Here (p. 125) the locality is given as "Council Bluff, N. T." (Nebraska Territory.)

More important than the difference in political divisions, however, is that between the ecological regions on the opposite sides of the Missouri river. The Nebraska side of the valley is bordered by less abrupt and more heavily wooded bluffs, while those bordering the Iowa side are formed by abrupt bald ridges which stand out in sharp contrast with those of the opposite side. These differences affect the local distribution of both plants and animals, and forest forms are much more common on the Nebraska side. For this reason it does make a difference whether Council Bluff is located on the east or the west side of the river.

For the convenience of those who are interested in the distribution records of our biota, and who do not have access to the older works which refer to Council Bluff, and to other localities in this part of the country, the writer here presents a series of notes on older Iowa records, with incidental references to the Council Bluff records, which it must be clearly understood do not belong to Iowa. It must also be remembered that the more recent references to Council Bluffs, where they are not mere

[16]The Lymnaeidae of North and Middle America—Special Publication, No. 3, Chicago Academy of Sciences, 1911.

copies of old records, as in the writer's papers on loess, etc., apply to Council Bluffs, Iowa, and not to the Nebraska locality.

The older reports on Iowa plants and animals follow:

PLANTS.

The earlier records of plants, namely those in the Lewis and Clark and the Long reports, are for the most part very unsatisfactory both as to identification (general and common names being used in part), and as to exact localities. Clark's Journal contains references to plants, mostly trees, which were observed as the party ascended the Missouri along the present boundary of Iowa, but it is usually impossible to determine on which side of the river they were observed, as they were mostly bottomland species. The only definite Iowa reference is that to the black walnut, which was observed on the return trip near Floyd's grave, near the present site of Sioux City.[17]

Concerning the plants collected by the Lewis and Clark expedition Pursh reports as follows:[18]

". . . a small but highly interesting collection of dried plants was put into my hands by this gentleman (i.e., Meriwether Lewis, then governor of Upper Louisiana) in order to describe and figure those I thought new. The collection of plants just spoken of was made during the rapid return of the expedition from the Pacific Ocean towards the United States. A much more extensive one made on their slow ascent towards the Rocky mountains and the chains of the Northern Andes, had unfortunately been lost, by being deposited among other things at the foot of those mountains." The latter collection probably contained some Iowa material. The small collection submitted to Pursh probably contained none, as all locality references to it in the text suggest localities west of the Missouri river.

In the account of the Long Expedition comparatively little is said of the flora, but in the description of the return of Major Long from St. Louis to Council Bluff a footnote, evidently referring to Iowa, states[19] that a Caenothus (smaller than *C. americana*), *Amorpha canescens*, and *Symphoria* (i.e., *Symphoricarpos) racemosa* "are almost the only shrubs seen on the prairie." Again, on the following page, in both editions, in connection with a description of the territory six miles below the

[17] Thwaites' edition, Vol. V, p. 376; Coues' edition, Vol. III, p. —.
[18] Flora Americana Septentrionalis, 1814 (2d edition 1816), p. x.
[19] Volume II, London edition, p. 109; Thwaites' edition, p. 186.

Platte, on the Iowa side, the following statement is made: "On the precipitous and almost naked argillaceous hills, which here bound the Missouri valley, we found the Oxytropis lamberti and the great flowering pentstemon; two plants of singular beauty. Here also we saw, for the first time, the leafless prenanthes, the yellow euchromia, and many other plants." The "pentstemon" is evidently *Pentstemon grandiflorus;* the "leafless prenanthes" is *Lygodesmia juncea;* and the "yellow euchromia" is *Castilleja (Euchroma) sessiliflora.*

Other less definite notes also occur, but they probably do not refer to Iowa.

The Nicollet report also contains some references to plants which may have been observed in Iowa (see p. 29), and in addition to this includes, on pp. 143 to 165, as Appendix B, a "Catalogue of plants collected by Mr. Charles Geyer, under the direction of Mr. I. N. Nicollet, during his exploration of the region between the Mississippi and Missouri rivers: By *Professor John Torrey, M. D.*" This contains specific references to plants collected at or near "Council Bluff", here undoubtedly the Council Bluff of Lewis and Clark on the Nebraska side of the river. On pages 144 to 168 of this catalogue forty-eight species of plants are specifically reported as occurring at or near Council Bluff, and these of course belong to the flora of Nebraska. Several other species are less definitely reported from the same general region, but it is impossible to determine on which side of the Missouri they were found.

This catalogue also contains certain Iowa species which were collected in other parts of the state. The Nicollet expedition visited the Spirit lake region, and the following specific reference to plants from that region are made:

Euonymus atropurpureus. Woods, Spirit Lake; common; p. 147.

Dalea alopecuroides (Willd.). Banks of Spirit Lake, etc; p. 148.

Darlingtonia (i.e., *Desmanthus*) *brachyloba var. glandulosa* (Torr. & Gray). Gravelly banks of Spirit Lake; p. 148.

Aster Novae-Belgii (Linn.), and *var. minor* (Torr. & Gray). Borders of Spirit Lake; p. 151.

Xanthium echinatum (Torr. & Gray). Banks of Spirit Lake and headwaters of Little Sioux river; p. 152.

Artemisia biennis (Nutt.). Arid banks of Spirit Lake, etc.; p. 153.

Solanum nigrum (Linn.). Sandy banks of Spirit Lake; p. 156.

Physalis viscosa (L.). Sandy banks of Spirit Lake; p. 156.

Euphorbia cyathophora (Willd.).[20] Sandy shores of Spirit Lake, etc.; p. 160.

Panicum virgatum (Linn.). Abundant on all the high prairies, but nowhere so luxuriant as near the Upper Des Moines river and Spirit Lake; p. 163.

Agrostis cryptandra (Torr.). Banks of Spirit Lake, Little Sioux river, etc.; p. 164.

Several additional species, reported from "between the Missouri and Mississippi rivers" also probably came from Iowa, but the references are not definite and the species are not listed here.

Another of the older Iowa plant catalogues was published by Dr. C. C. Parry in Owen's Report on the Geology of Wisconsin, Iowa and Minnesota, pp. 608-621. This catalogue specifically refers 205 species to Iowa, though probably many of the remaining species were also collected in the state, as Dr. Parry's home was in Davenport, Iowa. As the Owen report is quite accessible the species are not listed here.

ANIMALS.

Several groups of animals have been included in the reports of earlier explorations. The records of mollusks, insects, reptiles and birds are of especial interest, though mammals and fishes also received some notice.

Mollusks.

No reference to mollusks is made in the Lewis and Clark and Nicollet reports, nor in the narrative of the Long Expedition although Say, a student of mollusks, was a member of the party. However, Say reported a number of species from "Council Bluff" (in one case including Engineer Cantonment, also in Nebraska) in the Journal of the Academy of Sciences of Philadelphia in 1821,[21] and later in the American Conchology.[22]

These references were subsequently copied by Haldeman,[23] Amos Binney,[24] W. G. Binney in his edition of Say,[25] the Bibliography,[26] and the Land and Fresh-water Shells of North

[20]Now *E. heterophylla.*

[21]See Vol. II, pp. 150, 151, 159, 160, 161, 164, 172, and 173.

[22]Part IV, pp. 122, 142 (1832).; part VI, pp. 205, 206 (1834).

[23]A Monograph of the Limniades, etc., No. II, cover; No. IV, 1842, p. 25; No. VIII (no date), p. 4.

[24]The terrestrial Air-breathing Mollusks of the United States and Adjacent Territory, Vol. II, 1851, pp. 176, 178.

[25]1856, pp. 20, 21, 22, 63, 68.

[26]1863, pp. 258, 259, and 414. In this work the locality is sometimes changed to "Missouri," or "Upper Missouri," Nebraska at the time of Say's visit being a part of Missouri Territory.

America,[27] and by Gould in the Report on the Invertebrata of Massachusetts.[28] Baker, in the Lymnaeidae of North and Middle America,[29] also copies this reference to Council Bluff, but erroneously makes the locality Council Bluffs, Iowa, as already noted.

In 1859 W. G. Binney published a list of land shells (in Hayden's Report, p. 128, and copied on p. 414 of his Bibliography) which are credited to Council Bluff, N. T. (Nebraska Territory), and this is the only correct reference to this locality known to the writer. The list, however, contains several species which evidently were collected farther down the Missouri river.

Say's early reports contain but one undoubted reference to an Iowa locality. In the Journal of the Academy of Sciences of Philadelphia (Vol. II, p. 171) he reports *Physa gyrina* from "Bowyer Creek, near Council Bluff", which is on the Iowa side of the Missouri river opposite Council Bluff. The same reference is copied in W. G. Binney's Land and Fresh-water Shells of North America (part II, 1865, p. 77), but in his Bibliography (1863, p. 259) he quotes the locality as "Missouri".

Other early reports of Iowa mollusks may be of interest:

Haldeman's Monograph (No. I, 1840, p. 10) reports *Paludina integra* Say, from the Mississippi river in Iowa, and the report is reproduced in Binney's Bibliography, p. 66.

Wheatley's Catalogue (1845) includes the following species credited to Iowa:

Vitrina pellucida Drap. Iowa Terr.; p. 141.
Helix porcina Say (i. e., *Polygyra hirsuta*). Iowa; p. 142.
Pupa modesta Say. Iowa; p. 143.
Lymnaea megasoma Say. Iowa; p. 145.
Paludina (i. e., *Somatogyrus*) *subglobosa* Say. Iowa; p. 150.

From 1838 to 1849 Iowa Territory included Minnesota and the Dakotas east of the Missouri river, and it is probable that at least the first of the above listed species was not collected within the present limits of Iowa.

Prime's Monograph of American Corbiculadae (1865) contains the following species from Iowa:

Sphaerium sulcatum (Lam.) Pr.; p. 34.
Sphaerium striatinum (Lam.) Pr.; p. 37.
Sphaerium jayanum Pr.; p. 46.

[27]Part II, p. 116; part III, p. 12.
[28]1870, p. 287.
[29]1911, pp. 324, 326.

Binney's Land and Fresh-water Shells of North America (part II, 1865) contains the following:

Physa gyrina Say. Bowyer Creek, near Council Bluff; p 77.

Planorbis campanulatus Say. Quasquitan, (i. e., Quasqueton) Iowa; p. 110.

A. A. Gould reports *Helix monodon* from Iowa, on p. 420 of the Report on the Invertebrata of Massachusetts, 1870.

In several cases mollusks were reported from the Big Sioux river, as in Binney's Land and Fresh-water Shells of North America, part II, 1865, pp. 41, 44, 48, 67, 89, 105, 110, 121, 124, 134; part III, 1865, p. 83; in Roberts' Report on Mollusca, 1871, p. 467; and in Ingersoll's Special Report on the Mollusca, 1876, p. 405. In most of these cases it is impossible to determine whether the shells were collected on the Iowa or South Dakota side of the river, or in that part of the stream lying wholly within South Dakota. The former is more probable. In one case only is the reference given as ''Big Sioux river, Nebraska.'' This is in Roberts' Report. South Dakota was then a part of Nebraska Territory.

Insects.

In Say's American Entomology frequent references are made to ''Engineer Cantonment'' and ''Engineer Cantonment near Council Bluff'', and also to ''Council Bluff on the Missouri'' or ''in Missouri''. As noted, both localities are in Nebraska. Such references occur in volume I, on pp. 117 and 388, and in volume II, on pp. 32, 101, 128, 131, 135, 136, 138, 141, 144, 158, 167, 175, 196, 203, 231, 239, 243, 245, 246, 255, 257, 258, 259, 277, 528, 575, 579, 637. Several less definite references are also made to what are apparently Nebraska localities. The only definite Iowa references are the following, in volume II:

Colymbetes venustus—"in a pond near Bowyer Creek, Missouri"; p. 90.

Hydroporus undulatus—"In a pond near Bowyer Creek, Upper Missouri"; p. 99.

Fishes.

Few references to fishes occur in the older reports. The Lewis and Clark Journals (Thwaites' edition), Vol. I, p. 90, contain a reference to a ''white catfish'', probably *Ictalurus punctatus*,[30] probably from Iowa, and the narrative of the Long Expedition, (Thwaites' edition), Vol. I, p. 277, refers to a number of small fishes taken in a pond near the Boyer.

[30]See Coues' edition, Vol. I, p. 54.

Reptiles.

The only early references to reptiles of this region are based on Say's Council Bluff material. In the narrative of the Long Expedition (Thwaites' edition) several references are made to snakes, as on pp. 214 (footnote 163), 271 and 272. In the London edition the reptiles are listed in Appendix A, p. 267. Further references to Say's material from Engineer Cantonment are made in Holbrook's North American Herpetology, 1838, Vol. II, p. 99; Vol. III, pp. 13, 42, 48, 54, 87, 89; and Vol. IV, p. 78.

The only reference to Iowa reptiles appears in Thwaites' edition of Long, Vol. II, p. 139, where rattlesnakes are reported as occurring along Boyer creek.

Birds.

Few references to birds are made in the Lewis and Clark Journals. In Vol. I, Thwaites' edition, p. 90, several ''grous'' are reported to have been seen, and wild turkeys were also observed on the Iowa side, as recorded on pp. 90 and 101. Wild geese and pelicans are reported in Vol. V, p. 376.

In the Account of the Long Expedition, Thwaites' edition, Vol. I, many birds are reported from Engineer Cantonment. Such references occur in footnotes on pp. 214, 251, 252, 254, 255 and 284, and Appendix A contains a long list of birds from the same locality on pp. 318 to 328 in the Thwaites edition, and pp. 262 to 270 in the London edition.

The definite Iowa references in Long's Report, Thwaites' edition, are the following:

Limosa scolopacea, Vol. I, p. 253, footnote. "Pond near Bowyer Creek."

Swans, geese and ducks, near Sioux (Little Sioux) river; Vol. I, p. 278.

Sand-hill crane, along Boyer Creek; Vol. II, p. 137.

Mammals.

Frequent references to mammals collected or observed at or near Council Bluff are made in the older reports. Lewis and Clark, Vol. I, pp. 90 and 91, report deer and beaver, evidently from the Iowa side, and the Account of the Long Expedition, Thwaites' edition, Vol. I, p. 277, records one otter taken at a pond near the Boyer. Twelve bisons were killed, and an elk was seen near the Sioux (evidently Little Sioux) river, clearly in Iowa, as noted on p. 278. Other less definite references also occur.

A list of mammals obtained at Engineer Cantonment is given in the Long Report, on pp. 317 and 318 of the Thwaites edition, and pp. 261 and 262 of the Philadelphia and London editions. They of course represent the Nebraska fauna.

In considering references to localities such as Iowa, Missouri, etc., the following historical facts should be kept in mind:

In 1812 the northern part of Louisiana (including what is now Iowa) became "Missouri Territory."

In 1834 what is now Iowa was placed under the jurisdiction of Michigan.

In 1836 the same territory was attached to Wisconsin.

In 1838 Wisconsin was cut off and the remainder of its former territory was called Iowa Territory and included Minnesota and the Dakotas east of the Missouri river.

In 1849 Iowa was limited to its present territory, and Minnesota included the Dakotas to the Missouri river.

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THE ECOLOGICAL HISTOLOGY OF PRAIRIE PLANTS.

ELLA SHIMEK.

The investigation, the result of a part of which is here presented, was made for the purpose of ascertaining the character of the various structural adaptations to environment which appear in the ordinary plants of our Iowa prairies. Of the 271 characteristic species of our prairies 65, representing a wide range of families and genera, were selected for these studies. The material for this purpose was collected on the dry prairie ridges or bluffs in Harrison county, and on the less rugged prairie in the vicinity of the Okoboji lakes, and at Iowa City.

The limits of this paper do not permit a full presentation of the results of the work, but a few illustrations are given to show the chief characters which mark the flora of the prairie as essentially xerophytic.

The plants of the prairies usually show a reduced leaf surface, a large root system, a hairy or pubescent surface, or if smooth then leathery, and not infrequently may form rosettes for better protection. In short they present all the grosser structural adaptations which are usually recognized as characterizing xerophytes.

The microscopic structure, especially that of the leaves, also shows xerophytic adaptations, developed in various degrees. Frequently the impervious cutin is thick, as shown in figures 1 and 5, Plate XX; sometimes the stomatal guard cells are sunken in pits, as is shown in figures 1 and 2; the leaf parenchyma usually is very compact, while the intercellular spaces are very small; and various water-storage cells are developed.

The water storage tissues are usually of two types. The one consists of the bulliform cells of Duval-Joune, which form a part of the epidermis, as is shown in figure 8. The other is a chlorophylless parenchyma which usually surrounds the vascular bundles, as shown in figure 3, and which is known as border parenchyma. This sometimes extends in the form of a plate parallel to the two leaf surfaces, as is shown in figures 5 and 6; or it forms vertical plates or columns, as is shown in figures 4 and 8; or both may appear, as in figure 7. The first of these types is the most common.

The grouping of the xerophytic adaptations in the several species is brought out in the table which follows. It will be noticed that this grouping is quite irregular.

The following list contains the names of the plants which were specially studied. The Roman numerals at the heads of the columns apply to distinct xerophytic characters, and when the character is present it is marked with a plus sign. The explanation of the Roman numerals follows:

I.—Reduced leaf surface.
II.—The rosette habit.
III.—Large roots.
IV.—Spines or prickles on surface.
V.—Surface hairy or scaly.
VI.—With poisonous or offensive properties.
VII.—Milky.
VIII.—Tissues compact, with small intercellular spaces.
IX.—With thick cutin.
X.—Water-storage tissues, of the parenchymatous type.
XI.—Bulliform cells—water-storage.
XII.—Sunken stomata.
XIII.—Elongated palisade cells.

It is evident that the structural modifications of the prairie plants are distinctly xeromorphic, with considerable variation in the particular grouping of these characters.

Name of Species.	1	II	III	IV	V	VI	VII	VIII	IX	X*	XI	XII	XIII
Acerates viridiflora Ell.	+		+				+	+	+	+		+	+
Ambrosia psilostachya DC.	+				+			+	+	+			
Ambrosia artemisiaefolia L.	+				+			+				+	
Amorpha canescens Pursh.	+		+		+			+	+			+	+
Andropogon scoparius Michx.	+	+	+					+	+	+		+	
Andropogon furcatus Muhl.	+	+	+					+	+	+	+	+	
Anemone cylindrica A. Gray.					+			+	+			+	+
Aplopappus spinulosus (Pursh.) DC.	+		+					+	+	+			+
Artemisia ludoviciana Nutt.	+					+		+	+	+	+		+
Aster multiflorus exiguus Fern.	+		+		+			+	+	+	+		+
Aster laevis L.								+	+	+			+
Aster oblongifolius Nutt.	+		+	+	+			+	+	+		+	
Aster sericeus Vent.	+				+			+	+	+			+
Bouteloua curtipendula (Michx.) Torr.	+	+						+	+	+	+		
Brauneria pallida (Nutt.) Britt.	+		+	+	+			+	+	+		+	+
Cassia chamaecrista L.	+							+				+	+
Castilleja sessiliflora Pursh.	+	+	+		+			+	+			+	+
Ceanothus americanus L.			+		+			+	+				+
Ceanothus ovatus pubescens T. & G.			+		+			+		+		+	
Cenchrus carolinianus Walt.	+							+	+	+		+	
Chenopodium album L. (Introduced)								+	+	+			+
Cirsium iowense (Pam.) Fern.		+		+	+			+	+			+	+
Cirsium iowense Crattyi Fernald		+		+	+			+	+			+	+
Dalea alopecuroides Willd.	+							+	+			+	+
Dyssodia papposa (Vent.) Hitch.	+					+		+	+	+			+
Elymus canadensis L.	+							+	+	+			+
Erigeron canadense L.	+							+		+		+	+

*The record for column X is not complete.

Name of Species.	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII
Eryngium yuccifolium Michx..........		+	+					+	+	+		+	+
Euphorbia marginata Pursh............							+	+	+			+	+
Euphorbia Preslii Guss................							+	+		+			+
Euphorbia serpyllifolia Pers...........	+	+					+	+		+		+	+
Gerardia aspera Dougl.................	+			+				+	+			+	+
Grindelia squarrosa (Pursh.) Dunal....	+					+		+	+	+		+	+
Helianthus scaberrimus L.............			+	+				+	+	+			+
Houstonia angustifolia Michx...........	+		+					+	+	+	+	+	+
Kuhnia eupatoroides corymbulosa T. & G.	+		+					+	+	+		+	+
Lactuca ludoviciana (Nutt.) DC........							+		+	+		+	
Lactuca canadensis L..................							+	+		+	+	+	
Lepachys pinnata (Vent.) T. & G.......	+				+			+	+	+	+		
Liatris punctata (Hk.) Kuntze..........	+	+	+			+		+	+	+			+
Liatris scariosa Willd..................	+	+	+					+	+	+	+	+	+
Linum sulcatum Riddell................	+							+	+				+
Lygodesmia juncea (Pursh.) D. Don....	+						+	+	+				+
Medicago sativa L. (Introduced).......			+					+			+		+
Œnothera biennis L...................					+			+		+			+
Onosmodium occidentale Maken........			+		+			+	+			+	
Oxytropis Lamberti Pursh.............	+	+	+		+			+	+	+		+	+
Panicum Scribnerianum Nash..........	+		+					+	+	+	+		
Panicum capillare L...................	+							+	+	+			
Panicum virgatum L...................	+		+					+	+	+			+
Petalostemum candidum Michx........	+							+	+	+		+	+
Physalis pubescens L..................	+					+		+	+				
Prenanthes aspera Michx..............			+		+		+	+	+	+		+	+
Quercus macrocarpa depressa Nutt.....	+		+		+			+	+			+	+
Rhus glabra L........................			+				+	+	+				+

Rosa Woodsii Lindl.								+	+	+		+	+
Salix humilis Marsh.	+		+		+			+	+				+
Silphium laciniatum L.	+	+	+	+		+		+	+	+			+
Solidago canadensis L.	+		+		+			+		+			+
Solidago nemoralis Ait.	+		+		+			+	+	+		+	+
Solidago rigida L.			+	+				+	+	+			+
Solidago speciosa angustata T. & G.	+		+					+	+	+		+	+
Sorghastrum nutans (L.) Nash	+		+					+	+	+	+		
Strophostyles pauciflora (Bent.) Wats.	+							+					+
Symphoricarpos occidentalis Hook.			+		+			+	+				+
Verbena stricta Vent.			+		+			+					
Vernonia noveboracensis (L.) Willd.								+	+				+

CONCLUSION.

The foregoing studies suggest the following conclusions:

1. That the flora of the prairie is essentially xerophytic, differing from the desert flora chiefly in the degree of modification for protective purposes.

2. That these xerophytic adaptations are to some extent variable in the same species.

3. That they vary in different species in much the same manner, though usually in lesser degree, as the xerophytes of the desert.

BOTANICAL LABORATORY,
STATE UNIVERSITY OF IOWA.

EXPLANATION OF PLATE XX.

Leaf sections:
a—Cutin.
b—Stoma.
c—Trichomes.
d—Bulliform cells.
e—Water storage parenchyma.
The shaded cells are palisade cells.
The following species are represented:
Fig 1.—*Dalea alopecuroides* Willd.
Fig. 2.—*Amorpha canescens* Pursh.
Fig. 3.—*Solidago nemoralis* Ait.
Fig. 4.—*Lactuca ludoviciana* (Nutt.) Ridd.
Fig. 5.—*Oxytropis Lamberti* Pursh.
Fig. 6.—*Solidago speciosa var. angustata* T. & G.
Fig. 7—*Grindelia squarrosa* (Pursh) Dunal.
Fig. 8.—*Panicum Scribnerianum* Nash.

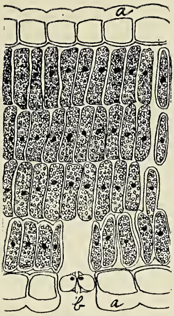


Fig. 1.

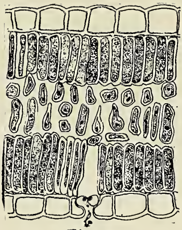


Fig. 2.

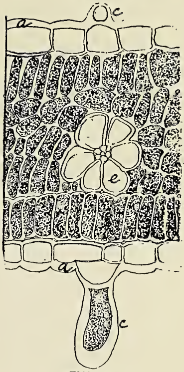


Fig. 3.

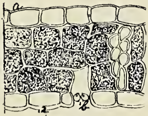


Fig. 4.

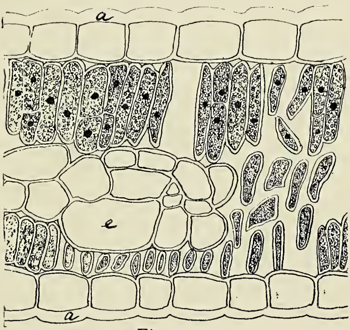


Fig. 5.

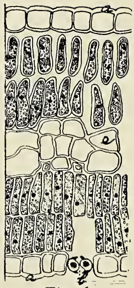


Fig. 6.

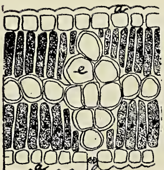


Fig. 7.

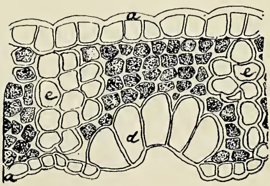


Fig. 8.

Leaf-sections of prairie xerophytes.

A HYBRID RAGWEED.

ROBERT BRADFORD WYLIE.

During the summer of 1914 an unusual specimen of Ambrosia was noted which seems likely to have been a hybrid. The plant grew by the roadside on bottom land a few hundred yards from the Butler's Landing bridge a couple of miles north of Iowa City. It stood near the foot of the long hill beyond the bridge and near the margin of the lowland. The location in the edge of the grading was favorable in that its soil received the wash from the higher land. The plant was surrounded by various weeds and among them and near by were several specimens of the supposed parent species, *Ambrosia trifida* L., and *Ambrosia artemisiifolia* L.

Since much interest centers in hybrid forms, and further because crosses between species of this genus are not common, a brief description should perhaps be given as a matter of record.

The plant was first noted about the middle of July and was then so conspicuously different from the common ragweeds that the writer noticed it among the roadside vegetation while riding along the highway. The location was marked by a ring of small stakes in the hope that it would escape the scythe. A mowing machine subsequently passed within a few inches but it was uninjured and grew undisturbed until autumn. Flowers were produced in abundance but no seeds were set, and so the story ended with the one plant.

The plant grew to the height of about a meter—slightly taller than the surounding specimens of *Ambrosia artemisiifolia*. At the time of its discovery it was seemingly further along in its development than either of the supposed parent species.

The stem was stoutish, branching freely at about 3 or 4 dm. from the ground, and was about 1.5 cm. in diameter at the base. The height of the plant was almost certainly retarded by a gall or distortion on the stem that seemed to involve most of its tissues 3 or 4 dm. above the ground and among the lower branches. There is a possibility, of course, that this wound, due perhaps to the sting of an insect, might have induced the abnormalities noted in the plant as a whole. But while such a wound might lead to vegetative peculiarities it would be less likely to account for the complete sterility of a vigorous plant which flowered profusely.

The stem leaves were quite large, 2 dm. long and 1.5 dm. wide, and were distinctly different from either of the supposed parents, though intermediate between them in a general way. (Plate XXI). Long petioles without margins carried triangular blades which were palmately 3—divided with segments somewhat pinnatified, the central one distinctly so (Pl. XXI, fig. 1). From another point of view the leaf might be looked upon as a pinnate leaf with greatly enlarged and opposite basilar segments, remotely suggestive of *Ambrosia artemisiifolia*. There is less difference than in this species between the stem leaves and those of the inflorescenses, the latter being somewhat simpler and considerably smaller. The leaf surface was finely puberulent on both sides, the lower surface being slightly paler in color. The leaves, and in fact the whole plant, differed strongly from *Ambrosia psilostachya* DC.

Flowers were developed abundantly and in the usual relation with long spikes of staminate heads above and the short stalked pistillate flowers in the axils below. The pollen looked normal and the stigmas of the pistillate flowers emerged in the usual fashion. Unfortunately no visit was made to the plant at a time favorable for securing collections of flowers suited for critical morphological study. The only sections obtained were those of mature staminate flowers; these showed an abundance of seemingly normal pollen though there was no opportunity to determine its capacity for germination at the time the collections were made. As the plant entered into decline in the early autumn it was uprooted and portions preserved. A careful examination was made of every pistillate flower but not one seed was found.

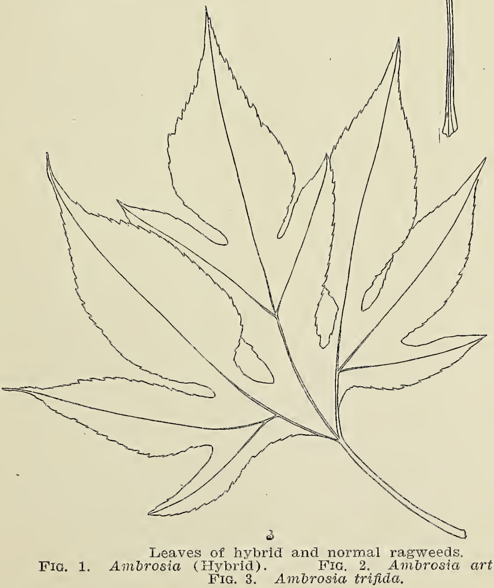
The close proximity of several specimens of both the common species of ragweed, *Ambrosia artemisiifolia* and *ambrosia trifida*, suggests that the plant was infertile not only with its own pollen but also with that from either of the supposed parent species. Some of these plants stood within two feet of it, and there would be the fullest opportunity for pollen transfer from plant to plant. While this sterility has interrupted an interesting experiment it may be that it has inhibited a new weed—for this plant looked like one that would make a place for itself on Iowa soil.

Botanical Laboratory,
State University of Iowa.

PLATE XXI.

2

1



3

Leaves of hybrid and normal ragweeds.
FIG. 1. *Ambrosia* (Hybrid). FIG. 2. *Ambrosia artemisiifolia.*
FIG. 3. *Ambrosia trifida.*

PRELIMINARY NOTES ON NECTAR PRODUCTION.

L. A. KENOYER.

Few people realize the importance that the beekeeping industry is attaining in our state. For its size, Iowa is second in importance of the states of the union. The hives number into hundreds of thousands, and the value of the product probably into millions of dollars. Aside from this is the great indirect value which comes from the pollen-carrying of our bees.

Nevertheless very little is known regarding the plants that furnish pasturage for bees, and about the factors controlling nectar flow in these plants. Twenty-five bee men of this and neighboring states were asked recently concerning the weather conditions that permit of nectar production. Without a single exception they answer ''warm'' or ''hot'', and almost without exception added ''moist''. One man considers rather dry weather preferable, while some mention electric storms and one south winds as desirable. Clear weather is preferred by two or three; others make a distinction between plants, basswood and smartweed being said to demand cloudy weather, while clover and Spanish needle require clear.

Gaston Bonnier, who wrote a lengthy monograph on nectar about thirty-six years ago, found that nectar secretion increases with soil moisture, that it increases with humidity of the air, that it is greatest about the time of the fertilization of the flower, being later resorbed. He noticed, also, that nectar production is sensibly greater in the latitude of Norway than in that of France, and furthermore that it increases with altitude. This increase at high latitudes and altitudes, he suggests, may be due to the extreme between the maximum and minimum daily temperatures, but he gives no experimental data on the influence of temperature upon nectar. In fact, many of his tables seem to be quite contrary to the opinion of our beekeepers, that warm weather is necessary. To him, nectar production seems almost wholly a matter of the accumulation of sugar in the vicinity of the ovary as a reserve in store for the development of the latter, and the secretion of this sugar because of an excess of water in the tissues. He considers nectar secretion analogous to the excretion of water through water stomata of leaves, the only difference being the presence of sugar in the underlying tissues in the former case and their absence in the latter.

F. L. Sladen, Entomologist for the Canadian government, recently wrote a paper on nectar production. He cites many observations, but makes few generalizations. Great differences are noted in the behavior of different plants: heather yields well at low temperatures, the banner yield from it in England being on a frosty morning in September; white clover requires for nectar much moisture and moderate heat; sweet clover permits while alfalfa requires dry air and considerable heat. He also finds differences due to character of the soil and subsoil, drainage, part of the blooming period and treatment of the crop.

One of our most interesting problems is, I think, that of alfalfa, which is one of the standbys for honey in the Rocky Mountain states, but which is scarcely visited by bees in the Mississippi Valley states. It would seem that the warm moist weather conditions which beekeepers desire would be more certainly fulfilled in Iowa than in Colorado. Might the difference be due to the altitude of the western fields, and to the greater daily range in temperature that is given them, as Bonnier suggests?

The botany department of the State Experiment Station is beginning work on some of the problems of nectar production. We intend this merely as a brief preliminary report, rather with a view toward receiving suggestions than toward giving information. For we have as yet no important results to give.

One part of the work the past summer has been the collection of the insect visitors of many sorts of flowers. Very striking is the preference exhibited by certain kinds of wild bees for certain flowers. For example, this spring a little solitary bee which swarms over the plum blossoms hardly notices the apple. We hope to ascertain the distribution of honey bees over flowers in such a way as to give the beekeepers a clearer idea concerning what kinds of forage, fruit and ornamental plants to grow in order to secure a large honey production. Sweet clover seemed a great favorite of the bees last summer, even in the driest weather. White clover yielded very poorly, perhaps because it was weakened by the drought of the previous summer.

It was found by making tests with Fehling's solution and weighing the precipitates that a gram of mature alfalfa blossoms contains about 34 mg. of sugar, while a gram of the buds just unopened contains about 20 mg. and a gram of the leaves only about 6 mg. Of the 34 mg. in the blossoms, only about one part in 29 was outside the floral organs in the form of nectar in material collected in the morning before insects had worked. White sweet clover contained as the average of numerous tests 18 mg. of sugar per gram of blossoms, or only half as much as in alfalfa. But of this, one ninth or 2 mg. is available as nectar —nearly double the amount available in alfalfa. The available nectar was estimated by shaking a weighed quantity of blossoms for half an hour in distilled water and then testing the water.

Some plants evidently nectariferous, such as the green milkweed, are much visited by wasps and almost wholly neglected by bees. Perhaps the nectar is not to their liking. Some flowers are, of course, so constructed that certain insects cannot obtain nectar from them. But one that has the tube apparently much too long for the honey bee, namely the horse mint, is visited by this bee with such earnestness as to lead the observer to conclude that something worth while must be obtained.

Our work will be continued this summer along lines that seem hopeful in contributing to our knowledge of nectar production and its bearing upon apiculture.

LEANDER CLARK COLLEGE.

AN ANOMALOUS HICKORY-NUT.

GUY WEST WILSON.

During the fall of 1914 the writer observed in the vicinity of Iowa City a tree of the common shag-bark hickory (*Carya ovata* (Mill.) K. Koch.) which produced a number of abnormal nuts. As none of these were found with the husk intact no data can be given except for the nuts themselves. Bicarpillary fruits were not uncommon on this tree as at least a dozen examples were found without making a careful search. In most instances the paired nuts separated readily and showed no tendency toward adhesion. They were, however, very much flattened on the appressed surfaces. A cross section of these nuts showed them to be normal except in shape. Both lobes of the embryo were well developed, but somewhat distorted by the pressure. The walls of the shell were of about the same thickness on the free sides as were those of normal unicarpillary nuts from the same tree, while the inner appressed walls were very thin.

Among these paired nuts one example was found of what appeared to be a complete union of the two nuts into one with a resultant form suggestive of a fasciation. Upon attempting to cross-section this specimen, however, the two parts separated, leaving evidence of but a partial adhesion of the two nuts which had been borne in this bicarpillary husk. A cross section showed that the embryo of each of these nuts was developed in the same manner as were those of the other paired nuts. The most noteworthy points were the exceedingly thin walls of the nuts on the sides adjacent to each other and the manner in which the pressure of each upon the other had deformed the embryos. Both of these pushed out on the same side of the fruit with the same resultant form as that which appeared in the paired nuts.

AN EXOBASIDIUM ON ARMILLARIA.

GUY WEST WILSON.

(ABSTRACT.)

In one locality near Iowa City *Armillaria mellia* was attacked by a parasitic fungus which caused extensive hypertrophy of the upper region of the pileus of its host without rendering the gills sterile. The parasite developed a hymenium which spread over a series of thin, sharp-edged and highly convoluted ridges or gills. The microscopic characters show the fungus to be closely related to that which has been designated *Exobasidium mycetophilum* (Peck) Burt.

BOTANICAL LABORATORY,
STATE UNIVERSITY OF IOWA.

PIONEER PLANTS ON A NEW LEVEE.

FRANK E. A. THONE.

A year ago this spring the city of Des Moines cut a new channel and mouth for the Raccoon river, causing it to change its course for a distance of about half a mile and to empty into the Des Moines river a little more than half that distance below its old mouth. The bulk of the excavated material was piled upon the south bank of the new channel to form a levee about fifteen feet high, sixty feet wide at the base, and twelve feet wide at the top, with a space of twelve feet intervening between the foot of the embankment and the river. The material first excavated, part sand and part a very sandy, silty alluvium, was dumped into place by the steam-shovel and worked over into permanent shape by grading shovels; the material from the bottom of the cut, practically pure sand, was dumped on the opposite bank and left there in long, irregular heaps. The western end of the levee was also left more or less unshapen, and is in consequence some six or seven feet higher than the rest of the embankment; it also has a larger proportion of sand in its makeup than the levee proper, though it is not so nearly pure sand as the heaps on the opposite bank.

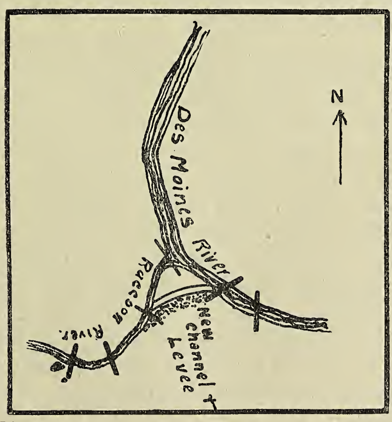


Fig. 3.—Diagram of area studied. Heavy lines indicate bridges.

The area first came to my attention during a visit to Des Moines about the middle of May, 1914. At that time the work of excavation and grading was just being finished, and though the growing season was, of course, well begun, there was little or no sign of vegetation on any part of the embankment. The sandy loam of the levee proper, the half-and-half mixture of its western end, and the sand hills on the opposite shore were alike as bare and lifeless as a desert.

A month later I returned to Des Moines, this time to stay all summer. I was struck with the remarkably changed appearance presented by the surface which had been so devoid of anything green only a few weeks before. A vigorous stand of wild grasses and of those hardy pioneer plants that most people contemptuously term weeds had made its appearance and like an army was overrunning the territory. On the parts of the work which had been finished first the plants stood close and dense, pushing ahead vigorously to overcome their handicap of a late start, and, young as they were, already beginning the eternal struggle for a place in the sun. On the sandy western end of the levee where the ground was poorer and where the steam shovel had longest postponed the start there was a straggling advance guard, but the sand heaps on the opposite shore remained bare and unattacked. Only here and there, where a chance streak of loam in the matrix of sterile sand had received a chance seed did any green leaves show themselves; here they were mostly pigweed, *Amaranthus retroflexus.*

As the summer advanced these relative densities of vegetation maintained themselves much as they were in the beginning: on the sand dunes there was little growth, on the ungraded western end of the levee there was a fairly well-developed flora, and on the levee proper the growth was thick and rank. I took occasion to visit the place frequently during the summer, and from time to time carried home a handful of specimens, so that by the time the first frosts began to take their toll of my weed garden I had botanized the whole area pretty thoroughly.

From an ecological viewpoint, the area falls naturally into three rough divisions, along the lines indicated above. First, there are the sand heaps of the north shore; then the ungraded, sandier part of the levee toward the west, and finally the graded levee composed of rather better soil than either of the two preceding portions.

The sand heaps, as has been stated already, represent for the most part the last of the material thrown up by the steam shovel, a coarse, gritty sand from the bottom of the ancient river bed. Due partly to the natural sterility of this material, partly to its inability to hold any amount of water, and partly also doubtless, to the fact that the lateness of the completion of the heaps delayed the development of any vegetation they might have had, these artificial dunes did not present much in the way of plant life. A thin sprinkling of annuals, mostly *Amaranthus retroflexus, Chenopodium album*, and *Abutilon theophrasti,* together with a few tufts of wild grasses, told the whole story.

The shapeless western end of the embankment presents several interesting peculiarities in soil formation. The sand heaps opposite this part of the work are smaller than elsewhere, for the steam shovel dumped a good part of the sand from the bottom of the cut right on top of the soil from nearer the surface, instead of on the opposite bank. The result is that in places the top of the levee here is as sterile as the sand-heaps of the north bank, and the soil in general is sandier than it is on the levee proper. Even where the top is covered with sterile sand, however, the soil on the level space between the embankment and the channel is a sandy loam much like that of the levee proper, and it is on this table that most of the vegetation of this part of the area is concentrated. Here, and on the more fertile parts of the slopes, the vegetation is of the same general character as that of the eastern end of the levee, described below, while on the sandier parts it is more like that of the sand heaps of the opposite bank, though perhaps a little denser. One or two species were found here that were not found elsewhere: the *Cynodon dactylon*, and most of the *Eragrostis megastachya*.

But it was on what I have already mentioned several times as the eastern end of the levee that the weeds flourished in all their glory. Here the better soil from near the surface of the cut had been piled up and shaped into the real prism of the levee, and the sterile sand had been dumped out of the way on the far shore. In consequence the seeds that alighted here fell upon good ground, with only a few sterile streaks, and the tree-stumps and root-scraps of perennial plants had a chance here to take up anew the struggle for existence. Moreover, this portion had been completed before the less favorable western end, and of course the plants here had a couple of weeks' start. And they utilized it to good advantage. They climbed over the whole eastern portion of the levee, concealed its slopes with a thick, rank growth, and carpeted the top with green. They struck their roots into the fresh, virgin soil that the steam shovel had given them and prospered wonderfully. There were tall ragweed and wild sunflowers as high as my head, thick sods of wild grass, patches of a Cyperus that burrowed in the streaks of sand that lay here and there upon the surface, Jimson-weeds as high as my waist and with stalks as thick as my wrist at the base, single plants of the sprawling amaranth making mats six feet or more in diameter, and pigweed, pigweed everywhere.

The pigweed was the dominant plant. It was ubiquitous. It led the forlorn hope against the forbidding strongholds of the sand on the far shore; together with its near relative, the goosefoot, it constituted the bulk of the first line of advance into the unfavorable western end of the levee; back where the plants stood thicker it asserted itself powerfully. In one or two limited spots it was outnumbered by other plants: on the reverse slope of the levee at its extreme eastern end, for instance, the tall ragweed was the dominant, but the tall ragweed was practically limited to just this narrow area, and you could scarcely walk ten feet anywhere on the whole embankment without brushing shoulders with a pigweed, and here and there, especially toward the western end, it would appropriate whole stretches of the terrain unto itself.

And it rejoiced in its supremacy in true kingly fashion. It built up tall, slender spires, and it spread itself out in thick, round bushes. It disported in half a score of interesting variants: in shape from stiff and stocky to slender and graceful; in color from green to red, on leaves, or stem, or seed-head. There were stout, green pigweeds, and slender, green pigweeds; and there were stout, red pigweeds; and slender, red pigweeds; and there were pigweeds, both stout and slender, that were gorgeously variegated and pied.

In pitiful contrast to the sleek and prosperous condition of the weeds was the losing fight that the few stray cultivated plants were carrying on. Formerly part of the area where the channel and levee now are was inhabited, and some of the houses had vegetable and flower gardens attached. When the steam shovel's wrecking revolution swept through, most of these pampered, man-served vegetable aristocrats perished, but by chance the seeds of a few were left close enough to the surface to sprout and grow and try their luck against the bourgeoisie of weeds. The tomato plant that I found was probably of this origin, also the watermelon. The solitary cultivated sunflower that stood majestically towering above a jostling crowd of pigweed may have come with the tomato and the watermelon, or perhaps from a seed dropped by a bird. The two varieties of morning-glory that I found competing with the wild bindweed were probably wind-sown. The two specimens of corn were very likely remnants of a meal of one of the workhorses; one of them was a half-sized runt with a nubbiny, abortive ear, and the other I picked up in mid-October, a mere starveling sprout with its half-devoured seed still among its roots. Oddly enough, there was little bluegrass on the levee—not enough, I should judge, to fill a peck measure; and when I lost the one specimen of white clover I had, I could not, for the life of me, find another.

So much for the cultivated species and their sources. Now how did the new possessors of the land make their appearance? Variously. A few of them were there to begin with. At the eastern extremity of the levee the level space between the embankment and the channel had been covered rather thinly with debris, and through this new layer of soil a few perennials, like the goldenrod and the aster, managed to fight their way. To this class also, I suppose, must be added the cottonwood shoots that appeared down on the slopes of the channel itself, on the ends of the roots that the steam shovel had severed.

Again, some of the plants must have come from fragments cast up by the steam shovel. To this class must be relegated the shoots that I found sprouting from stumps and root fragments at various points on the slopes and bottom of the embankment: willow, catalpa, cottonwood, maple, and box-elder. Some of the perennial herbs, like the burdock and the dandelion, may have had this origin. Certainly the *Oenothera biennis* that I found in full bloom must have come from a previous foothold somewhere else. And, of course, it is highly probable that a good many seeds were sown in this fashion, along with the root fragments and the seeds of the cultivated plants.

Finally, much, if not most, of the vegetation must have originated from wind-blown seeds. The seedlings of the maple and the cottonwood could have come from no other source, for these are pre-eminently flying seeds, and moreover must germinate within a few hours after they leave the tree, or else perish. Again, the seeds of many of the weeds, like the Amaranths, Chenopodium, Oxalis, Datura, the grasses, and in fact most of the plants on the levee, if not winged are at least small and light and could be carried through the air like grains of dust or sand. Some of the plants, like Amaranthus, Chenopodium, Abutilon, and Datura, hold a goodly portion of their seeds in the previous year's seed-head until well into the following season. And the universal distribution of the vegetation over the surface of the levee, and even on the heaps of sand from the deeper parts of the excavation, must argue for some impartial distributor like the wind.

In brief summary, then, we have the following facts: (1) On the sand heaps of the north shore and on the sandier portions of the western end of the levee, which presented poor opportunities for vegetation on account of the lateness of their exposure to seeding, their natural sterility, and the fact that they came from the deeper portions of the cut and hence had in themselves no seeds or root fragments, there were few plants, and these exclusively from seeds presumably sown by the wind. (2) On the more loamy patches at the western end of the levee the conditions of vegetation approached more nearly those of the eastern portion, or levee proper, though the vegetation was still practically exclusively in its first year from seed, that is, annuals and seeding perennials. (3) On the best soil of the whole area, that of the eastern portion of the levee, the vegetation reached its best maturity, and here it consisted not only of annuals and seeding perennials, but also of growths of perennials in their original position, or from tree stumps or root scraps, and included as well one biennial in its second year of growth and a number of cultivated plants and a few natives whose seed probably had been sown by agencies other than the wind.

Of the fifty-six species collected over the whole area, six (seven, if *Andropogon halepensis* be an escape) were cultivated plants recently escaped, and the balance native or naturalized. Of the cultivated plants, *Zea mais* and *Andropogon halepensis* probably were from feed dropped by horses, *Ipomoea purpurea* possibly was wind-sown, though possibly also of a common origin with the other four cultivated species, namely *Lycopersicum esculentum*, Petunia sp., *Citrullus vulgaris*, and *Helianthus* *annuus,* which apparently were remnants of former cultivations cast up by the steam shovel.

Of the native and naturalized species six were trees and one a liane; the rest were herbs. The liane and five of the trees sprang from fragments of previous vegetation; two of the trees also appeared as wind-sown seedlings, and one tree only appeared exclusively as a seedling, presumably also wind-sown. Of the wild herbs one was a biennial in its second year, and the balance annuals and (apparently) seedling perennials. Of these the biennial must have been deposited with excavated material, and some of the seeds probably also came from the same source; most of the seeds, however, probably were wind-sown.

I have appended a list of all plants that I found on the area, giving also in tabular form such information as I have been able to extract from them regarding their age, past history and present condition. The classifications were made originally from Britton and Brown and afterward checked over and corrected from Gray's Manual. I wish to acknowledge with thanks the assistance of Professor Pammel of Ames and of Doctor Conard of Grinnell in classifying the collection, the latter especially also for his valuable suggestions and encouragement in the preparation of this paper. The following will serve as a key to the symbols tabulated at the right of the list. In the first column the symbols refer to the position of the plant on the embankment. "A" signifies that it was found exclusively on the top or slopes of the levee, "B" that it was found exclusively on the flat space at the base, and "C" that it grew indiscriminately over top, slopes, and base. In the next column the figure "1" indicates an origin from seed. I have listed most of the perennial herbs I found under this heading, for though some of them may have sprung from fragments of root or stem I have no positive evidence that any of them did. "2" indicates that the plant in question grew from a stump or root fragment, and "3" indicates that some specimens were from seeds and others from stumps or roots. In the last column "X" indicates that the plant was a recent escape from cultivation, and "Y" that it was a native or naturalized species.

Andropogon halepensis (Sorghum halepense)	A	1	X
Digitaria sanguinalis	C	1	Y
Panicum dichotomiflorum	C	1	Y
Setaria glauca	C	1	Y
Muhlenbergia mexicana	C	1	Y
Cynodon dactylon (?)	C	1	Y
Eragrostis megastachya	C	1	Y
Poa pratensis	A	1?	Y?
Zea mais	A	1	X
Cyperus esculentus	A	1	Y
Salix sp. (alba?)	C	2	Y
Populus deltoides	C	3	Y
Cannabis sativa	C	1	Y
Rumex crispus	A	1?	Y
Polygonum pennsylvanicum	C	1	Y
Polygonum persicaria	C	1	Y
Polygonum convolvulus	C	1	Y
Chenopodium album	C	1	Y
Amaranthus retroflexus	C	1	Y
Amaranthus blitoides	C	1	Y
Mollugo verticillata	C	1	Y
Stellaria media	C	1	Y
Brassica nigra	C	1	Y
Radicula armoracia	B	2	Y
Polanisia graveolens	A	1	Y
Gleditsia triacanthus	A	1	Y
Trifolium pratense	A	1	X?
Melilotus sp. (alba or officinalis)	A	1	Y
Strophostyles angulosa	A	1	Y
Oxalis stricta	A	1	Y
Acer saccharinum	B	2	Y
Acer negundo	C	1	Y
Vitis vulpina	B	2	Y
Abutilon theophrasti	C	1	Y
Hibiscus trionum	A	1	Y
Oenothera biennis	A	2	Y
Asclepias syriaca	C	1	Y
Ipomoea purpurea (2 vars.)	A	1	X
Convolvulus arvensis	A	1	Y
Teucrium canadense	C	1	Y
Petunia sp. (?)	A	1	Y
Lycopersicum esculentum	B	1	X
Solanum nigrum	A	1	Y
Datura stramonium	C	1	Y
Verbascum thapsus	A	1	Y
Catalpa sp. (bignonioides?)	B	2	Y
Plantago major	A	1	Y
Citrullus vulgaris	B	1	X
Solidago canadensis	C	3	Y
Aster ericoides (?)	C	3	Y
Ambrosia trifida	C	1	Y
Ambrosia artemisaefolia	C	1	Y
Xanthium commune	C	1	Y
Helianthus annuus	C	1	Y
Helianthus scaberrimus	C	1	Y
Arctium minus	C	3	Y
Taraxacum officinalis	A	1	Y

Botanical Laboratory,
Grinnell College.

FLORA OF THE EAST SLOPE OF THE CASCADE MOUNTAINS, IN CROOK COUNTY, OREGON.

MORTON E. PECK.

In the latter part of June, 1914, the writer joined a company of biological investigators and collectors, working under the general direction of Mr. Vernon Bailey, field naturalist of the U. S. Biological Survey, on a trip across the Cascade mountains, by way of the McKenzie Pass. The purpose of the expedition was to secure certain zoological and botanical data and specimens of the animal and plant life of the region, with a view to determining the life zones of this section of Oregon, as well as to add material to the collections of the several institutions represented by the members of the party.

The McKenzie Pass crosses the Cascades nearly due east of Eugene, where McKenzie river enters the Willamette. Eugene is not far from the center of the state north and south, and about fifty miles from the coast.

We left Eugene on June 27, and traveled by stage up the valley of the McKenzie for fifty miles, to McKenzie Bridge, where we remained for some time. The last third of this distance led through the heavy coniferous forest characteristic of the western slope of the Cascades. Much of this has now been cut off.

It may be well, for the sake of comparison, to touch upon some of the main features of the flora of the western slope and the summit before considering that of the eastern slope, in order to bring out more clearly the remarkable contrast due to the difference in precipitation.

The elevation at McKenzie Bridge is about 500 meters, the annual precipitation 1743 mm., a considerable part of which is snow. The flora is almost typically Transition, resembling in the main that of the Willamette Valley, but the presence of such species as *Thuja plicata, Tsuga heterophylla, Echinopanax horridum, Pyrola bracteata, Arctostaphylos tomentosa, Gaultheria shallon,* and several others, give it something of the Humid Transition or coastal slope character. There is also an admixture of true Canadian forms, though these do not comprise a very large part of the total number. Such are *Pinus monticola, Clintonia uniflora, Tiarella unifoliata, Chimaphila umbellata, Pentstemon fruticosa*, and *Senecio triangularis.* The dense forests that cover most of this region are made up of *Pseudotsuga mucronata* (comprising at least half of the total bulk), *Thuja plicata, Abies grandis, Tsuga heterophylla, Pinus monticola,* and an occasional *Pinus lambertiana.* There are numerous unforested slopes and ridges, mostly supporting a dense growth of shrubs of various species. Along the banks of the river is an abundant growth of *Taxus brevifolia, Alnus oregana,* and *Acer circinatum.*

From McKenzie Bridge a three days' trip was made to Horse Pasture Mountain, ten miles to the southwest. This mountain has an elevation of about 2000 meters. The sides are mainly forested but the summit is mostly bare of trees and carries the flora quite through the Canadian zone, which is represented by a long list of species. Near the summit occurs *Tsuga mertensiana* and several other typically Hudsonian forms.

From McKenzie Bridge to the summit of the Cascades by way of the McKenzie Pass is about twenty miles. The road follows the canyon of Lost creek, a tributary of the McKenzie. Most of the way of ascent is gradual. Nearly half of the distance is through the usual dense forest, but the eastern half is through a more open region, mostly covered with undergrowth and intersected by sharp ridges and peaks with numerous slides of black porous lava. The elevation at the summit is approximately 1600 meters.

The flora at this point is high Canadian, about equivalent to that found at the top of Horse Pasture Mountain, where the elevation was somewhat greater. The divide does not form a sharply defined ridge, but there is a considerable area of moderately level country, with occasional shallow ponds, furnishing suitable conditions for a great variety of plant life. For the most part, the forest is not dense. The dominant tree is *Pinus contorta,* with a considerable abundance of *Pinus monticola, Tsuga mertensiana, Abies nobilis,* and in places, *Pseudotsuga mucronata* and *Picea engelmanni.* Deciduous trees are wanting and shrubs are small and not abundant. The latter are: one or two species of *Salix, Ribes lacustre, Spiraea densiflora, Pyrus sitchensis, Gaultheria ovatifolia, Vaccinium scoparium, and V. macrophyllum.* Among herbaceous plants, species of *Carex, Ra-*

nunculus, Delphinium, Saxifraga, Viola, Epilobium, Pentstemon, Mimulus, Pedicularis, and *Arnica,* are especially in evidence. *Pinus contorta* is abundantly infested with a diminutive mistletoe, *Razoumofskya americana.*

While encamped in this neighborhood, several days were spent investigating the plant and animal life of one of the Three Sisters, which are among the highest peaks in the Cascades of Oregon. The three mountains are in close proximity to each other, and retain sufficient snow to support several glaciers. The summit of the Middle Sister is about six miles from the nearest point on the road we were following. This is the only one of the three peaks visited. The flanks of the mountain in many places are fashioned into exceedingly rough and precipitous ridges and chasms by volcanic action, some of the lava flows being so recent as scarcely to support any vegetation. In other places, however, the slope is more gentle and even, and there is a good layer of soil.

As one begins the ascent from the 1600-meter elevation where we were encamped, the character of the vegetation is seen to change rapidly. *Pinus contorta* and *Abies nobilis* begin to thin out, and *Tsuga mertensiana* soon becomes the dominant conifer. A great variety of Hudsonian plants appear, at first as scattered individuals, but becoming more and more numerous. At about 2000 meters there is a fine pure growth of *Tsuga mertensiana,* with the ground beneath almost entirely devoid of smaller plants. When this has been passed the trail crosses several of the rough steep lava ridges, where *Pinus contorta* and *P. monticola* barely persist and just reach the lower limit of *Pinus albicaulis.*

Having crossed the last of the lava ridges, one finds himself on the bank of a tumbling torrent of milky water that issues from a glacier some two miles farther up the slope. The true Hudsonian zone is now reached. Here are growing in abundance *Juncoides piperi, Salix commutata, Pulsatilla occidentalis, Ranunculus eschscholtzii, Mitella pentandra, Lutkea pectinata, Potentilla flabellifolia, Lupinus alpicola, Phyllodoce empetriformis, Cassiope mertensiana, Valeriana sitchensis,* and *Agoseris alpestris.* This is within 400 to 500 meters of the forest line, and at the date of our visit, July 15, considerable areas were still covered with deep drifts of snow, that grew more extensive as we advanced. At the forest line most of the above named species are still abundant, together with several others that belong more properly to the Arctic zone.

It should be noted that at this elevation, about 2500 meters, where *Tsuga mertensiana* and *Pinus albicaulis* dwindle down into low gnarled shrubs, there may be found open southward slopes, where certain Canadian plants, or even of lower zones, can maintain an existence, such as *Pinus contorta, Ribes cereum,* and *Spiraea densiflora.* This, of course, is saying merely that the life zones are not necessarily altitudinal zones, but are of a somewhat isothermal character.

The species most characteristic of the Arctic zone, that is, those occurring more or less plentifully at 2700 meters and upward and not found abundantly below timber line are, *Anemone hudsoniana, Oxyria digyna, Draba aureola, Phyllodoce glandulifera, Collomia debilis, Sibbaldia cuneifolia, Erigeron compositus,* and an undetermined *Senecio.* In addition to these, a number of species plentiful in the upper Hudsonian were also found,—*Carex straminiformis, C. breweri, Polygonum newberryi, Erigonum pyrolaefolium, Spraguea umbellata, Saxifraga tolmiei, Phyllodoce empetriformis, Pentstemon menziesii davidsonii,* and *Antennaria media.* It was too early in the season to study the Arctic flora to good advantage, as comparatively very little of the ground lying well within this zone was uncovered by snow. The mountain, moreover, is relatively young, and the soil above timber line is so scanty that it cannot support a very copious vegetation.

From this very brief account some idea may be gained of the altitudinal limits of the several life zones represented in this section of the Cascades, and of a few of the most characteristic species of each. From this region of copious moisture we will now pass on to a somewhat more detailed consideration of the plants of the eastern slope, where, within a few miles, we encounter an enormous decrease in the precipitation.

We started eastward again on July 19, and soon came to the edge of a vast lava field, which, spread out before us in black and rugged desolation, presented a truly remarkable geological spectacle. Two or three of the craters from which the most recent flows had issued could be made out easily. The dark jagged blocks of lava were tilted and tumbled in the wildest confusion, apparently just as they were left when first split and upheaved by the movement of the deeper and more fluid portion of the mass. The rough surfaces of the blocks showed scarcely a sign of weathering, and vast areas were almost utterly destitute of vegetation; only very rarely could be seen a low stunted specimen of *Pinus contorta.* But there are older flows also, as at least three different periods of volcanic activity are represented. The more recent flows have followed the depressions in the older, islanding a number of elevations which are fairly well covered with vegetation. The width of this lava field where the road crosses it is, perhaps, between four and five miles. At its eastern edge, at an elevation of about 1500 meters, is a small canyon with abundant moisture where several Hudsonian species were found, among them *Phyllodoce empetriformis* and *Valeriana sitchensis.*

The flora of the east slope of the Cascades may be regarded as beginning at the eastern edge of these lava fields, which also form the eastern edge of the divide. Within a distance of three or four miles we descend into the Arid Transition. For thirty miles we have been ascending very gradually through a mesophytic flora from pure Transition to high Canadian, and the change, as we drop within an hour into the Arid Transition, is most striking. This seems all the more remarkable from the fact that there is no steep descent. In the eight or ten miles we have covered (somewhat less than this in a straight line) in passing from the summit into the Arid Transition zone, we have descended scarcely more than 300 meters, and beyond this there is little general eastward slope. McKenzie Pass is, of course, one of the lowest points in the great Cascade divide, yet the drop to the general level is nowhere as great as we might expect to find, for the whole of central Oregon is a plateau region from 1000 to nearly 2000 meters in elevation.

Our road follows the edge of the lava for some distance and *Pinus contorta, Abies nobilis* and *Tsuga mertensiana* continue to be the dominant conifers, but soon we come upon scattered specimens of yellow pine, *Pinus ponderosa,* and *Pseudotsuga mucronata* appears and suddenly becomes abundant; it seems to form, however, a remarkably narrow zone for a species ordinarily of such wide altitudinal range. With the increase of the yellow pine the other conifers thin out, though maintaining a sporadic distribution for two or three miles; finally they quite disappear, and for five or six miles we ride through a practically pure growth of yellow pine.

The yellow pine forest has a wholly different aspect from the coniferous forests that clothe the western slope. The trees stand far apart, their trunks are relatively stout, their tops broad and rounded, their foliage thin. They are clothed with no luxuriant growth of mosses and lichens, but the older trunks especially have a clean-cut appearance and are of a rich cinnamon color. No less conspicuous is the almost total lack of undergrowth of every description. One shrub, *Arctostaphylos manzanita,* does occur here and there, and one herbaceous plant, *Horkelia fusca,* but otherwise the thin sandy soil is covered only by a bed of dry pine needles. It is possible that there is a limited amount of short-lived spring herbage of which no trace could be seen while merely riding through in mid-summer.

For a long distance we pass no spring or stream, but as we draw near to the little town of Sisters we cross an irrigation ditch, the water of which is derived from Squaw creek. The forest now becomes more open and interrupted. Sagebrush, *Artemisia tridentata,* and juniper, *Juniperus occidentalis,* begin to appear, and other species of the open dry regions east of the Cascades; we are, in fact, almost before we can realize it, in the heart of the Arid Transition zone. Here at Sisters we are to remain for a few days to make a brief survey of the flora. Let us consider, therefore, a few of the most important physical features of the immediate locality where our observations are to be made.

The altitude of Sisters is a little over 1100 meters. It has an annual precipitation of 451 mm., of which a large part falls as snow. The summer temperature is never extremely high, and there are late spring and early autumn frosts; in fact, frosts are common in June. The town, of some four or five hundred, is situated on Squaw creek. This is a stream of some size, that takes its rise on the eastern slopes of the Three Sisters and flows in a northeasterly direction, to empty into Des Chutes river. During the summer practically the whole stream is diverted for irrigation.

The water of Squaw creek furnishes conditions favorable for a more varied plant life than is to be found in most localities in this part of the state. Though apparently along most of the stream's course the arid conditions prevail almost to the edge of the stream bed, there are in the neighborhood of Sisters some good sized meadows, swampy in places, and very narrow bottom lands. To the southward of Sisters on the east side of the creek, there is a rather large tract of level country, portions of which are irrigated and under cultivation. The country to the north-east is rough and hilly. Everywhere there is an uneven growth of yellow pine and juniper (*Juniperus occidentalis*). In the cultivated sections the soil is fairly fertile, but over most of the area that came under our observation it is rather thin and poor, being made up largely of volcanic sand and gravel, with much loose rock in larger fragments, and occasional solid basaltic out-crops. The topographic and other conditions are thus seen to be sufficiently varied to give a fair idea of the general floral character of this part of the state.

It should be stated, before we proceed to a more detailed account of the species inhabiting the several areas studied, that the date (July 20-26) was too advanced to secure specimens of the short-lived vernal vegetation so characteristic of arid regions in our latitude. An examination showed, however, that this had not been particularly abundant.

In our present study we will arrange our species in four groups according to the moisture conditions of their habitat, viz., (1) species growing in water or saturated soil; (2) species of damp meadows and bottom lands; (3) species of level, moderately dry ground; (4) species of very dry, mostly hilly ground. Some of these groups, particularly (3) and (4) intergrade to a great extent, but we shall attempt to assign to each form its most characteristic habitat.

The first group consists of hydrophytes and subhydrophytes, most of which are of wide distribution. They are

Potamogeton pusillus	Salix sp.
Alopecurus geniculatus fulvus	Salix sp.
Eleocharis palustris	*Polygonum amphibium*
Carex utriculata	*Comarum palustre*
Carex sp.	*Sphaerosciadium capitellatum*
Carex sp.	*Cicuta occidentalis*
Carex sp.	*Veronica scutellata*
Juncus ensifolius major	*Veronica americana*

Of these sixteen species, at least half are of more or less general distribution over the United States, while probably three or four of the others occur on both sides of the Cascades. It is merely a Transition group, unaffected, of course, by the general aridity of the region.

The second group, plants of ordinary mesophytic conditions, includes the following:

Phleum pratense
Sporobolus sp.
Agrostis alba
Holcus lanatus
Deschampsia elongata
Poa pratensis
Poa compressa
Agropyron tenerum
Hordeum jubatum
Carex sp.
Juncus balticus
Juncus orthophyllus
Juncus regelii
Juncus badius
Hookera hyacinthina
Iris missouriensis
Sisyrinchium bellum
Sisyrinchium idahoense
Ibidium romanzoffianum
Betula sp.
Alnus tenuifolia
Alsine sp.
Ranunculus flammula repens
Ranunculus eiseni
Ranunculus oreganus macounii
Roripa obtusa
Ribes inerme (?)
Spiraea douglasii
Rubus macropetalus
Argentina anserina concolor
Amelanchier sp.
Lupinus polyphyllus
Melilotus albus
Trifolium longipes
Sidalcea oregana
Epilobium adenocaulon
Taraxia heterantha taraxacifolia
Pyrola incarnata
Gentiana acuta
Gentiana affinis
Gentiana simplex
Scutellaria galericulata
Castilleja miniata
Orthocarpus hispidus
Galium boreale
Lonicera coerulea
Agoseris glauca
Erigeron armeriaefolius
Aster campestris
Aster eatoni
Aster occidentalis
Aster sp.
Arnica sp.

Of these fifty-four species of mesophytes, nineteen are of very wide distribution and are mostly Transition forms; seven others are of general occurrence in Oregon, being found also on the west side of the Cascades.* Not over half of the total number are Arid Transition.

The third group, made up of species that grow mostly in moderately dry situations, comprises the following:

Pinus ponderosa
Pinus contorta
Abies nobilis
Gayophytum lasiospermum
Gayophytum diffusum
Gayophytum ramosissimum

*This expression, as used here and elsewhere, is meant to include mainly the Willamette valley, and not the Klamath Mountain region.

Pseudotsuga mucronata
Sporobolus depauperatus
Koeleria cristata
Elymus condensatus
Populus tremuloides
Polygonum erectum
Silene menziesii
Cerastium sp.
Ribes cereum
Philadelphus lewisii
Rosa pisocarpa
Potentilla biennis
Potentilla fastigiata
Horkelia fusca
Fragaria crinita
Drymocallis convallaria
Lupinus minimus
Lupinus laxiflorus
Phaca purshii
Vicia americana
Lathyrus bijugatus sandbergii
Linum digynum
Viola sp.
Epilobium paniculatum
Arctystaphylos manzanita
Gilia pharnaceoides
Gilia humilis
Collomia grandiflora
Collomia linearis
Phacelia linearis
Cryptanthe ambigua
Pentstemon confertus
Pentstemon collinus (?)
Pentstemon sp.
Mimulus nanus
Mimulus cusickii
Symphoricarpos racemosus
Ptiloria virgata
Agoseris heterophylla normalis
Hieracium griseum
Solidago missouriensis
Macheranthaera sp.
Hemizonella durandi
Achillea millefolium lanulosa
Artemisia ludoviciana
Senecio sp.
Antennaria geyeri

In this list of fifty-three species we find seven that have a very wide distribution, and eleven others that occur plentifully west of the Cascades, while several belong regularly to higher zones. Here, then, the dry region element is seen to predominate.

The fourth class, consisting of those species found mainly on very dry, stony hills, is necessarily more poorly represented in our list than the others, since it contains a greater proportion of delicate, short-lived forms that had disappeared before our arrival. We find here:

Juniperus occidentalis
Agropyron spicatum
Calochortus macrocarpus
Eriogonum proliferum
Eriogonum compositum
Eriogonum umbellatum
Silene sp.
Thelypodium laciniatum
Conanthus parviflorus
Lithospermum ruderale
Chrysothamnus viscidiflorus
Chrysothamnus puberulus
Chrysothamnus nauseosus
Townsendia florifer
Erigeron poliospermum
Erigeron linearis

Kunzia tridentata
Gilia pungens hookeri
Mentzelia albicaulis
Phacelia heterophylla
Phacelia sp.
Erigeron sp.
Eriophyllum multiflorum
Chaenactis douglasii
Artemisia tridentata
Senecio howellii

Of these twenty-six species none is of very general distribution and none is of more than exceptional occurrence west of the Cascades.

In summing up, we find that there are in all fifty-three species that are of very general distribution over the United States, or at least within this state, as they are found plentifully on both sides of the Cascades, and many of them in all the zones represented in Oregon except Hudsonian and Arctic. This wide range is due partly to great adaptability, partly to the moisture conditions under which they thrive. These forms are merely called Transition, but their presence here must be taken as of only minor significance in the determination of the zone.

Omitting those forms of uncertain identification, the rest fall into three groups, those characteristic of the Canadian, those of the Arid Transition, and those of the Upper Sonoran. The Canadian species are very few, and for the most part not abundantly represented by individuals. They are

Pinus contorta
Abies nobilis
Juncus regelii
Eriogonum umbellatum
Arctostaphylos manzanita
Gentiana simplex
Lonicera coerulea
Erigeron armeriaefolius

The position of one or two of these even is not very secure, as that of *Eriogonum umbellatum*.

As we might expect, it is impossible always to distinguish sharply between Arid Transition and Upper Sonoran zones, since they are not limited by any well marked physical features. So far as we can make out, the following are mainly Arid Transition forms:

Juniperus occidentalis
Pinus ponderosa
Agropyron spicatum
Juncus orthophyllus
Iris missouriensis
Sisyrinchium bellum
Sisyrinchium idahoense
Linum digynum
Sidalcea oregana
Taraxia heterantha taraxacifolia
Gayophytum lasiospermum
Gayophytum diffusum
Sphaerosciadium capitellatum
Cicuta occidentalis

Alnus tenuifolia	*Gentiana affinis*
Ranunculus eiseni	*Gilia humilis*
Ranunculus oreganus macounii	*Collomia linearis*
Philadelphus lewisii	*Phacelia heterophylla*
Potentilla biennis	*Lithospermum ruderale*
Potentilla fastigiata	*Pentstemon confertus*
Horkelia fusca	*Mimulus nanus*
Drymocallis convallaria	*Ptiloria virgata*
Argentina anserina concolor	*Agoseris glauca*
Lupinus minimus	*Chrysothamnus puberulus*
Lupinus laxiflorus	*Solidago missouriensis*
Trifolium longipes	*Aster eatoni*
Phaca purshii	*Senecio howellii*
Lathyrus bijugatus sandbergii	*Antennaria geyeri*

The species that are more characteristic, on the whole, of the Upper Sonoran are,

Sporobolus depauperatus	*Cryptanthe ambigua*
Elymus condensatus	*Mimulus cusickii*
Calochortus macrocarpus	*Chrysothamnus viscidiflorus*
Eriogonum proliferum	*Chrysothamnus nauseosus*
Eriogonum compositum	*Townsendia florifer*
Thelypodium laciniatum	*Erigeron poliospermum*
Kunzia tridentata	*Erigeron linearis*
Mentzelia albicaulis	*Aster campestris*
Gayophytum ramosissimum	*Eriophyllum multiflorum*
Gilia pungens hookeri	*Chaenactis douglasii*
Gilia pharnaceoides	*Artemisia ludoviciana*
Phacelia linearis	*Artemisia tridentata*
Conanthus parviflorus	*Tetradymia canescens*

But the merely numerical comparison of species does not give a full idea of the relative importance of the two groups in the general make-up of the flora. For example, the above named species of *Calochortus, Mentzelia, Gilia, Conanthus, Eriophyllum, Tetradymia,* and a number of others so abundant in the Upper Sonoran territory, here form an inconspicuous part of the flora, while sagebrush (*Artemisia tridentata*), which there lends color and character to almost the whole landscape, here assumes a much less prominent place, and the same is true, to a less marked degree, of the species of *Chrysothamnus.*

For the sake of comparison, let us consider much more briefly the flora of one other locality, namely, that of the neighborhood of the town of Bend, situated on Des Chutes river, about twenty-five miles southeast of Sisters.

The road between Sisters and Bend leads through a somewhat diversified region, parts of which are under cultivation, but much of it arid, stony and broken. Yellow pine and juniper are abundant but unevenly distributed, and sagebrush and rabbit bush (*Chrysothamnus*) are everywhere in evidence, though not dominating the landscape.

Only one day (July 27) was spent at Bend, which allowed but a very limited survey of the flora. In general it closely resembles that of the neighborhood of Sisters, but in regard to moisture the conditions are more severe. The elevation is a little greater, and the annual precipitation about 400 mm.

In the narrow strip of bottom land along Des Chutes river there is a copious vegetation of mesophytic species, including among forms not found at Sisters, *Monolepis nuttalliana, Monolepis spatulata, Ribes irriguum (?), Senecio triangularis,* and *Senecio* sp.

In the water and in mud along the margin of the stream were several widely distributed hydrophytes: *Potamogeton perfoliatus richardsonii, Anacharis canadensis, Carex aquatilis, Batrachium aquatile, and Callitriche verna.*

On land a little higher, but still affected to some extent by the proximity of the river, were found, in addition to many noted at Sisters, *Thelypodium* sp., *Lathyrus oregonensis, Rhus toxicodendron, Phacelia* sp., *Capnorea nana, Collinsia tenella,* and *Carduus undulatus.*

On the dry uplands sagebrush and rabbit bush predominate, with yellow pine and juniper, which have become less abundant as we have moved eastward. Here also we find *Festuca octoflora, Eriogonum vimineum, Delphinium depauperatum, Lupinus aridus,* and several others.

This brief discussion should serve to give some idea of the Arid Transition flora of central Oregon, though the area covered by the observations was too limited to yield a very extensive list of species, and the season too advanced for the early vegetation.

The following list includes practically all the species that were noted from the time we reached the eastern edge of the lava fields until we left Bend. Brief notes regarding distribution, habit, relative abundance, etc., are added. Specimens of all but a few of the commonest were preserved.

Juniperus occidentalis Hook. First noted a little to the westward of Sisters, and increasing steadily in abundance to the Des Chutes (Bend).

Pinus monticola Dougl. Plentiful along the eastern edge of the lava fields, but thins out to the eastward and soon disappears.

Pinus ponderosa Dougl. The most abundant and characteristic tree of the Arid Transition. First appeared near the edge of the lava fields (elevation about 1300 m.) and continued abundant to the Des Chutes and eastward.

Pinus contorta Dougl. Common along the eastern margin of the lava fields, but thinning out and soon disappearing eastward. A single specimen found along Squaw creek at Sisters.

Abies nobilis Lindl. With the preceding and about equally common in our area. A specimen of this also was found at Sisters.

Pseudotsuga mucronata (Raf.) Sudw. Abundant for a short distance to the eastward of the lava fields, then fading out rather abruptly. A few specimens along Squaw creek.

Tsuga mertensiana (Bong.) Carr. Abundant along the eastern margin of the lava, but soon disappearing eastward.

Potamogeton perfoliatus richardsonii Benn. Abundant in Des Chutes river, covering the bottom over large areas.

Potamogeton pusillus L. Common in pools along Squaw creek, and in the Des Chutes.

Alisma plantago-aquatica L. Frequent in muddy ground along the Des Chutes.

Anacharis canadensis (Mich.) Planch. Abundant in the Des Chutes.

Oryzopsis hymenoides (R. & S.) Rick. Apparently not very plentiful, in high dry ground, Bend.

Alopecurus geniculatus fulvus (Smith) Sonder. Plentiful in moist meadows, Sisters.

Phleum pratense L. Abundant in damp meadows, Sisters.

Sporobolus depauperatus (Torr.) Scrib. In dry soil, Sisters. Only one or two specimens.

Sporobolus sp. A low, densely matted perennial found in one locality along Squaw creek.

Agrostis alba L. Abundant in damp meadows, Sisters, also along the Des Chutes.

Agrostis hyemalis (Walt.) B. S. P. A few specimens in damp ground along Squaw creek.

Holcus lanatus L. Common in damp meadows, Sisters.

Deschampsia elongata (Hook) Munro. In slightly moist places along the edge of the lava fields, and in damp ground along the Des Chutes.

Koeleria cristata (L.) Pers. Common in meadows, Sisters.

Poa pratensis L. Common in meadows, Sisters.

Poa compressa L. With the preceding; not so common.

Festuca octoflora Wald. Plentiful in dry ground, Bend.

Festuca pacifica Piper. In rather dry ground, Bend.

Festuca elatior L. A few specimens in damp ground along the Des Chutes.

Panicularia nervata (Willd.) Kuntze. Plentiful in wet ground along the Des Chutes.

Agropyron spicatum (Pursh.) Scribn. & Sm. Probably at one time bunch grass was more or less abundant over all this region, but close pasturage has nearly exterminated it here as in many other places. Sisters and Bend.

Agropyron tenerum Vas. Plentiful in meadows, Sisters.

Hordeum jubatum L. In meadows, Sisters.

Elymus condensatus Presl. Common in moderately dry ground, especially in "draws" and other depressions, Sisters.

Eleocharis palustris (L.) R. & S. Common in swampy meadows, Sisters, and along the Des Chutes.

Carex utriculata Boott. Swampy ground, Sisters and margin of the Des Chutes.

Carex lanuginosa Michx. Frequent in swampy meadows, Sisters.

Carex aquatilis Wahl. Found in one locality, in shallow water of the Des Chutes; a very tall, robust form.

Carex sp. In wet meadows, Sisters.

Carex sp. With the preceding.

Carex sp. With the preceding.

Carex sp. In dry ground, Sisters, and along the Des Chutes.

Juncus balticus Willd. Scarce; in moist meadows, Sisters.

Juncus orthophyllus Cov. Frequent in moist meadows, Sisters.

Juncus regelii Buch. With the preceding.

Juncus badius Suks. With the preceding; not common.

Juncus ensifolius major Hook. Infrequent; in swampy meadows, Sisters.

Hookera hyacinthina (Lindl.) Kuntze. In moist meadows, Sisters; apparently not very plentiful.

Calochortus macrocarpus Dougl. Found sparingly in very dry ground, Sisters.

Iris missouriensis Nutt. Frequent in moist meadows, Sisters, and along the Des Chutes.

Sisyrinchium bellum Wats. Plentiful in damp meadows, Sisters. Our material is somewhat doubtfully referred here. The species of this genus in Oregon are not very well understood.

Sisyrinchium idahoense Bick. Common in moist meadows, Sisters.

Ibidium romanzoffianum (Cham.) House. Infrequent; in moist meadows, Sisters.

Salix sp. In wet meadows and along the margin of Squaw creek.

Salix sp. With the preceding. These two willows form large clumps and extensive close thickets. They were not in a condition to be determined with certainty.

Populus tremuloides Michx. Plentiful in rather dry ground along Squaw creek. This is quite different from the eastern form, and perhaps distinct.

Betula microphylla Bunge. Common along the Des Chutes.

Betula sp. Common along Squaw creek. The species of Betula in Oregon are rather confused. Two forms seem to occur at Sisters, but they are possibly only extreme variations of the same species.

Alnus tenuifolia Nutt. Very plentiful along Squaw creek. An alder also occurs in abundance on the Des Chutes at Bend, but no specimens were collected. It is perhaps *A. rhombifolia* Nutt.

Rumex persicarioides L. In wet ground near the Des Chutes.

Polygonum erectum L. A few specimens in rather dry ground, Sisters.

Polygonum amphibium L. In a swampy meadow, Sisters.

Eriogonum proliferum T. & G. In very dry ground, Sisters and Bend; more common at the latter place.

Eriogonum vimineum Dougl. In dry ground, Bend; not abun dant. A form with very minute flowers.

Eriogonum compositum Dougl. Rather common in dry ground, Sisters.

Eriogonum umbellatum Torr. Scarce; in very dry ground, Sisters. This form has a remarkable altitudinal range, occurring from Arid Transition to Arctic. It varies extremely in size, the high altitude forms being very dwarf. Our material is possibly the subspecies *majus* Benth.

Chaenopodium botrys L. Frequent in damp ground along the Des Chutes.

Monolepis spatulata Gray. Frequent in moist ground near the Des Chutes.

Monolepis nuttalliana (R. & S.) Greene. With the preceding, and about equally common.

Claytonia parviflora Dougl. Moist ground near Bend; one locality.

Silene menziesii Hook. A few specimens found in moderately dry ground at Sisters. The forms of this species found east of the Cascades have been variously set off as distinct. Our material represents a low bushy variety, with the leaves of the copious inflorescence greatly reduced.

Silene sp. Frequent in very dry ground, Sisters.

Cerastium sp. Several specimens found in rather dry ground at Sisters. A form resembling *C. nutans* Raf., but the petals and pedicels too short.

Alsine sp. Damp ground near Squaw creek; one locality. Possibly a form of *A. longipes* (Gold.) Cov.

Batrachium aquatile (L.) Wimm. Plentiful in the Des Chutes.

Ranunculus flammula reptans (L.) Sehl. Common in wet meadows, Sisters. Some of the specimens are strongly pubescent.

Ranunculus eiseni Kell. Infrequent; in moist ground, Sisters and Bend. Our material is referred doubtfully to this species of southern Oregon and northern California.

Ranunculus oreganus macounii (Britt.) Piper. Plentiful in wet meadows, Sisters.

Ranunculus cymbalaria Pursh. Frequent in wet ground along the Des Chutes.

Delphinium depauperatum Nutt. One specimen in very dry ground, Bend.

Roripa obtusa (Nutt.) Britt. One specimen found in damp ground near Squaw creek.

Thelypodium laciniatum (Nutt.) Endl. Dry stony ground at the foot of a cliff, Sisters.

Thelypodium sp. Found plentifully in one locality near the Des Chutes. A very small species for the genus.

Ribes inerme Ryd. (?) Plentiful in low thickets along Squaw Creek. Not fruiting.

Ribes irriguum Dougl. (?) Plentiful along the Des Chutes. Scarcely fruiting.

Ribes cereum Dougl. Frequent in dry ground, Sisters and Bend.

Philadelphus lewisii Pursh. Frequently in moderately dry ground, Sisters.

Spiraea douglasii Hook. In several localities in damp meadows, Sisters. This species is rare east of the Cascades. We should expect here *S. menziesii* Hook.

Rubus macropetalus Dougl. Common in damp ground along Squaw creek.

Rosa pisocarpa Gray. Common in somewhat dry grounds, Sisters.

Potentilla biennis Greene. Frequent in dry grounds, Sisters.

Potentilla fastigiata Nutt. Rather common in dry ground, Sisters and Bend.

Horkelia fusca Lindl. First noted in the yellow pine forest several miles to the west of Sisters, where over large areas it was almost the only herbaceous plant occurring in any abundance. Scarce at Sisters.

Fragaria crinita Ryd. In moderately dry ground, Sisters; rather scarce. *F. platypetala* Ryd. was found in the Cascades, Canadian zone, but it seems to be mainly an Arid Transition form, and is the one we should expect here. The species of *Fragaria* in Oregon are not well understood.

Argentina anserina concolor Ryd. Plentiful in wet meadows, Sisters, also along the Des Chutes.

Comarum palustre L. In a swampy meadow, Sisters.

Drymocallis convallaria Ryd. Common in rather dry ground, Sisters.

Kunzia tridentata (Pursh.) Spreng. Common on dry hills, Sisters and Bend.

Amelanchier sp. Common along Squaw creek. The material collected was in poor condition.

Lupinus aridus Dougl. Plentiful in dry ground, Bend.

Lupinus minimus Dougl. Frequent in dry ground, Sisters.

Lupinus polyphyllus Lindl. In wet meadows, Sisters; scarce. A small purple-flowered form.

Lupinus laxiflorus Dougl. Common in dry ground, Sisters.

Melilotus albus Desr. Common in moist ground, Sisters and Bend.

Trifolium longipes Nutt. Frequent in damp meadows, Sisters. A form with purple flowers.

Phaca purshii (Dougl.) Piper. In dry ground, Sisters; not common.

Vicia americana Muhl. A few specimens in moist ground near Squaw creek. A form approaching *V. a. linearis* (Nutt.) Wats.

Lathyrus oregonensis White. In dry ground, Bend; one locality.

Lathyrus bijugatus sandbergii White. Infrequent; in moderately dry ground, Sisters.

Linum digynum Gray. Scarce; in dry ground, Sisters.

Calitriche verna L. In pools along the Des Chutes.

Rhus toxicodendron L. In rather dry, stony ground, Bend; one locality.

Sidalcea oregana Gray. Moist meadows, Sisters; infrequent.

Hypericum scouleri Hook. Frequent in wet ground along the Des Chutes.

Viola sp. Abundant in one small area in sandy open ground, Sisters. A peculiar small, caulescent species, with cinerous -puberulent foliage and ovate leaves with repand margins. Not flowering.

Mentzelia albicaulis Dougl. Scarce; in high dry ground, Sisters.

Epilobium paniculatum Nutt. Common in rather dry ground, Sisters and Bend.

Taraxia heterantha taraxacifolia (Wats.) Small. A few specimens in moist ground along Squaw creek.

Gayophytum lasiospermum Greene. Common in dry ground, Sisters.

Gayophytum diffusum T. & G. With the preceding, but less common.

Gayophytum ramosissimum T. & G. With the preceding, frequent.

Sphaerosciadium capitellatum Gray. A few specimens in a swampy meadow, Sisters.

Cicuta occidentalis Greene. Scarce; in swampy meadows, Sisters.

Pyrola incarnata (DC.) Fisch. In one locality in damp shady ground along Squaw creek.

Arctostaphylos manzanita Parry. From the eastern border of the lava fields, through the yellow pine forest (where over large areas it is almost the only shrub), to Bend where it occurs sparingly. Though typically a Canadian species, it is thus seen to extend nearly across the Arid Transition.

Phyllodoce empetriformis (Smith) D. Don. Found sparingly, much out of its normal range, in a small canyon at the eastern edge of the lava fields.

Gentiana acuta Michx. Plentiful in damp meadows, Sisters, and along the Des Chutes.

Gentiana affinis Griseb. With the preceding and about equally common.

Gentiana simplex. Found sparingly in a wet meadow, Sisters. This seems an unusual locality for this species, which probably belongs to the Canadian zone, and has hitherto apparently been found only in the Sierra Nevada, Klamath, and Blue mountains.

Gilia pungens hookeri Gray. Scarce; on high dry ground, Sisters.

Gilia pharnaceoides Benth. Frequent in dry ground, Sisters and Bend.

Gilia humilis Greene. Infrequent; in moderately dry ground, Sisters and Bend.

Collomia grandiflora Dougl. Common in rather dry ground, Sisters.

Collomia linearis Nutt. Common in dry ground, Sisters and Bend.

Capnorea nana Raf. Moist ground, one locality, Bend.

Phacelia linearis (Pursh.) Holz. Rather plentiful in slightly moist ground, Sisters.

Phacelia heterophylla Pursh. In dry ground, Sisters; not common.

Phacelia sp. One specimen in dry ground, Sisters. Related to the preceding, but apparently distinct.

Phacelia sp. In one locality on a dry, stony hillside, Bend.

Related to *P. ramosissima* Dougl., and possibly a form of that species.

Conanthus parviflorus Greene. A few specimens in very dry ground, Sisters.

Cryptanthe ambigua (Gray) Greene. Frequent in rather dry ground, Sisters and Bend.

Lithospermum ruderale Dougl. A few specimens in high, dry ground, Sisters.

Scutellaria galericulata L. Scarce; in a damp meadow, Sisters.

Marrubium vulgare L. Common in dry ground, Bend.

Collinsia tenella (Pursh.) Piper. Moist ground, Bend; one locality.

Pentstemon glaber Pursh. Infrequent; in very dry ground, Bend.

Pentstemon confertus Dougl. Common in rather dry ground, Sisters and Bend.

Pentstemon collinus Nels. (?) Dry ground, Sisters and Bend; not common.

Pentstemon sp. Dry ground, Sisters.

Veronica americana Schw. Common in wet meadows, Sisters.

Veronica scutellata L. With the preceding.

Mimulus nanus H. & A. In moderately dry, sandy ground, Sisters and Bend. Extremely abundant in places, sometimes nearly covering the ground over an area of an acre or more, imparting a brilliant red color that may be seen for a distance of several miles.

Mimulus cusickii (Greene) Piper. In somewhat dry ground, Sisters; infrequent.

Castilleia miniata Dougl. In damp meadows, Sisters; not common.

Orthocarpus hispidus Benth. A few specimens in damp meadows, Sisters.

Chamaesaracha sp. A small colony representing an undetermined species of this genus was found in slightly moist, sandy ground along the Des Chutes.

Galium boreale L. Common in damp meadows, Sisters.

Galium trifidum subbiflorum Wieg. With the preceding.

Symphoricarpos racemosus Michx. Plentiful in rather dry ground, Sisters and Bend. A stout form, with thick glabrous leaves.

Lonicera involucrata Banks. In a small canyon at the eastern edge of the lava fields.

Lonicera coerulea L. A small colony at the edge of a meadow, Sisters.

Sambucus callicarpa Greene. A few specimens in the clefts of the rocks at the edge of the lava fields.

Valeriana sitchensis Bong. Plentiful in a small canyon at the edge of the lava fields. The subspecies *scouleri* (Ryd.) Piper, is found regularly in the Canadian and often in the Transition, while the type is Hudsonian. Our form is quite typical, and is therefore out of its normal range.

Ptiloria virgata (Benth.) Greene. Infrequent; in dry ground, Sisters.

Agoseris glauca (Nutt.) Greene. Rather scarce, in damp meadows, Sisters.

Agoseris heterophylla normalis Piper. Common in moderately dry ground, Sisters and Bend.

Hieracium griseum Ryd. Frequent in rather dry ground, Sisters.

Chrysothamnus puberulus Greene. High, dry ground, Sisters and Bend, more common at the latter place. This seems much to the westward of the regular range of the species.

Chrysothamnus viscidiflorus (Hook.) Nutt. High dry ground, plentiful at Sisters, very abundant at Bend.

Chrysothamnus nauseosus (Pall.) Britt. With the preceding and equally common. The two species are known as "Rabbit brush", and in the Upper Sonoran zone are second only to the sagebrush in abundance.

Solidago missouriensis Nutt. Frequent in moderately dry ground.

Townsendia florifer (Hook.) Gray. Frequent in dry ground, Sisters.

Erigeron poliospermus Gray. In dry ground, Sisters. Only one specimen found.

Erigeron linearis (Hook.) Piper. Frequent in very dry ground, Sisters and Bend.

Erigeron armeriaefolius Turez. A high altitude species of the Blue and Rocky mountains, and the Sierras, seemingly not hitherto known from the Cascade region.

Erigeron sp. In dry ground, Sisters; one specimen. A form resembling *E. hispidissimus* (Hook.) Piper, but with the pubescence short and soft and the rays much narrower.

Aster campestris Nutt. In meadows, Sisters; apparently not common.

Aster eatoni (Gray) Howell. With the preceding; not very common.

Aster occidentalis Nutt. With the preceding, common.

Aster sp. With the preceding.

Machaeranthera sp. Dry ground, Sisters and Bend; not common.

Hemizonella durandi Gray. A few specimens in rather dry ground, Sisters.

Eriophyllum multiflorum (Nutt.) Ryd. Infrequent in very dry ground, Sisters.

Eriophyllum lanatum (Pursh.) Forbes. A few specimens in dry ground, Bend.

Chaenactis douglasii (Hook.) H. & A. Very dry ground, Sisters; apparently scarce.

Achillea millefolium lanulosa (Nutt.) Piper. Frequent in dry ground, Sisters. A densely lanate form.

Artemisia ludoviciana Nutt. Common in dry ground, Sisters.

Artemisia tridentata Nutt. Sagebrush was first noted a little to the west of Sisters. It steadily increases eastward, and a few miles east of Bend, where the yellow pine disappears, it becomes the dominant species.

Tetradymia canescens DC. One specimen on high dry ground, Sisters.

Arnica sp. In damp meadows, Sisters; scarce.

Senecio howellii Greene. Common; in dry ground, Sisters and Bend.

Senecio triangularis Hook. A few specimens on the margin of the Des Chutes. It is rather suprising to find this Canadian and Hudsonian species in this locality. Our material represents a very tall and robust form.

Senecio sp. In rather dry ground, Sisters; one locality.

Senecio sp. One specimen of a small undetermined species found in damp ground, Bend.

Antennaria geyeri Gray. In moderately dry ground, Sisters; scarce.

Carduus undulatus Nutt. On a rather dry hillside, Bend.

Willamette University,
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AN IMPROVED HEATING APPARATUS FOR MAINTAINING CONSTANT TEMPERATURES IN WORK WITH POLARIMETERS AND REFRACTOMETERS.

J. N. PEARCE.

In the course of some work upon the effect of temperature upon the specific rotation of optically active substances in solution, it was found necessary to maintain constant temperatures over long periods of time. The conditions demanded that the heating apparatus be one which is simple and convenient and at the same time one which permits the easy reproduction of any given temperature.

Various forms of apparatus devised for this purpose are described in the literature. Some of these consist in principle of a coil for running water heated either by a Bunsen flame, or an electric coil. Where such methods are used in large crowded chemical laboratories the results obtained are unsatisfactory owing to fluctuations both in the gas and water pressures. Several modifications of this form were tried and discarded. While satisfactory as regards the regulation of temperature, the heating apparatus devised by Landolt for polarimeters is nevertheless inconvenient.

After several attempts the apparatus sketched in the accompanying diagram was perfected and the results obtained far exceeded our expectations.

In the figure, *A* is a round cylindrical vessel 25 cm. in diameter and 40 cm. in depth. Directly in the center and at the bottom of *A* is soldered the small cylinder, *B*, 6.2 cm. in diameter by 7.5 cm. in depth. Within the small cylinder rotates a motor-driven stirrer of propeller form. At *C*, slightly below the water level, is soldered a 9 mm. galvanized iron tube. A similar tube opening directly into the center of *B* is soldered to the bottom of the bath. The two open ends, *D*, *E*, are attached directly to the jacketed observation tube by means of short pieces of rubber tubing. Surrounding the bath is a layer, *F*, of felt or asbestos paper.

For temperatures near that of the ordinary laboratory temperature, the bath is heated by means of an immersed incandescent lamp and the temperature electrically controlled by means of a contact toluene regulator in series with a telegraph relay and battery. For temperatures considerably above that of the room, a second lamp is connected in parallel with the first. By applying the heat from a Bunsen burner the bath may be quickly heated and adjusted to any desired higher temperature. Owing to the presence of the small cylinder, *B*, the bath is

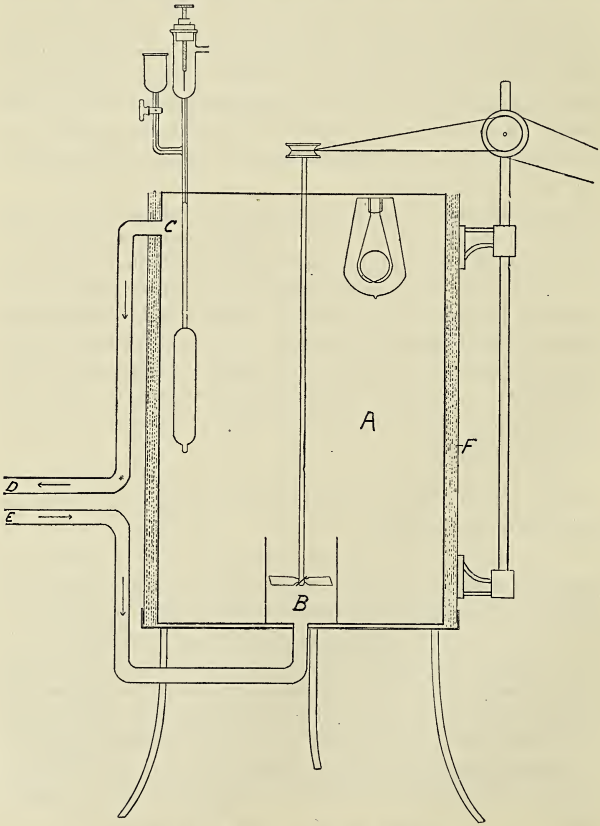


Fig. 4.—Diagram of heating apparatus.

equally adapted for use with ice at 0°, while for temperatures between 0° and that of the room a cooling coil connected with the water supply may be introduced.

When the bath is connected with the observation tube and the stirrer is driven at the rate of 500 to 600 r. p. m., the water circulates through the tube with an exceedingly high velocity. To judge of the force driving the water, it may be stated that when the tubes, *D*, *E*, are open and the stirrer is revolving at the above rate, the lifting power of the stirrer is sufficient to support a column of water eight inches in height. The speed with which the water is driven under hydrostatic equilibrium is, therefore, obvious. Under these conditions it is possible to maintain any desired temperature constant to ±0.01° — ±0.02° for any desired period of time.

Owing to the fact that the observation tube is of necessity at some distance from the bath, its temperature will be slightly lower and the difference will be greater, the higher the temperature to which the bath is heated. If the liquid in the observation tube must be at a definite temperature, the temperature of the bath can be adjusted easily so as to produce the desired temperature and the temperature of the tube regulated with the same degree of constancy.

PHYSICAL CHEMICAL LABORATORY,
THE STATE UNIVERSTY OF IOWA.

A CONVENIENT STANDARD CELL.

DIEU UNG HUONG AND J. N. PEARCE.

Until recently both the Clark and the Weston cells have served as standard sources of electromotive force. Both of these consist of an amalgam of a metal as the anode covered by a saturated solution of the sulphate of the metal and this in conjunction with mercury and mercurous sulphate which serves as the cathode.

Clark cell: (Hg–Zn)–$ZnSO_4$–Hg_2SO_4–Hg.
Weston cell: (Hg–Cd)–$CdSO_4$–Hg_2SO_4–Hg.

For various reasons the acceptance of the Clark cell as a standard has been discontinued. The Weston cell, chiefly on account of its approximately negligible temperature coefficient, is now the sole accepted standard of electromotive force.

The object of this investigation was to make a study of amalgam cells of the Weston type and to determine whether there may not be other amalgam cells which might serve as suitable and convenient standards of electromotive force.

With this idea in mind, amalgams of several metals were prepared and used as anodes against the mercury as cathode. Of these the copper amalgam cells appeared most favorable. They present at least one distinct advantage, viz., all of the constituents of the cell are easily obtained in a very pure form. A number of these cells have been prepared, their reproducibility has been determined and their temperature coefficients measured.

EXPERIMENTAL.

Mercury. The so-called "chemically pure" mercury (Kahlbaum) was further purified by vigorously shaking with pure dilute nitric acid. The acid and the dissolved impurities were then completely removed by shaking ten times with successive portions of hot distilled water. The mercury and the water were then separated by means of a separatory funnel and the mercury allowed to trickle through a dry filter.

Mercurous Sulphate. Kahlbaum's chemically pure mercurous sulphate was shaken with five successive portions of a saturated solution of copper sulphate. After each shaking the mercurous sulphate was allowed to settle and the supernatant liquid decanted.

Copper Sulphate. The pure salt was further purified by recrystallization. Clear stock crystals were carefully picked and dissolved in hot water. This solution was then filtered and allowed to crystallize. Clear crystals of about the size of a pea were picked and these were washed with distilled water. The saturated solution was preserved for preparing the cells.

Amalgam. The copper amalgam was prepared electrolytically. For this purpose a standard solution of copper sulphate containing exactly 25 grams of copper per liter was prepared. To make an amalgam of any desired concentration, a given weight of the pure mercury was placed in the electrolyzing vessel and the number of cc containing the desired weight of copper was added from a burette. Sufficient water was added to give a workable solution volume. Contact with the mercury cathode was made by means of a small platinum wire sealed into the end of a narrow glass tube containing the mercury which made the contact with the copper wire terminal. In order to hasten the electrolytic deposition of the copper, the platinum spiral anode was rapidly rotated by means of a small electric motor. The current was allowed to pass until a few drops of the solution tested with potassium ferrocyanide gave no indication of copper. After deposition the amalgam was quickly separated from the supernatant liquid by means of a stop-cock at the bottom of the electrolyzing vessel.

Cells. Only cells of the "H-type" were used and these were specially constructed for immersion purposes. According to Wolff and Waters, the size and dimensions of the cell do not affect the electromotive force but they do affect the rapidity with which the cells assume the temperature equilibrium.

The cells were made up in the usual. The amalgam and mercury were introduced into their respective limbs by means of pipettes, each to the depth of one and one-half centimeters. Upon the mercury was placed a two centimeter layer of a thick paste consisting of the mercury, mercurous sulphate and the saturated solution of copper sulphate. In each limb was next placed a two centimeter layer of clear picked copper sulphate crystals and the cell was then nearly filled with the saturated solution of copper sulphate. The limbs were then sealed with paraffin, cork and sealing wax, care being taken to admit an air bubble to allow for the expansion of the liquid.

All measurements of the electromotive force were made at both 18°±.02 and 25°±.02. The constant temperature bath was electrically heated and the temperature electrically controlled by means of the familiar contact toluol regulator and telegraph relay system. The temperatures were read on a certified thermometer, graduated in 0.10° and readable to 0.01°.

A recently certified Clark cell was used as reference cell. It was placed in a deep glass beaker and carefully covered with cotton. Owing to its high temperature coefficient the beaker and the cell were immersed in the water of the bath. The exact temperature of the cell was read from a certified thermometer imbedded in the Clark cell and the electromotive force of the cell corrected for the temperature.

No readings of the electromotive force were made until after the cells had come to temperature equilibrium. This equilibrium was considered as established when readings, taken at half-hour intervals, were identical. In no case were readings taken within three hours of the time of immersion.

The measurements of the electromotive force were made by means of a 5-dial Wolff potentiometer in connection with a sensitive galvanometer (type "H", L. and N.).

The temperature coefficients were calculated by means of the expression:

$$\frac{dE}{dt} = \frac{E_{18} - E_{25}}{E_{18} \cdot t},$$

where E_{18} and E_{25} are the electromotive forces measured at 18° and 25°, respectively, and t is the temperature interval. No attempt was made to derive a more elaborate expression for the temperature coefficients.

The results obtained are recorded in the following tables. Tables I to V show the results for five different cells. The vertical columns represent the successive measurements of different dates and the deviations of each from the mean in 0.00001 volt. Tables VI and VII give the records of two Clark and two Weston cells set up by Guthe and von Ende. These are added for comparison. Their measurements were made at 25°, and their results show greater deviations than have been found for the copper amalgam cells. Table VIII gives a summary of the results for the eight copper cells.

TABLE I.

CELL NO. I. PREPARED NOVEMBER 24, 1914.

		25°			
E	Dev.	E	Dev.	E	Dev.
.34677	—4	.34674	—7	.34680	—1
.34674	—7	.34674	—7	.34679	—2
.34679	—2	.34679	—2	.34679	—2

TABLE II.

CELL NO. II. PREPARED JANUARY 9, 1915.

E	Dev.	E	Dev.	E	Dev.
.34687	+6	.34688	+ 7	.34670	—11
.34687	+6	.34688	+ 7	.34670	—11
.34688	+7	.34670	—11	.34670	—11

TABLE III.

CELL NO. III. PREPARED MARCH 24, 1915.

E	Dev.	E	Dev.	E	Dev.
.34687	+6	.34680	—1	.34680	—1
.34686	+5	.34680	—1	.34680	—1
.34686	+5	.34680	—1	.34680	—1
.34686	+5	.34680	—1	.34680	—1

TABLE IV.

CELL NO. IV. PREPARED FEBRUARY 12, 1915.

E	Dev.	E	Dev.	E	Dev.
.34673	—8	.34673	—8	.34688	+7
.34686	+5	.34686	+5	.34680	—1
.34681	0	.34680	—1	.34685	+4
.34677	—4	.34681	0	.34680	—1
.34678	—3	.34679	—2	.34683	+2
.34682	+2	.34681	0	.34681	0
.34685	+4	.34685	+4	.34686	+5
.34684	+3	.34685	+4	.34679	—2
.34679	—2	.34679	—2	.34679	—2
.34680	—1	.34680	—1	.34680	—1

TABLE V.

CELL NO. V. PREPARED FEBRUARY 12, 1915.

E	Dev.	E	Dev.	E	Dev.
.34672	—9	.34673	—8	.34674	—7
.34681	0	.34679	—2	.34681	0
.34686	+5	.34686	+5	.34685	+4
.34680	—1	.34680	—1	.34680	—1
.34679	—2	.34678	—3	.34679	—2
.34679	—2	.34683	+2	.34680	—1
.34684	+3	.34684	+3	.34683	+2
.34682	+1	.34682	+1	.34680	—1
.34682	+1	.34682	+1	.34677	—4

TABLE VI.

Clark Cell (A_2). Prepared October 13, 1906.

E	E	E
1.41968	1.41992	1.41994
1.41982	1.41980	1.42004
1.42003	1.41999	1.41980
1.41987	1.42006	1.42005

Clark Cell (A_4). Prepared October 13, 1906.

E	E	E
1.42040	1.42045	1.42045
1.42045	1.42044	1.42048
1.42038	1.42038	1.42038
1.42037	1.42037	1.42037

TABLE VII.

Weston Cell (C_1). Prepared November 2, 1906.

E	E	E
1.01840	1.01838	1.01835
1.01835	1.01836	1.01836
1.01839	1.01844	1.01833

Weston Cell (D_1). Prepared November 9, 1906.

E	E	E
1.01837	1.01805	1.01815
1.01811	1.01805	1.01833
1.01833	1.01823	1.01819
1.01819	1.01814	1.01810

TABLE VIII.

Summary of Results of Eight Copper Cells.

No.	Percent Copper in amalgam.	E_{18} volts.	E_{25} volts.	Temperature coefficients.
I.	0.7	.35099	.34676	—.001721 volt
II.	4.0	.35100	.34681	—.001705
III.	5.0	.35102	.34681	—.001705
IV.	0.5	.35100	.34680	—.001705
V.	5.0	.35102	.34682	—.001705
VI.*	2.7	.35099	.34677	—.001717
VII.*	4.0	.35095	.34678	—.001697
VIII.*	4.3	.35080	.34676	—.001645
	Mean	.35096	.34679	.001700

*Cells Nos. VI, VII and VIII were constructed simply for checking, and therefore no detailed records were made.

SUMMARY.

Copper amalgam cells giving an electromotive force of 0.3468 volts at 25° can easily be duplicated to within a few one-hundred thousandths of a volt. The necessary materials are to be found in almost all laboratories. These materials are more easily purified than those used in the preparation of either the Clark or the Weston cells.

The electromotive force of these cells is independent of the concentration of the copper in the amalgam.

The temperature coefficient (0.001700 volt) is slightly higher than that of the Clark cell which has a temperature coefficient of 0.00119 volt.

These cells are recommended for use as standards for routine laboratory work or in laboratories where a Weston cell is not available. While the electromotive force is rather small, it may be increased to any desired value by connecting several cells in series.

PHYSICAL CHEMISTRY LABORATORY,
THE STATE UNIVERSITY OF IOWA.

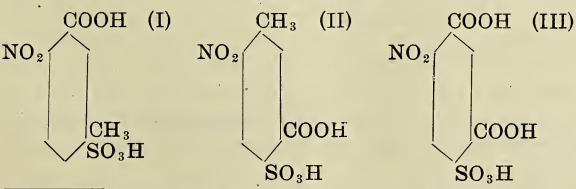
THE 4-NITRO-5-METHYL-2-SULPHOBENZOIC ACID AND SOME OF ITS DERIVATIVES.

WILLIAM J. KARSLAKE AND PERRY A. BOND.

The 4-nitro-5-methyl-2-sulphobenzoic acid has been investigated to a limited extent as one of the products formed when the 6-nitro-1, 3-dimethyl-4-sulphonic acid is oxidized by potassium permanganate in dilute alkaline solution. Previous to this research,[1] the only record of its preparation was by Limpricht,[2] in which case only a small amount of the neutral potassium salt was isolated. He gives this as occurring with one-half a molecule of water of crystallization, but does not state which of the two methyl groups of the original acid had been oxidized. The neutral potassium salt does not seem to contain any water of crystallization, however, and some doubt is cast upon the value of the observation as made by him.

Since the preparation of our acid is intimately associated with the work of Karslake and Bond upon the oxidation of the 6-nitro-1, 3-dimethyl-4-sulphonic acid, it seems best to outline the work already done. This is the more necessary, as since the publication of the results of that work it has been found that the materials were not absolutely pure, and that certain irregularities occurring as a result of this fact may be explained and corrected in the new work. It may be said here, however, that in no case does this error affect the final conclusions which were drawn at that time.

When 6-nitro-1, 3-dimethyl-4-sulphonic acid is oxidized in very dilute potassium hydroxide solution, three main products are formed. These are the salts of the 6-nitro-3-methyl-4-sulphobenzoic acid (I), the 4-nitro-5-methyl-2-sulphobenzoic acid (II), and the 6-nitro-4-sulphoisophthalic acid (III).



[1]Karslake and Bond, J. Am. Chem. Soc., 31, 405, 1909.
[2]Limpricht, Ber., 18, 2191, 1885.

As has been shown by Remsen,[3] List and Stein,[4] and others, the ortho sulphobenzoic acids either substituted or unsubstituted, give two isomeric acid chlorides, while such isomers are not found in case the carboxylic and sulphonic acid groups are in the meta or para position with respect to one another. In this instance it was found that on treatment with phosphorous pentachloride, the three salts of the acids which had been isolated from one another behaved differently, one of the dibasic acids giving only one acid chloride, while the isomeric acid gave two acid chlorides. The tribasic acid gave two chlorides also, as would be expected from the theory.

The original investigation of these acids was carried only far enough to establish their constitution. The analyses of the products covered a few salts of each, and the presence or absence of the isomeric acid chlorides was confirmed by the preparation of the ammonia derivatives. None of the products were analyzed, their differentiation being by means of their melting points and crystalline form.

Later, Karslake and Huston[5] made derivatives of the 6-nitro-3-methyl-4-sulphobenzoic acid. They confirmed the presence of only one acid chloride not only directly, but also through the appearance of a single series of derivatives including the amide, anilide, toluide, and diester, in which nothing was found that would indicate that the acid chloride as made could be other than a simple substance. The present work was undertaken to complete cur knowledge of the second of these three acids.

In previous work by Karslake and Bond,[6] the 4-nitro-5-methyl-2-sulphobenzoic acid was obtained in the form of the neutral potassium salt as the first crop of crystals from the oxidized nitro-xylene sulphonic acid. Analyses of this salt were persistently low in potassium, as is shown by the reported 20.96 per cent potassium as against the calculated 23.21 per cent. Analyses of the barium, acid barium, and silver salts gave very close results, however, and the constitution of the acid was considered fixed in spite of the discrepancy in the values for the potassium salt. Since then it has been found that this first crop of crystals is usually contaminated with unoxidized 6-nitro-1, 3-dimethyl-4-sulphonic acid in the form of the potassium salt.

[3] Am. Chem. J., 30, 247, 1903.
[4] Ber., 31, 1648, 1898.
[5] J. Am. Chem. Soc., 31, 1057, 1909.
[6] Loc. cit.

The separation was accomplished finally by systematic fractional crystallization, the crystals being filtered off first from the fairly concentrated solution at 50°, and then from the cold, somewhat diluted filtrate after standing several hours. The products thus obtained were recrystallized with due attention to temperature and concentration, until a complete separation was effected. Two criteria were used in determining purity. First, the salt of the original xylene sulphonic acid crystallized in needles, the complete absence of which under the microscope indicated purity; second, it was found that while the unoxidized nitro-xylene sulphonic acid salt has a very intense bitter sweet taste, the pure oxidized substance has practically none, what little can be perceived being only that characteristic of the potassium ion. This latter test is more delicate than the first and was used largely in determining the purity of a given fraction. About one hundred separate crystallizations were made in the purifying of the 235 grams of the potassium salt used as a basis for this research. The influence of the impurity has very definite effects, and its removal was a necessity, as will be seen especially in the preparation of the acid chlorides. Analyses of the purified potassium salt, while slightly low, are much better than before.

.1678 g. potassium salt gave .0859 g. K_2SO_4.
.1560 g. potassium salt gave .0800 g. K_2SO_4.

Theory for $C_8H_5O_7NSK_2$	Found
Potassium, 23.21 per cent.	22.95 - 23.01 per cent.

The neutral barium salt was prepared and analyzed previously, as was also the neutral silver salt. Neither contain water of crystallization. The acid barium salt crystallizes with two molecules of water. In addition to the foregoing, we have prepared the acid potassium salt and the lead salt.

Neutral Lead Salt.

$$\overset{4}{NO_2} \cdot \overset{5}{CH_3} \cdot C_6H_2 \left\langle \begin{matrix} \overset{2-1}{SO_3} \\ COO \end{matrix} \right\rangle Pb \cdot 3H_2O$$

This salt was made by adding slightly more than the calculated amount of $Pb(NO_3)_2$ to the water solution of the potassium salt. It crystallizes quickly from moderately concentrated solution in fine crystals, which in some cases form leaf-like groups. Lead was determined by direct ignition in the crucible as the sulphate.

.2000 g. of the lead salt gave .0200 g. water and .1154 g. $PbSO_4$.

Theory for $C_8H_5O_7NSPb \cdot 3H_2O$		Found
Water,	10.38 per cent.	10.00 per cent.
Lead,	39.8 per cent.	39.45 per cent.

Acid Potassium Salt.

$$\overset{4}{NO_2} \cdot \overset{5}{CH_3} \cdot C_6H_2 \cdot \overset{2}{SO_3K} \cdot \overset{1}{COOH} \cdot H_2O$$

This salt has been prepared in two ways; either by precipitating the silver from the silver potassium salt by dilute hydrochloric acid, evaporating and crystallizing; or by recrystallizing the neutral potassium salt from very concentrated hydrochloric acid. In the latter case, unless the hydrochloric acid is strong in the solution, the neutral potassium salt crystallizes out again, probably on account of its lesser solubility in water. The acid potassium salt once formed, however, can be recrystallized from water without decomposition. It comes out of the solution in beautiful fine needles containing one molecule of water of crystallization.

.1863 g. potassium acid salt gave .0107 H_2O and .0490 g. K_2SO_4.
.2258 g. potassium acid salt gave .0600 g. K_2SO_4.
.3061 g. potassium acid salt neutralized 8.9 cc. .10676N NaOH.

Theory for $C_8H_6O_7NSK \cdot H_2O$		Found
Water,	5.67 per cent.	5.74 per cent.
Acid hydrogen,	0.315 per cent.	0.317 per cent.
Potassium,	12.33 per cent.	11.81 - 11.92 per cent.

The Free Acid.

$$\overset{4}{NO_2} \cdot \overset{5}{CH_3} \cdot C_6H_2 \cdot \overset{2}{SO_3H} \cdot \overset{1}{COOH} \cdot 3H_2O$$

The free acid was prepared from the pure neutral silver salt by adding just a trifle more than the calculated amount of 0.1 N hydrochloric acid to the water solution of the salt, boiling, filtering, and evaporating to a small volume. The acid crystallized from water in platelike needles strongly rosetted and easily broken. It had only a slight yellowish tint. It was insoluble in ether, ligroin, and carbon tetrachloride. It was soluble in acetone, ethyl acetate, or glacial acetic acid. Its melting point when it was crystallized from acetone or alcohol was

94°. The acid was titrated with sodium hydroxide, using phenolphthalein as the indicator.

.1916 g. acid gave .0330 H_2O and required 5.60 cc .1088N HCl for its neutralization in the Kjeldahl process.

.2057 g. acid required 11.90 cc. .1088N NaOH for direct neutralization.

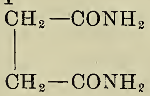
Theory for $C_8H_7O_7NS{\cdot}3H_2O$		Found
Water,	17.14 per cent.	17.22 per cent.
Acid hydrogen,	.635 per cent.	.626 per cent.
Nitrogen,	4.44 per cent.	4.45 per cent.

The Acid Chlorides.

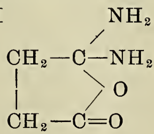
When the potassium salt of the 4-nitro-5-methyl-2-sulphobenzoic acid is heated with phosphorous pentachloride, it is converted into the acid chloride. The product is not a simple substance. On crystallizing from carbon tetrachloride, it gives two characteristically different crystalline forms which have the same composition, but which differ materially in respect to their behavior with certain reagents such as ammonia, aniline, etc. The appearance of these isomeric chlorides is characteristic of the ortho acids either of the ortho dicarboxylic or ortho sulphobenzoic type. It is among the latter especially that the problem has been worked upon,[7] since the dicarboxylic acids, e. g., ortho phthalic acids, have a tendency to form a large excess of one isomer and very little of the other.

The original argument regarding the constitution of these acid chlorides was based probably on the work done by Auger[8] on the chlorides of the dibasic acids. He found that if succinyl chloride was treated with ammonia, it gave a different diamine than when the ester of succinic acid was acted upon, and, since the latter could not have a symmetrical formula (I), he assigned to the isomeric body the formula (II). The ease with which the symmetrical diamine goes over into the imine (III) is comparable with that of the formation of the acid anhydride, and forms part of the argument.

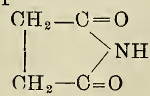
I



II



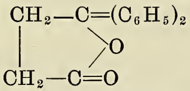
III



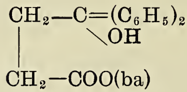
[7]Remsen and Students, Am. Chem. J., 30, 247, 1903.
[8]Auger. Bl. 39, 346, 1888.

Auger also points out that when the succinyl chloride is treated with benzene and aluminium chloride, it gives two products, mainly, however, one, to which he gives the unsymmetrical formula (IV) on the ground that when saponified with barium hydroxide, it gives not the original succinic acid, but a diphenyl derivative, a monobasic acid, which may be formulated (V), while the isomeric product, which may be ten per cent of the total, is not acted upon.

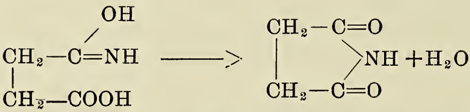
IV



V



The analogy is carried to the phthalic acids which, according to Auger, occur only in the unsymmetrical form. D. Vörlander[9] has objected to the idea of isomeric chlorides. He explains the action of the imine on the basis of the formation of an isomer of an amido acid.



He objects to any form of reasoning through the use of the acid chloride with benzene where a substance like aluminium chloride is involved in the reaction. However, the isolation of the ortho sulphobenzoic acid chlorides in two forms as carried on by Remsen and his pupils, has put an end to any doubt which there may have been regarding the existence of two separate distinct acid chlorides in such cases, and has strongly reflected credit on the work of Auger. We shall use the terms symmetrical and unsymmetrical in the same sense in which he used them.

It was formerly stated[10] that the treatment of the potassium salt of the 4-nitro-5-methyl-2-sulphobenzoic acid with phosphorous pentachloride in a flask with reflux condenser at boiling temperature produced an oily substance which solidified with difficulty, but on being dissolved in carbon tetrachloride, dried, and partly evaporated, gave two products, one melting at 133°, the other an oily substance for which a melting point of 93° was suggested. It had been the experience of others that the

[9]Ber., 30, 2268, 1897.
[10]Loc. cit. (Karslake and Bond.)

low melting and high melting chlorides crystallized in a constant melting mixture which had a lower melting point than that of the low melting chloride. The two were separated in these cases by distilling in a vacuum.

The formerly observed melting point for the high melting chloride is approximately correct, the new value adopted being 134°, but now it has been definitely shown that the low melting point acid chloride melts at 83°, and is not involved as the prime cause of the oily mixture. In this case, as distinguished from the experience of others, no oil was produced when pure initial potassium salt was used, the two chlorides crystallizing out in absolutely distinct crystalline form. They were separated by fractional crystallization, and the symmetrical, high melting chloride showed a tendency toward the formation of supersaturated solutions in carbon tetrachloride, the solvent used for the purification. The oily mass formerly found by Karslake and Bond was, however, reproduced by mixing with the low melting acid chloride, a portion of the acid chloride of the unoxidized nitro-xylene sulphonic acid. Its source in that work was evidently the impurity mentioned at the beginning of this paper.

Symmetrical Acid Chloride.

$$\overset{4}{N}O_2 \cdot \overset{5}{C}H_3 \cdot C_6H_2 \cdot \overset{2}{S}O_2Cl \cdot \overset{1}{C}OCl$$

The symmetrical acid chloride was formed in the largest amounts when the potassium salt of the acid was treated with phosphorous pentachloride in an open dish at the temperature of the steam bath, the ratio of the symmetrical to the unsymmetrical acid chloride thus formed being about three to five, and the total yield reaching seventy-five per cent of the theoretical.

When the heating had caused complete liquifaction of the mass in the open dish, it was removed from the steam bath and poured into cold water. Phosphorous oxychloride and any phosphorous pentachloride remaining were dissolved in the water, and after a time the oil hardened. It was broken up with a stirring rod and ground with fresh water in a mortar. Finally the powder was let stand in more water over night, filtered, and the solid dried over sulphuric acid in a dessicator. It was next dissolved in hot carbon tetrachloride, filtered, and let stand to crystallize. If the solution was concentrated, the unsymmetrical chloride crystallized first and later there were superimposed on the crystalline mass hard, glistening, rhombohedral crystals of the symmetrical chloride. These were picked out by hand from the mass. In another experiment it was found that this chloride crystallized in the form of long white needles. Once these were produced in the laboratory, the rhombohedral forms never appeared again. The needles seemed to be less soluble than the unsymmetrical acid chloride, and hence could be taken out from the carbon tetrachloride solution as the first crop of crystals. In some cases the solution was seeded to bring about the rapid production of this form.

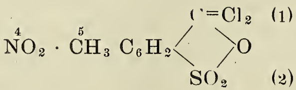
The identity of the two crystalline forms of the symmetrical acid chloride was shown by the identical melting points, 134°, and also by the fact that when the rhombohedral form was dissolved in carbon tetrachloride and a trace of the needles added, the whole amount present crystallized out in the needle form.

The symmetrical acid chloride was recrystallized from carbon tetrachloride several times until the melting point was constant at 134°, and then was analyzed. Chlorine was determined by saponifying with sodium hydroxide, acidifying with nitric acid, and precipitating as silver chloride. Sulphur was determined by Pringsheim's method using sodium peroxide; nitrogen was determined by the Gunning method.

.1569 g. chloride gave .1500 g. silver chloride.
.1278 g. chloride gave .1241 g. silver chloride.
.1264 g. chloride gave .0896 g. barium sulphate.
.3140 g. chloride required 9.68 cc of .1084N HCl.
.2973 g. chloride required 9.08 cc of .1084N HCl.

Theory for $C_8H_5O_5NSCl_2$		Found
Chlorine,	23.80 per cent.	23.65 - 24 02 per cent.
Nitrogen,	4.70 per cent.	4.68 - 4.64 per cent.
Sulphur,	10.74 per cent.	10.72 per cent.

Unsymmetrical Acid Chloride.



This acid chloride constituted about five-eighths of the total yield of the acid chlorides as made by the open dish method. Its formation is apparently favored by the presence of phosphorous oxychloride, for when a reflux condenser is used in the preparation of the chlorides, and the condensed phosphorous oxychloride formed is kept in the mixture, a much larger per cent of the unsymmetrical chloride is produced, although the absolute yield seems to be smaller. Holmes[11] used phosphorous oxychloride in sealed tubes for the preparation of the pure unsymmetrical acid chloride of p-nitro-o-sulphobenzoic acid. In this case we found it not necessary, and the shorter process was used.

The purification of the unsymmetrical acid chloride by fractional crystallization from carbon tetrachloride was not difficult. It crystallized in short, tufted, rather soft needles, yellowish in color. An attempt was made to use the method of List and Stein[12] for the purification of the acid chlorides by distillation in vacuo. It was expected that the symmetrical chloride would decompose at the distillation temperature, while the unsymmetrical would distil unchanged. Distillation took place at the following temperatures and pressures.

Pressure in mm. mercury	Boiling point
21	218 - 220°
11	214°
10	212°

It was found that both acid chlorides distilled unchanged under these conditions. The distillation mixture was composed of nearly pure 83° melting chloride; no attempt was made to distil the 134° melting acid chloride either alone or when there was any large per cent of it in the mixture. No difference was made in the melting point of the pure 83° melting point substance, though its color was nearly destroyed by the distillation.

The acid chloride melting at 83° was analyzed, the methods used being the same as in the case of the high melting chloride.

.3849 g. acid chloride gave .3626 g. silver chloride.
.3848 g. acid chloride gave .3646 g. silver chloride.
.2780 g. acid chloride gave .2636 g. silver chloride.
.2780 g. acid chloride gave .2180 g. barium sulphate.
.2869 g. acid chloride required 9.06 cc 1084N HCl.
.1823 g. acid chloride required 5.80 cc 1084N HCl.

Theory for $C_8H_5O_5NSCl_2$		Found
Chlorine,	23.80 per cent.	23.3 - 23.40 - 23.46 per cent.
Nitrogen,	4.70 per cent.	4.82 - 4.79 per cent.
Sulphur,	10.74 per cent.	10.77 per cent.

[11] Am. Chem. J., 25, 204, 1901.
[12] Ber., 31, 1648, 1898.

The slightly low values shown for chlorine are due probably to the presence of some acid in the acid chloride. In all its reactions this form of the chloride seems more labile than the symmetrical form, and while the decomposition is very slow by water or heat, yet it seems to take place to a definite degree. It will be noted that the values for nitrogen or sulphur would be almost unaffected by the transformation of a small amount of the acid chloride into the acid, what little difference might be produced being according to the indications of the analysis.

Some Other Attempts to Make the Acid Chlorides.

Since the use of phosphorous pentachloride is attended by the production of the fumes of phosphorous oxychloride, and also as the yield of the acid chlorides made by that method is not as large as might be desired, an attempt was made to use sulphuryl chloride for their preparation. An attempt was made on the potassium salt of the 6-nitro-3-methyl-4-sulphobenzoic acid, which forms the chloride more easily than the acid which we were investigating. Four grams of the material were mixed with about 3 grams of the SO_2Cl_2, and the mixture heated with the use of a reflux condenser for several hours. On pouring into water, it solidified at once, but when an attempt was made to crystallize from carbon tetrachloride it refused to dissolve, showing that the acid chloride, which is easily soluble, had not been formed. The product slowly dissolved in water. The acid chloride apparently could not be formed in this way.

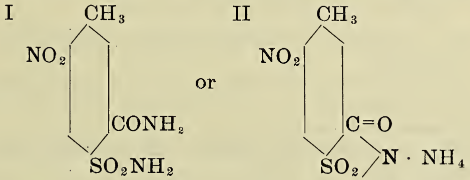
Since chlorsulphonic acid has a higher boiling point than the sulphuryl chloride, an attempt was made to use it as in the preceding case. Four grams of the potassium salt of the 6-nitro-3-methyl-4-sulphobenzoic acid were treated with the calculated amount of chlorsulphonic acid, and heated with the use of a reflux condenser. The material melted and gases were given off, the action apparently being vigorous. On pouring into water and filtering the residue, only a very small amount of the acid chloride seemed to have been formed.

Another attempt was made by using twice the theoretical amount of the chlorsulphonic acid, heating on the steam bath, and dropping more carefully into cold water so as to prevent hydrolysis. The oily precipitate solidified and settled over night. When this was filtered and washed, the yield was about twenty-five per cent of that demanded by the theory. On recrystallizing from carbon tetrachloride, it gave a melting point of 90° which corresponds to the acid chloride of this acid.

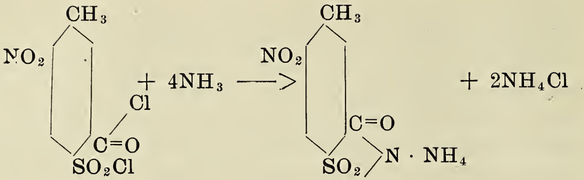
While the use of the chlorsulphonic acid is of moderate value for the preparation as given above, it has been found that in the case of the isomeric 4-nitro-5-methyl-2-sulphobenzoic acid in which we are interested, the yield approaches zero. The change which is produced in this case runs almost wholly along the line of the production of a soluble crystalline substance which is formed as a by-product in the making of the acid chlorides by all the methods tried. This body was not investigated. A few analyses showed that it probably was neither the acid nor the acid potassium salt.

DERIVATIVES OBTAINED BY THE ACTION OF AMMONIA ON THE ACID CHLORIDES.

A. *From the Symmetrical Acid Chloride.*—The symmetrical acid chloride is only slightly acted upon in nonaqueous solutions by ammonia, but when treated with strong aqueous ammonia, the pure chloride may be dissolved at boiling temperature with the formation of a substance soluble in water which might be either the diamide (I), or the ammonium salt of the imide (II).



The product is the latter, since it can be formed from the imide by simple neutralization with ammonia, also because when its solution is treated with sodium hydroxide as in the Kjeldahl method and the mixture distilled, the presence of one and only one ammonium group is shown. The passage from the o-diamide to the ammonium salt, moreover, would be very easy under the conditions of the experiment. No other substance was recovered in the preparation, excepting, of course, the ammonium chloride formed in the reaction.



A suitable amount of the acid chloride was placed in an open beaker and treated with concentrated ammonia. Apparently there was no action in the cold, but on raising the temperature slowly to boiling, so as to keep the concentration of the ammonia as high as possible, the acid chloride dissolved. When the excess of ammonia was evaporated off and the residue was cooled somewhat, the ammonium salt of the imide crystallized out as small glistening cubes. These were recrystallized from water several times. They then gave a melting point, with decomposition, of 310°-320°.

Total nitrogen was determined by the modified Gunning method, and sulphur by the Liebig method. Ammoniacal nitrogen was determined by dissolving a weighed portion of the salt in water in a Kjeldahl flask, adding 30 cc. of strong sodium hydroxide, and distilling into .1N hydrochloric acid.

.2193 g. ammonium salt required 23.41 cc .1084N hydrochloric acid.

.1950 g. ammonium salt required 20.80 cc .1084N hydrochloric acid.

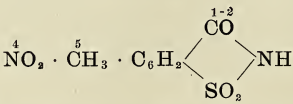
For ammoniacal nitrogen—

.3002 g. ammonium salt required 11.00 cc .1088N hydrochloric acid.

.1674 g. ammonium salt gave .1509 g. barium sulphate.

	Theory for $C_8H_9O_5N_3S$	Found
Total nitrogen,	16.21 per cent.	16.20 - 16.18 per cent.
Ammon. nitrogen,	5.40 per cent.	5.58 per cent.
Sulphur,	12.35 per cent.	12.38 per cent.

The Imide.

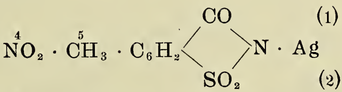


When the cold mother liquor from the crystallization of the ammonium salt of the imide is made acid with hydrochloric acid, the imide separates almost quantitatively from the solution. At slightly elevated temperatures it is more soluble so that it comes out in a nice crystalline condition. It is colorless, and the crystals as viewed under the microscope are platelike needles, so thin in one dimension that the edge appears only as a line under a magnification of 150 diameters. The insolubility of the precipitate makes it unnecessary to purify except by washing with water until free from chlorides. The imide is bitter tasting. It is readily soluble in alkali, as would be expected from the presence of the imide group. It forms salts with various metals, by which it may be characterized more completely. Its melting point is 213.5°. The methods of analysis were those used for the ammonium salt.

.1168 g. imide required 9.00 cc .1084N HCl.
.1156 g. imide required 8.97 cc .1084N HCl.
.1643 g. imide gave .1584 g. barium sulphate.

	Theory for $C_8H_6O_5N_2S$	Found
Nitrogen,	11.57 per cent.	11.77 - 11.68 per cent.
Sulphur,	13.22 per cent.	13.25 per cent.

Silver Salt of the Imide.

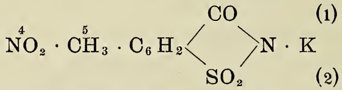


When the imide was dissolved in a large volume of hot water, and a solution of silver nitrate added, a white crystalline precipitate slowly appeared. The crystals were platelike needles, somewhat rosetted, but these rosettes were very loosely held together and easily broke up into the long, thin, square ended needles. The salt contained no water of crystallization. It was less soluble than the silver salt of the cyan acid to be described later. The determination of silver was made by charring the salt in a porcelain crucible with sulphurc acid, and reducing the silver sulphate directly in the same container. This seemed to give better results than attempting to precipitate the silver as the chloride from a litre or more of solution. Some difficulty was encountered in the heating, however, as the silver salt decomposed suddenly and the loss by the puffing from the crucible spoiled the analysis, unless the rate of charring was carefully regulated.

.1173 g. silver salt gave .0362 g. silver.

Theory for $C_8H_5O_5N_2S.Ag$	Found
Silver, 30.92 per cent.	30.87 per cent.

Potassium Salt of the Imide.



The potassium salt of the imide, which is much more soluble than either the silver salt or the original imide, is made by treating the ammonium salt of the imide in hot, quite concentrated solution with an excess of strong potassium carbonate. An immediate crystalline precipitate appears, which may come down more slowly from more dilute solution. It can be recrystallized from water as there is considerable difference between its solubility in hot and cold water. The mother liquors and wash waters if acidified give the free imide, and in this way the material may be saved. The potassium salt crystallizes in peculiar shaped plates, which are sometimes rosetted together, but often occur separately.

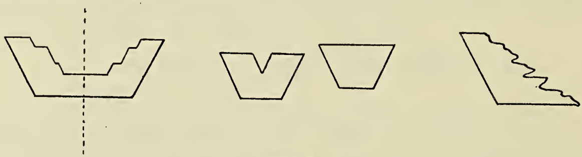


FIG. 7.

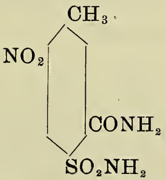
The figures given, figure 7, excepting the last one, are all double, as the rosetting, when such occurs, takes place at the middle of the figures shown above, ie., along the dotted line. The second crystallization gave a solution free from alkali. It has a weak bitter taste. There is no water of crystallization. Potassium was determined as potassium sulphate in the manner described for the silver salt.

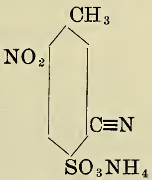
.1610 g. potassium salt imide gave .0499 g. potassium sulphate.

Theory for $C_8H_5O_5N_2S{\cdot}K$	Found
Potassium, 13.96 per cent.	13.91 per cent.

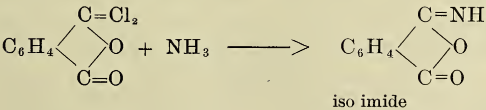
B. From the Unsymmetrical Chloride.—If the acid chloride melting at 83° is treated with cold concentrated ammonia, an action takes place which while beginning slowly, at last goes on rapidly with the evolution of heat. The behavior in this respect is characteristically different from that of the symmetrical chloride. In making the ammonia derivative in practice, the ammonia was diluted with three parts of water to lessen the action. If the ammonia is evaporated off and the remaining liquid is concentrated and cooled, crystals form in nodules. These crystals are not as sharply defined as those of the corresponding ammonium salt of the imide; the nodules appear to be made up of compact masses of radiating crystals which branch continually into fanlike shapes. When these nodules are crushed, it is impossible to find any characteristic crystalline form. Recrystallized from alcohol, however, the crystals were not bunched but seemed to be laminated plates almost cubical in form, but with no smooth surfaces. The yield of the product is good. In no case was there any indication of the ammonium salt of the imide. The salt is more soluble than the ammonium salt of the imide. Its melting point is 310-311°, with decomposition.

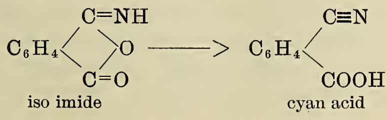
Since this salt is not the ammonium salt of the imide, it must be either the diamine (I), or the ammonium salt of the cyan acid (II).

I 

II 

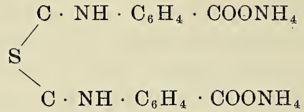
The cyan formula for bodies of this type is derived from the work of Hoogewerff and Van Dorp[13], on the action of ammonia on phthalic chloride. They give the reaction thus—





[13]Rec. Trav. Chim., 11, 84; 12, 12, 1892.

If this latter is treated with alcoholic ammonium sulphide, it gives



analogous to benzamide as made from benzonitrile and ammonium sulphide. This indicates the nitrile formula. That our compound is the cyan acid is also shown by its salts, which characterize it as a monobasic acid.

The ammonium salt has a very bitter taste. The free acid was not prepared. When hydrochloric acid is added to solutions of its salts, no precipitate appears. Analyses were made for nitrogen by the Gunning method, and for sulphur by Pringsheim's method.

.2966 g. ammonium salt required 31.19 cc .1084N HCl.
.1397 g. ammonium salt required 14.83 cc .1084N HCl.
.2801 g. ammonium salt gave 4 times .0623 and .067.

Theory for $C_8H_9O_5N_3S$	Found
Nitrogen, 16.21 per cent.	16.11 - 15.95 per cent.
Sulphur, 12.35 per cent.	12.31 - 12.24 per cent.

Silver Salt of the Cyan Acid.

$$\overset{4}{NO_2} \cdot \overset{5}{CH_3} \cdot C_6H_2 \cdot \overset{1}{CN} \cdot \overset{2}{SO_3} \cdot Ag$$

The silver salt of the cyan acid was first prepared by adding silver nitrate solution to the hot solution of the ammonium salt. An attempt was then made to purify the precipitate by dissolving in much water, and letting it crystallize slowly. It was found, however, that decomposition was likely to take place when boiling the silver salt at high dilutions, and so the procedure was changed. The very dilute solution of the ammonium salt was heated, the silver nitrate solution was added only slightly in excess of the calculated amount, and the solution was cooled slowly. The silver salt precipitated in fairly heavy, pointed needles which were not clustered. When washed with cold water, they were ready for analysis. The drying should take place in the dark if a pure white product is obtained. The silver salt of the cyan acid is somewhat more soluble than the silver salt of the imide, but is still quite insoluble at ordinary temperatures. There is no water of crystallization. Silver was determined directly.

.2100 g. silver salt gave .0647 g. silver.

Theory for $C_8H_5O_5N_2S \cdot Ag$	Found
Silver, 30.92 per cent.	30.81 per cent.

Potassium Salt of the Cyan Acid.

$$\overset{4}{NO_2} \cdot \overset{5}{CH_3} \cdot C_6H_2 \cdot \overset{1}{CN} \cdot \overset{2}{SO_3K}$$

The potassium salt of the cyan acid was made by dissolving two grams of the ammonium salt in thirty-five cubic centimeters of water, and adding while hot one gram of potassium carbonate in ten cubic centimeters of water. The solution was boiled to drive off the ammonia at least partly, and then allowed to cool. The potassium salt crystallized out in clustered crystalline plates similar to figure 8, or sometimes in pairs resembling figure 9.

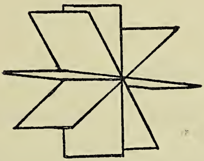


FIG. 8.

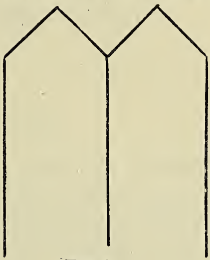


FIG. 9.

The salt was recrystallized from pure water. Its solubility is greater than that of the corresponding potassium salt of the imide. The taste is bitter in a degree corresponding to that of others of these compounds. The salt contained no water of crystallization. Potassium was determined as the sulphate.

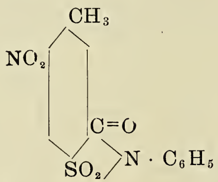
.1509 g. substance gave .0472 grams potassium sulphate.

Theory for $C_8H_5O_5N_2S \cdot K$	Found
Potassium, 13.96 per cent.	14.03 per cent.

DERIVATIVES OBTAINED BY THE ACTION OF ANILINE ON THE ACID CHLORIDES.

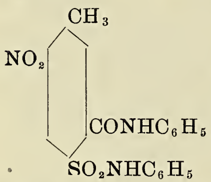
A. From the Symmetrical Chloride.—The formation of the anilids of the acid chlorides by previous experimenters in this field has been carried out in three ways: first, by the treatment of the solid acid chloride with aniline; second, by the treatment of the acid chloride with aniline in ether or chloroform solution; and third, by the action of aniline on the acid chloride in the presence of water. The first method has been found to be unsatisfactory. In general, the third method has been chosen by Remsen and his students[14] as it seemed to give the most constant results. In this work, however, it has been found that by using carbon tetrachloride as the solvent the products were of the same nature as those obtained by Remsen and his students by the water method. The process is shorter and the substances are easily separated from one another.

From the symmetrical acid chloride two products were obtained. One of these, which is insoluble in cold, reasonably dilute sodium hydroxide, is known as the anil. It corresponds to the formula

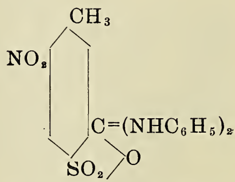


It resembles the imide in many respects, but does not form salts as it contains no imido hydrogen.

The other product contains two aniline residues and forms salts, ie., is easily soluble in dilute sodium hydroxide. For this the formula has been given as—



rather than—

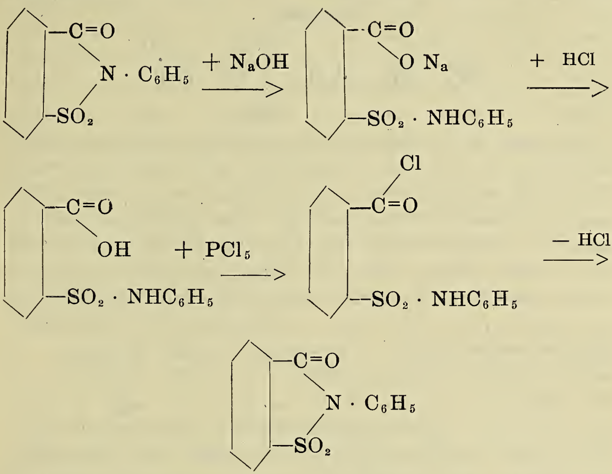


The proof of these formulæ is given by analogy with that of the anil and symmetrical dianilid of o-sulphobenzoic acid. Remsen and Kohler[15] found that if the anil was boiled with sodium hydroxide solution it dissolved and could be precipitated again by acidifying the solution. It was not, however, the anil after this treatment, but an anilido acid, which could be transformed again into the anil by treating with phosphorous

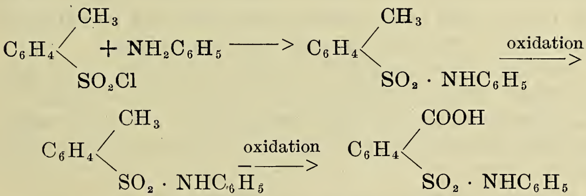
[14]Loc. cit.

[15]Am. Chem. J., 17, 338, 1895.

pentachloride in chloroform solution. The reactions may be represented as follows:



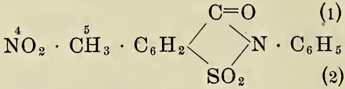
The structure of the anilido acid given above was shown synthetically by oxidizing with potassium permanganate the product obtained when o-toluene sulphonchloride was treated with aniline.



The product made in this way is identical with that from the anil as mentioned above.

When the symmetrical anilide is boiled in alkaline solution, the first product is the salt of the anilido acid. If boiling is continued the neutral salt of the sulphobenzoic acid is formed. On account of the two steps in which the reaction takes place, Remsen and Kohler consider that the two anilido groups bear different relationships to the molecule. The reactions given would seem to indicate strongly the above presented structures for both the anil and the dianilide.

The Anil.



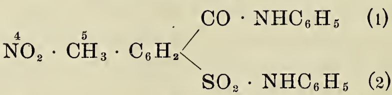
One gram of the symmetrical acid chloride was dissolved in about fifty cc of carbon tetrachloride at boiling temperature. While this was hot there was added aniline in excess of the amount calculated for the dianilide. This aniline also was dissolved in carbon tetrachloride, and the mixture was warmed for an hour. There was only a slight precipitate at the end of that time, hence the carbon tetrachloride was evaporated and the residue treated with dilute hydrochloric acid. After kneading the residue, which at this stage was oily in nature, for several minutes, the mass solidified. It was then broken up into fine fragments and was allowed to stand over night in order that the excess aniline might all dissolve as the hydrochloride. The residue was filtered, ground in a mortar with hydrochloric acid, filtered and washed with water to remove the excess of acid. It was next treated with cold, dilute potassium hydroxide. The solution became bright yellow, and a dirty white precipitate was left in an amount small as compared with the bulk of the original precipitate. This insoluble material, which was the anil, was washed with water, dried, and recrystallized from alcohol. The yield of crude anil was .27 gram.

The anil is very insoluble in alcohol except close to the boiling point. About one hundred cc of alcohol were required to recrystallize the anil as above. When pure, it is nearly white, and crystallizes in needles which have a melting point of 202-203°.

.1185 g. substance required 7.00 cc .1088N HCl.

Theory for $C_{14}H_{10}O_5N_2S$	Found
Nitrogen, 8.81 per cent.	9.00 per cent.

The Symmetrical Anilide.



The sodium hydroxide solution filtered from the anil was acidified with hydrochloric acid. A white curdy precipitate at once came down and was filtered off and washed free from acid. It was then redissolved and reprecipitated for further purification. Finally, it was washed, dried, and recrystallized from 75 per cent alcohol. It formed a fine cottony mass of soft needles with a melting point of 195°. The yield of the anilide was .98 gram. The substance was identified in this case not by analysis but by its exact correspondence with the dianilide formed under like conditions as a derivative of the unsymmetrical acid chloride. Mixtures of the two preparations showed the same melting point as that of either of the pure specimens.

List and Stein[16] state that there are three products formed by the action of aniline on the symmetrical chloride, but there was no indication of a third body here, and a consideration of the yields obtained will show that no very large amount of the material is unaccounted for.

.27 grams of anil is equivalent to	.25	grams of acid chloride.
.98 grams dianilide is equivalent to	.71	grams of acid chloride.
	.96	
Amount of acid chloride taken	1.00	

B. *From the Unsymmetrical Chloride.*—The process of making the derivatives of the unsymmetrical chloride was the same as that used in the action upon the symmetrical chloride. The unsymmetrical chloride was dissolved in carbon tetrachloride and to the hot solution was added aniline in carbon tetrachloride so long as the white precipitate—which in contradistinction to the action of the symmetrical chloride, came down on the first addition of aniline—continued to form. Hydrochloric acid vapor was evolved copiously, and the aniline hydrochloride apparently did not form to any great extent. There was required for the completion of the reaction a moderate excess above the two molecules of aniline to each molecule of the acid chloride. The precipitate which was thus formed, on being stirred gathered into a gummy mass which hardened as the solution cooled. Only a small amount of material was left in the carbon tetrachloride, but in order that all the products might be recovered, it was evaporated to dryness as before and the whole solid residue ground with hydrochloric acid in a mortar and then allowed to stand to remove soluble products. After some hours it was filtered and washed with a considerable amount of water. The washings were saved with the original filtrates. The precipi-

[16]Loc. cit.

tate, which was insoluble in water was now treated with dilute sodium hydroxide in which it was almost completely soluble. Only a faint cloudiness remained in the solution, hence the conclusion was that nothing but the merest traces of anil could have been formed. The amount of anil produced from five grams of pure unsymmetrical acid chloride was only great enough to stain the filter paper. No positive identification of it was possible. This corresponds with the observation by Holmes[17] that no anil was produced from the unsymmetrical chloride of o-sulphobenzoic acid. From this solution the anilide was precipitated by hydrochloric acid as in the case of the symmetrical compound, washed, dried and recrystallized from alcohol. It was found in this case, however, that a large portion of the precipitated material would not dissolve even in hot alcohol. This substance, which proved to be the unsymmetrical anilide, will be described later.

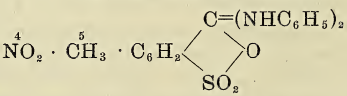
Symmetrical Anilide.

The alcohol solution mentioned above, on cooling gave a mass of soft needles which on recrystallization melted at 195°. This substance is identical with the anilide formed from the symmetrical chloride, and in conformity with the argument used in that case, is known as the symmetrical anilide. It is tasteless. The anilide was analyzed for sulphur by Pringsheim's method, and for nitrogen by the modified Gunning method.

.1461 g. substance required 9.78 cc .1084N HCl.
.1661 g. substance required 11.00 cc .1084N HCl.
.1775 g. substance gave .0255 × 4 g. barium sulphate.

	Theory for $C_{20}H_{17}O_5N_3S$	Found
Nitrogen,	10.22 per cent.	10.15 - 10.06 per cent.
Sulphur,	7.78 per cent.	7.91 per cent.

The Unsymmetrical Anilide.


(1)
(2)

The substance insoluble in alcohol was purified by dissolving in hot 75 per cent alcohol with the aid of sodium hydroxide added drop by drop until the precipitate had disappeared. To this solution acid was added, and the precipitate which formed after a delay of some seconds was nicely crystalline. The crystals

[17]Am. Chem. J., 30, 275, 1903.

were very fine. The melting point seemed to be at 342°; but fusion did not occur until after the product was quite black with heating. This behavior corresponds with that of the symmetrical anilides which have been described by others. The formula is given from the fact that it is formed only by the action of the unsymmetrical acid chloride, and also that the two anilido groups are intact in the compound.[18]

The unsymmetrical anilide is insoluble in most ordinary solvents and this is a general characteristic of such substances. Carbon tetrachloride, alcohol and benzene have little if any action on it. Analysis for sulphur was by Liebig's method and that for nitrogen by the modified Gunning method.

.1962 grams substance required 19.49 cc .1088N HCl.
.2187 grams substance gave .1237 grams barium sulphate.
.2253 grams substance gave .1261 grams barium sulphate.

	Theory for $C_{10}H_{17}O_5N_3S$	Found
Nitrogen,	10.22 per cent.	10.02 per cent.
Sulphur,	7.78 per cent.	7.77 - 7.69 per cent.

The third substance produced by the action of aniline on the unsymmetrical acid chloride is soluble in water, and was recovered by evaporating the filtrates from the various washings of the original dianilides. It crystallizes in clumps of needles whose fineness or coarseness is dependent on the rate of formation.

It is suspected that this body is the anilido acid, but it is not easy to purify and no very satisfactory analyses were obtained. It gives an acidity approaching that expected, but rather less, while it is high in nitrogen.

The total yields of the two anilides were almost equal, but the weight of the third body was less than either. This latter fact may be due to incomplete recovery, as the substance crystallized out in a fashion which showed it to have a solubility only slightly less than the sodium chloride with which it was mixed. It is also probable that there was considerable hydrolysis to the 4-nitro-5-methyl-2-sulphobenzoic acid. The total yield from a given amount of the acid chloride is not sufficient to account for all the material.

TRANSFORMATIONS OF THE ANILINE DERIVATIVES.

When either the symmetrical or unsymmetrical anilide is treated with phosphorous oxychloride, at boiling temperature,

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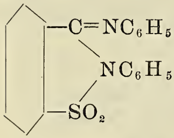
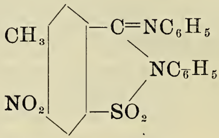
[18] Remsen and Hunter; Am. Chem. J., 18, 812, 1896.

for about one-half hour, a yellow colored solution is produced. If the excess of phosphorous oxychloride is distilled off with care, an air blast being used to help the process, a thick brownish oil is left, which after being cooled and treated with water to remove phosphoric acid, becomes a bright yellow powder. This powder is the dianil.

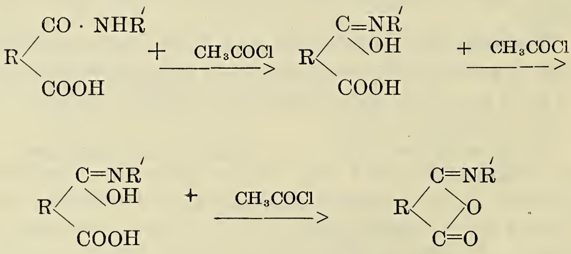
The dianil of o-sulphobenzoic acid was made and analyzed by Remsen and Hunter.[19] The formula assigned to the compound was—



corresponding to which we have

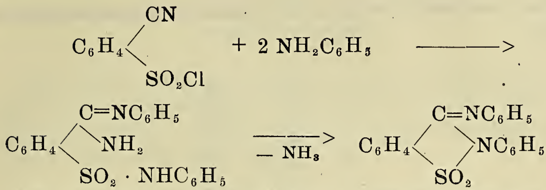


The basis of the formula is found in the work of several investigators. Hoogewerff and Van Dorp,[20] using phosphorous oxychloride or acetyl chloride, effected the formation of isoimides, by treating the amino derivatives of certain dibasic acids.

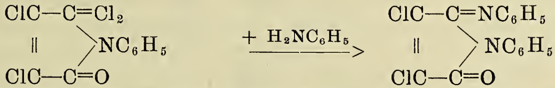


Jesurun[21] used practically the same reaction upon the ortho cyan benzene sulphone chloride, and obtained what appear to be analogous results.

[19]Loc. cit.
[20]Loc. cit.
[21]Ber. 26, 2292, 1893.



Also Anschultz and Beavis[22] give a reaction of this kind for maleic dianil, which they form by the action of dichlor maleic anil on aniline.



The dianil recrystallizes nicely from acetone diluted with water, and forms short, bright yellow, hexagonal needles. It is soluble in other solvents, such as benzene and alcohol, and may be recrystallized from them if desired. The substance when recrystallized melts constantly at 188°. It was analyzed for nitrogen and sulphur.

.1793 g. substance requires 12.67 cc .1088N HCl.
.1950 g. substance gives .1150 g. barium sulphate.

Theory for $C_{20}H_{15}O_4N_3S$		Found
Nitrogen,	10.69 per cent.	10.76 per cent.
Sulphur,	8.14 per cent.	8.10 per cent.

The anilides may be transformed into one another by various reagents. These processes have been worked out for various acids. Blanchard[23] worked with the anilides of p-brom sulphobenzoic acid, Henderson[24] and others with the corresponding p-nitro and unsubstituted bodies. The results in every case are similar to those given by the anilides herein described.

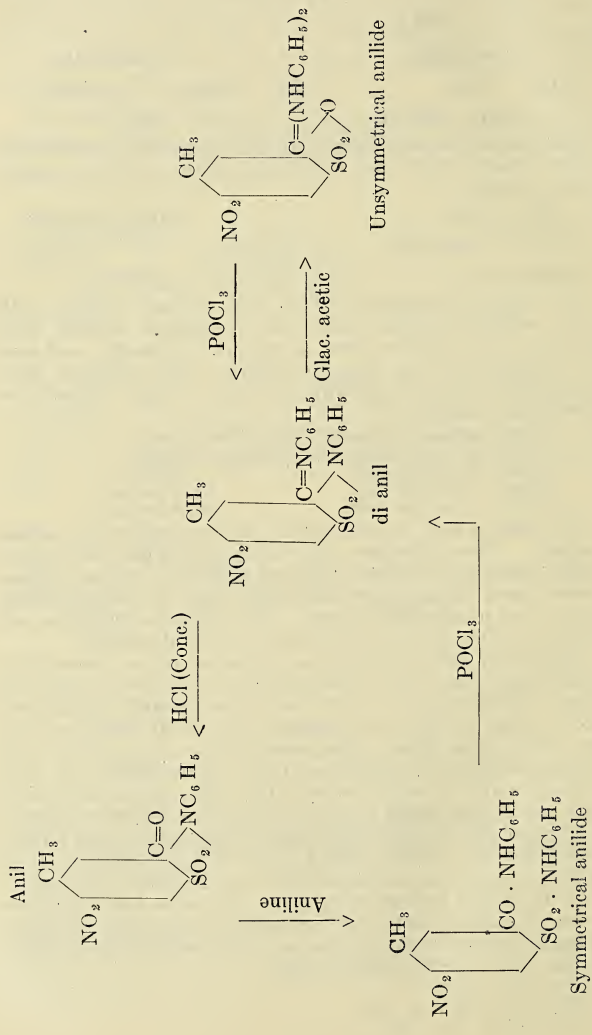
As has been stated, if either the unsymmetrical or symmetrical anilides are treated with phosphorous oxychloride we obtain the dianil. If the dianil is boiled with concentrated hydrochloric acid, it goes over into the colorless anil without dissolving, and the yellow color slowly disappears during the process. The melting point of the colorless solid, 202°, shows it to be the anil.

If the dianil is boiled for some time with glacial acetic acid until the solution, which is vivid yellow at first, becomes colorless, and the solution is allowed to stand, the unsymmetrical anilide crystallizes out. When washed with water and dried it has a melting point of approximately 342°, as described previously.

If the anil is warmed with aniline for some hours, and the excess of aniline distilled off with steam, the residue, when recrystallized from alcohol, proves to be the fusible or symmetrical anilide with a melting point of 195°.

[22] Ber., 28, 58, 1895.
[23] Am. Chem. J., 30, 485, 1903.
[24] Am. Chem. J., 25, 1, 1901.

These transformations may be represented diagramatically as follows:



DERIVATIVES OBTAINED BY THE ACTION OF ALCOHOL ON THE ACID CHLORIDES.

When either of the two acid chlorides of 4-nitro-5-methyl-2-sulphobenzoic acid is treated with alcohol, a reaction may occur which, at boiling temperature, results in the formation of the benzoic ester of the free sulphonic acid,

$$\overset{4}{N}O_2 \cdot \overset{5}{C}H_3 \cdot C_6H_2 \cdot \overset{1}{C}OOR \cdot S\overset{2}{O}_2OH$$

The symmetrical acid chloride on treatment with absolute alcohol at boiling temperature, dissolves and on cooling reprecipitates, in part at least, unchanged. If, however, the solution is boiled for some time, nothing crystallizes out on cooling. On evaporation an oil is left, which crystallizes after long standing as the alkyl ester of the free sulphonic acid mentioned above. There is no trace of chlorine in this product after recrystallization, hence the alkyl ester of the sulphone chloride appears not to be formed.

The unsymmetrical acid chloride goes into solution in alcohol rather easily even at ordinary temperatures. It was found best for purposes of obtaining the product, however, to dissolve the acid chloride at boiling temperature as in the other case. On cooling at once, there were deposited crystals which contained much chlorine, but which were not the original acid chloride. They were identified as the alkyl ester of the sulphone chloride,

$$\overset{5}{N}O_2 \cdot \overset{5}{C}H_3 \cdot C_6H_2 \cdot \overset{1}{C}OOR \cdot S\overset{2}{O}_2Cl$$

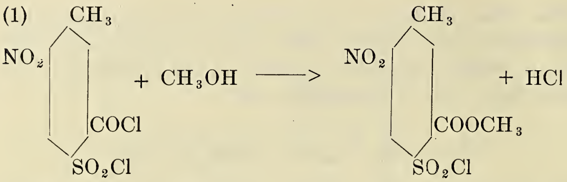
The filtrate, on evaporation gave the same product as was obtained from the symmetrical chloride.

In work which has been done upon the acid chlorides of related bodies, such as the o-sulpho benzoic acid, by Sohon,[25] Henderson,[26] and Kastle,[27] or the p-nitro-o-sulpho benzoic acid by Chambers,[28] the results finally have been shown to be exactly like those obtained for our acid. Sohon and Kastle worked with impure substances, but the work of Henderson and Chambers is in complete agreement. Kastle's explanation of the process has

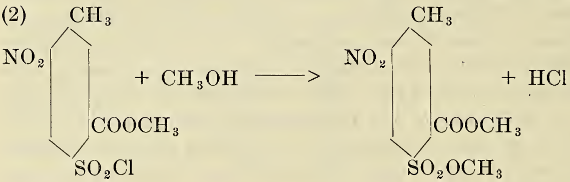
[25] Am. Chem. J., 20, 260, 1898.
[26] Am. Chem. J., 25, 8, 1901.
[27] Am. Chem. J., 11, 181, 1889.
[28] Am. Chem. J., 30, 387, 1903.

been adopted as the correct one. He states that the reaction proceeds in three steps according to which we would have,

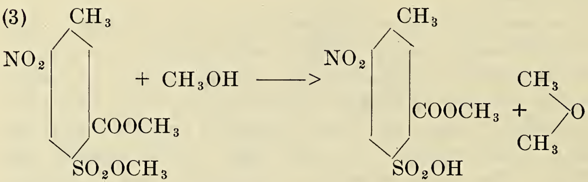
(1)



(2)



(3)



Of the three substances formed, two, the first and third, are produced by boiling the unsymmetrical acid chloride with alcohol; only one, the third, is formed from the symmetrical chloride. The second product shown above has not been isolated in this reaction. It, the diester, has, however, been made in another way. Its instability toward hydrolizing agents will explain its easy decomposition, though in the absence of hydrochloric acid, it can be recrystallized from alcohol with only slight loss.

In all of the experiments with the alcoholic derivatives of the two acid chlorides, the final products are the same, the only difference being the formation of the ester of the sulphone chloride as an intermediate product in the action of the alcohol on the unsymmetrical acid chloride.

Methyl Ester Sulphone Chloride.

$$\overset{4}{N}O_2 \cdot \overset{5}{C}H_3 \cdot C_6H_2 \cdot \overset{1}{C}OOCH_3 \cdot S\overset{2}{O}_2Cl$$

This substance was prepared from the unsymmetrical acid chloride by dissolving in hot alcohol. The warming was kept up only long enough to obtain solution. When the solution was cooled, the sulphone chloride ester separated in long platelike crystals. It was washed with a very little absolute alcohol under suction and dried. It is very soluble in benzene, alcohol, acetone, ether and chloroform, and on this account a great deal of difficulty was encountered in purifying it. The solvent finally used was ligroin, in which the ester is not very soluble. Drying was by suction in a partial vacuum. After standing over night in a desiccator, the product, which has a melting point of 101°, was analyzed.

Chlorine was estimated by saponification with dilute potassium hydroxide in a small Erlenmeyer flask, then by exactly neutralizing with nitric acid, and finally by titrating with .1 N silver nitrate solution, using potassium chromate as the indicator. Sulphur was determined by the Liebig and nitrogen by the Gunning methods.

.2278 g. substance gave .1828 g. barium sulphate.
.1140 g. substance gave .0892 g. barium sulphate.
.2553 g. substance required 7.77 cc .1084N HCl.
.1985 g. substance required 6.09 cc .1084N HCl.
.1859 g. substance required 6.37 cc .1N Silver nitrate.
.2959 g. substance required 10.02 cc .1N Silver nitrate.

Theory for $C_9H_8O_6NSCl$	Found
Sulphur, 10.92 per cent.	10.75 - 11.02 per cent.
Nitrogen, 4.77 per cent.	4.66 - 4.61 per cent.
Chlorine, 12.08 per cent.	12.09 - 12.01 per cent.

Methyl Benzoic Ester of the Sulphonic Acid.

$$\overset{4}{N}O_2 \cdot \overset{5}{C}H_3 \cdot C_6H_2 \cdot \overset{1}{C}OOCH_3 \cdot S\overset{2}{O}_2OH$$

The methyl ester acid was prepared as described, by boiling either acid chloride with methyl alcohol for some time and evaporating to a syrup. On cooling it slowly formed crystals which on account of their extreme solubility were not purified. The identification was by means of the barium salt, which could be made easily. The silver salt, which was very soluble, was made but not analyzed. It was used in the preparation of the dimethyl ester.

For the preparation of the barium salt of the methyl ester acid, a portion of the syrupy solution of the acid was diluted slightly, and barium chloride added while the mixture was heated. When the mixture was cooled, long, fine, white needles arranged in well developed nodules crystallized out. They were recrystallized from dilute alcohol and barium was determined directly as the sulphate by ignition with sulphuric acid. There was no water of crystallization.

.2691 g. substance gave .0917 g. barium sulphate.

Theory for $C_{10}H_{10}O_6NSCl$	Found
Barium, 20.04 per cent.	20.05 per cent.

Ethyl Ester Sulphone Chloride.

$$\overset{4}{NO_2} \cdot \overset{5}{CH_3} \cdot C_6H_2 \cdot \overset{1}{COO}C_2H_5 \cdot \overset{2}{SO_2}Cl$$

The ethyl ester sulphone chloride was prepared exactly as the corresponding methyl compound had been prepared. Its properties are practically the same, and the appearance of the crystals, which are flat needles, is so nearly like that of the methyl ester chloride, that they cannot be distinguished under the microscope. The needles have characteristic ends, as illustrated in figure 10.

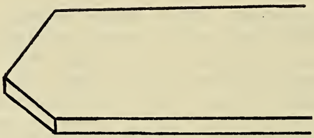


Fig. 10.

The melting point of the ethyl ester chloride is 72°, which seems peculiar, for the melting point of the methyl ester chloride is 101°.

The ester chloride was analyzed for nitrogen by the Gunning method, for sulphur by the Pringsheim method and for chlorine by saponifying, neutralizing with nitric acid, and titrating with silver nitrate solution.

.1748 g. substance required 5.04 cc .1084N HCl.
.1714 g. substance required 4.85 cc .1084N HCl.
.1463 g. substance gave 4×.0272 g. barium sulphate.
.2143 g. substance required 7.04 cc .1N Silver Nitrate.

Theory for $C_{10}H_{10}O_5NSCl$.	Found
Nitrogen, 4.55 per cent.	4.37 - 4.29 per cent.
Sulphur, 10.40 per cent.	10.21 per cent.
Chlorine, 11.54 per cent.	11.65 per cent.

Ethyl Benzoic Ester of the Sulphonic Acid.

$$\overset{4}{N}O_2 \cdot \overset{5}{C}H_3 \cdot C_6H_2 \cdot \overset{1}{C}OOC_2H_5 \cdot S\overset{2}{O}_2OH$$

This was made in the same manner as the methyl ester acid, and the free acid was not isolated, its presence being proven by the making and analysis of the barium salt. The salt crystallized in tufts of soft needles from the hot solution of the acid, to which barium chloride had been added. It was purified by recrystallizing from dilute alcohol.

.2244 g. substance gave .0742 g. barium sulphate.

Theory for $C_{10}H_{10}O_7NS.Ba$	Found
Barium, 19.26 per cent.	19.45 per cent.

The Dimethyl Ester.

$$\overset{4}{N}O_2 \cdot \overset{5}{C}H_3 \cdot C_6H_2 \cdot \overset{1}{C}OOCH_3 \cdot S\overset{2}{O}_2OCH_3$$

The dimethyl ester cannot be made by the direct action of the acid chlorides on alcohol. The method which seems to have been most commonly used (see Remsen and Bird,[29] or Cobb[30]) is the use of sodium methylate either dry or in absolute alcohol solution, with an absolute ether solution of the acid chloride. Cobb reports that the best yields are found when dry sodium methylate is added to the ether solution, but notes that in any case there is a tendency to pass over to the sodium salt of the ester acid, which is, of course, dissolved in the washing of the ether solution. This naturally affects the yield which can be obtained. This method was tried on both the symmetrical and unsymmetrical acid chlorides of our acid. It produced no satisfactory results. The pure acid chloride which melts at 134° gave no action which could be followed, when it was treated with dry sodium methylate in ether solution, though a pinkish color appeared as each portion of the methylate was added to the solution. The melting point of the substance recovered from the ether after treatment was 132°, and on analysis it gave 22.9 per cent chlorine as compared with the theoretical 23.5 per cent for the acid chloride. This indicates that in the main the acid chloride was unchanged.

The pure acid chloride which melts at 83° gave what was apparently a mixture of the unchanged acid chloride and the methyl ester chloride. The melting point of the product ranged

[29]Am. Chem. J., 30, 262, 1903.
[30]Am. Chem. J., 35, 488, 1908.

from 60°, at which it softened, to 101°, at which the final melting occurred. An effort was made to use pyridine and alcohol on the ether solution of the acid chloride. It resulted in a good yield of the methyl ester sulphone chloride, melting nicely at 101°, but no dimethyl ester was formed.

Failing by the methods above given, recourse was had to Kastle's method of treating the dry silver salt of the methyl ester acid with methyl iodide. The silver salt of the methyl ester sulphonic acid was made by adding silver nitrate solution to the syrup obtained by boiling down a solution of the acid chloride in alcohol. It crystallized from the strong solution in cottony needles which were sucked dry and used without purification. The silver nitrate which was in excess would finally precipitate as silver iodide, and not interfere with the formation of the diester.

The salt was dried at 110° (it puffs at 140° unless quite pure) and was ground in a mortar. It was then placed in a pressure bottle and methyl iodide added in excess. Immediately a rapidly increasing yellow precipitate of silver iodide came down. The mixture was heated, however, at 100° under the pressure of its vapor in order to make sure of the completion of the reaction. The excess of the methyl iodide was then evaporated and the dry residue extracted with absolute ether and filtered. The product obtained by evaporating the ether was recrystallized from absolute methyl alcohol and it then gave a constant melting point of 94.5°. This melting point is remarkably close to that of the free 4-nitro-5-methyl-2-sulphobenzoic acid, but the substance is insoluble in water, and gives no acid reaction. It contains no chlorine, as was shown by hydrolyzing with potassium hydroxide and testing with silver nitrate. The diester was analyzed for nitrogen only, on account of the small amount of the material available.

.1869 grams substance required 6.12 cc .1088N HCl.

Theory for $C_{10}H_{11}O_7NS$	Found
Nitrogen, 4.85 per cent.	4.98 per cent.

DERIVATIVES OBTAINED BY THE ACTION OF PHENOL ON THE ACID CHLORIDES.

The action of phenol upon the acid chlorides offers no new facts bearing on the constitution of the latter. The products are of the same general nature as those given by the alcohols. Both acid chlorides seem to give practically the same derivatives.

Remsen and Saunders[31] made the phenol derivatives of o-sulphobenzoic acid by heating the high melting acid chloride with phenol. They obtained only the symmetrical diphenyl ester. Remsen and McKee[32] found that the unsymmetrical acid chloride gave the same results. More thorough work by Humphreys,[33] in which careful attention was paid to the temperature of the reaction, shows that at 40° the symmetrical acid chloride gives both the diphenyl ester and some of the phenyl ester sulphone chloride, while the unsymmetrical gives only the phenyl ester sulphone chloride; at 60° both acid chlorides give equal amounts of the above mentioned products; at 130° both acid chlorides give only the diphenyl ester. It would seem that the behavior is largely a function of the temperature, and that it is not safe to draw any general conclusions from the experimental data. Chambers[34] found that even at low temperatures the p-nitro-o-sulphobenzoic acid, when a very weak alkaline solution was used, as in the Schotten-Baumann reaction, gave the diphenyl ester.

In every instance noted, a water soluble red substance is also formed, probably a phthalein. No investigation has been made of it, and none was made here in spite of its evident presence. It is removed in the washing of the diphenyl ester with water. It shows the properties of an indicator. Alkalies, including ammonia, give a deep purple color, mineral acids a salmon pink solution. With acetic and tartaric acids, even in the presence of hydrochloric acids, the color is lemon yellow. However, excess of sulphuric acid prevents the development of the yellow color. The material for these tests was the unpurified substance obtained by heating phenol and the acid chloride together at a high temperature for some time. The difference in the behavior of the acids may be due to the presence of other substances than the phthalein proper.

Three methods were used in preparing the diphenyl ester. First, the acid chloride was warmed with phenol. The production of phthalein was so marked, that this method was used only for a trial preparation. The diester appears to be the only product outside of the phthalein.

Second, the Schotten-Baumann method was tried. The acid chloride was dissolved by gentle warming in a slight excess of

[31]Am. Chem. J., 17, 353, 1895.
[32]Am. Chem. J., 18, 799, 1896.
[33]Am. Chem. J., 30, 292, 1903.
[34]Am. Chem. J., 30, 374, 1903.

phenol. When the solution was cooled, the yellow oil which formed was treated with an excess of dilute potassium hydroxide solution. There was instant reaction, though apparently no large amount of heat was developed. After being stirred for five minutes the oil solidified and was broken up with a stirring rod and allowed to stand. It was then filtered and washed with water. The amount of phthalein formed was small. On crystallizing from alcohol a melting point of 115° was obtained, but careful recrystallization from benzene, glacial acetic acid, and alcohol in order, gave a melting point of 123°. This identified it as the diphenyl ester, as will be shown later.

The third method is the one which was used practically for the preparation of the diphenyl ester for analysis. It consisted in treating the acid chloride with a mixture of pyridine and phenol. Two grams of phenol and an equal amount of pyridine were mixed in a small beaker and the powdered acid chloride added. At this point in the preparation occurred the only difference which was noticed between the action of the unsymmetrical and the symmetrical acid chlorides. The symmetrical acid chloride with the melting point of 134°, dissolved rapidly with the evolution of heat, while warming was neccessary in order that the unsymmetrical might react. The products were always the same, however, and the discussion of the method which follows will apply equally well to either acid chloride. It might be remarked that in all the chemical behavior of the two acid chorides this seems to be the only case when the high melting acid chloride is the more reactive. When the acid chloride had dissolved in the pyridine phenol solution the liquid was warmed for ten minutes on the water bath. This caused the formation of phthaleins, however, and in later preparations the warming was omitted, and instead the product simply was allowed to stand at room temperature for the completion of the reaction. Alcohol was then added and warmed until all the compound was in solution. As the liquid cooled crystals formed as colorless, flat needles somewhat resembling those of the ethyl benzoic ester of the sulphone chloride. These contained no chlorine, however, and were the diphenyl ester.

A scond crop of crystals which came down showed a canary yellow color. The crystal form was that of a blocky rhombohedron. The yellow color, it has been shown, while very persistent, is not characteristic, but due to the presence of phthalein dissolved in the crystal. Ordinary recrystallization does not remove the color. The crystals must be ground fine with water and allowed to stand with it for a long time in order to extract the phthalein. When this is done, they may be recrystallized from glacial acetic acid followed by alcohol, and are colorless, with a melting point of 206°. They contain no chlorine. These crystals were not formed in the Schotten-Baumann reaction. No sulphone chloride was formed by any of these three methods, a fact which was due in all probability to the temperature employed.

The Diphenyl Ester.

$$\overset{4}{NO_2} \cdot \overset{5}{CH_3} \cdot C_6H_2 \cdot \overset{1}{CO}OC_6H_5 \cdot SO_2\overset{2}{O}C_6H_5$$

The product melting at 123° which is formed in all of the preceding methods has been shown to be the diphenyl ester. The melting point of the crude product, is, according to our experience, always 115° or 116°, but by recrystallization from alcohol, benzene, alcohol, glacial acetic acid, and alcohol in the order named, the melting point becomes constant at 123°. The products which were obtained separately from the symmetrical and unsymmetrical acid chlorides, are identical in this respect as in all others. The pure substance was analyzed for nitrogen by the Gunning method, and for sulphur by the Liebig method.

.2066 g. substance required 4.65 cc .1088N HCl.
.2059 g. substance required 4.69 cc .1088N HCl.
.2023 g. substance gave .1144 g. barium sulphate.
.1631 g. substance gave .0933 g. barium sulphate.

Theory for $C_{20}H_{15}O_7NS$	Found
Nitrogen, 3.39 per cent.	3.42 - 3.47 per cent.
Sulphur, 7.75 per cent.	7.74 - 7.86 per cent.

The Product Melting at 206°.

The second product which was produced by the action of phenol in the presence of pyridine has not been identified positively. It gives the odor of pyridine on treatment with strong potassium hydroxide, and may be a pyridine salt of the phenyl benzoic ester of the sulphonic acid. Nitrogen, where pyridine groups are present, cannot be determined by any modification of the Kjeldahl method, as the results always are low, but the degree of loss in such case is fairly constant. If due allowance is made for this factor, the results vary only a few tenths of a per cent.

Theory for $\overset{4}{NO_2} . \overset{5}{CH_3} . C_6H_2 . \overset{1}{COOC_6H_5} . \overset{2}{SO_3H} . C_5H_5N$

	Theory	Found
Sulphur,	7.65 per cent.	7.69 per cent.
Nitrogen,	6.73 per cent.	5.91-5.99 per cent.

These figures cannot be called determinative. Lack of time prevented the determination of nitrogen by the absolute method.

CONCLUSIONS.

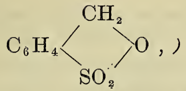
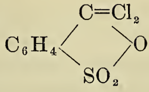
The writer cannot help feeling as a result of his study in this field, that the matter of the actual formulae of the two acid chlorides is still unsettled. It is true that the ammonia derivatives seem to give positive results, but when we come to the anilides, we find that the so-called symmetrical anilide is produced in equal quantity with the unsymmetrical anilide from the unsymmetrical acid chloride.

In the case of the alcoholic derivatives the differences in behavior are slight. The greater activity of the unsymmetrical acid chloride is manifest, and the formation of the sulphone chloride ester by it is different from the action of the symmetrical acid chloride which goes directly to the ester acid; but, as has been shown, the higher temperature required for the action of the symmetrical acid chloride on the alcohol would cause the hydrolysis of the ester of the sulphone chloride to give the ester of the sulphonic acid, just as it occurs on boiling the unsymmetrical acid chloride with alcohol. There is no reason to suspect that the mechanism of the reaction is different in one case from what is it in the other.

When we come to the phenols, the behavior of the two bodies is the same, even to the formation of the colored compounds. This further complicates the reasoning, as we have not only, as in the case of the anilides, an unsymmetrical body giving a symmetrical compound in part, but also, in the case of the phenols, a symmetrical compound giving a presumably unsymmetrical body, and that too in practically the same proportions in which it is formed from the unsymmetrical chloride.

The fact as shown by List and Stein[35] that the reduction of the symmetrical acid chloride gives the sulphobenzid, (I) has its most direct and reasonable explanation in the formation from (II), which is, however, the formula given for the unsymmetrical chloride.

[35]Ber., 31, 1648, 1898.

I  II 

This tends to cast a doubt on the situation, as it negatives partly, at least, by its influence the positive results given by the ammonia derivatives in favor of the other view.

Tautomeric change is not a suitable explanation, where the two bodies are so distinctly differentiated from one another, unless the mechanism of the reactions shows definitely how such change does occur. No proof for any such mechanism has been produced. The discovery of the two crystalline forms of the symmetrical acid chloride may or may not have a bearing on the question.

From a physical standpoint, the work on our acid confirms by analogy the work done by Remsen and his students upon this class of bodies.

SUMMARY.

1. Two acid chlorides, the symmetrical with a melting point of 134°, the unsymmetrical with a melting point of 83°, have been prepared. These bodies were peculiar only in that they could be separated by fractional crystallization from solution, and that when pure, they did not tend in the least to form constant melting mixtures. Two crystalline forms of the symmetrical acid chloride were isolated, but their differences were not investigated closely.

2. The derivative obtained by the action of ammonia upon the symmetrical acid chloride was the ammonium salt of the imide. From this the imide itself was prepared by the action of dilute hydrochloric acid. The silver salt and the potassium salt of the imide also were made and analyzed.

3. The derivative obtained by the action of ammonia on the unsymmetrical acid chloride was the ammonium salt of the cyan acid; no imide was found. The silver and potassium salts of the cyan acid also were made and analyzed.

4. The derivatives obtained by the action of aniline on the symmetrical acid chloride were the symmetrical dianilide and the anil.

5. The derivatives obtained by the action of aniline on the unsymmetrical acid chloride were the symmetrical dianilide and the unsymmetrical dianilide.

6. By the action of phosphorous oxychloride, each of the two dianilides was transformed into the dianil. This in turn when heated with concentrated hydrochloric acid gave the anil or, heated with glacial acetic acid it gave the unsymmetrical dianilide.

7. The derivative obtained by the action of the alcohols on the symmetrical acid chloride was the benzoic ester of the sulphonic acid.

8. The derivatives obtained by the action of alcohols on the unsymmetrical acid chloride were the benzoic ester of the sulphone chloride, and the benzoic ester of the sulphonic acid.

9. The derivative obtained by the action of phenol upon either of the acid chlorides was always the diphenyl ester. No particular effort was made to prepare the phenyl sulphone chloride. When pyridine was used in the reaction, a second body was formed which may be the pyridine salt of the phenyl benzoic ester acid. Its constitution was not established.

10. By the action of methyl iodide on the silver salt of the methyl benzoic ester acid, the dimethyl ester was formed.

Organic Chemistry Laboratory,
State University of Iowa.

SOME WELL KNOWN BUILDING MATERIALS.

NICHOLAS KNIGHT.

I. THE ANSTON STONE FROM KIVETON PARK, ENGLAND.

A specimen of the rock of which the Houses of Parliament, London, are constructed was sent us some months ago, for analysis, by the Honorable John Burns, member of the British Cabinet. We had read in one of the popular magazines that the rock in the Parliament buildings is quite rapidly weathering and crumbling. We desired to make the chemical analysis to ascertain, if possible, the reason for the decay. The rock has a buff color when first quarried or on a fresh fracture, but it is darkened by the London smoke except in some of the protected angles. The smoke is so thick on the rock that it can easily be rubbed off with a piece of paper, or a handkerchief, as we tested in many places throughout the building. The result of the analysis is as follows:

	Per cent.
$Ca\ CO_3$	46.32
$Mg\ CO_3$	49.70
$Si\ O_2$	1.85
$Al_2\ O_3$	1.54
$Fe_2\ O_3$	0.60
Total	100.01

The specific gravity of the rock is 2.60 which is a fair average for rocks of this type, and the buff color of such rocks seems uniformly due to the presence of the iron oxide, even though it is often present in very small amounts.

The following communication in regard to this rock was recently received from J. Allen Howe, Curator of the Geological Survey and Museum.

"At the request of Sir Archibald Geikie I have pleasure in sending you the following short note on 'Anston Stone' used in the Houses of Parliament.

"Anston Stone is, as you say, a dolomite, and light buff in color on the fresh fractured surface. It still retains traces of this tint in some of the inner quadrangles of the building, but where more exposed it has become a dark gray. I am quite unable to explain why it should have appeared to you to be red, unless it was seen about sunset.

"The stone comes from quarries at Kiveton Park, east of Sheffield in Yorkshire, where it occurs in the Magnesian Limestone division of the Permian formation. Other quarries in the same kind of stone are worked at Stutley and Mansfield (red and white).

"Very little sandstone is used by London builders."

The stone is used in the bank of England, Westminster Abbey and St. Paul's Cathedral, the Mansion House, Guild Hall, and many other buildings both public and private in the great metropolis. Neither the chemical analysis, nor the physical characters accounts for the disintegration in the Houses of Parliament. In appearance and composition it is not widely different from the Roman travertine which is still standing in buildings constructed 2500 years ago. The Houses of Parliament were begun in 1846, and completed in 1862.

II. THE RED SANDSTONE FROM THE VOSGES MOUNTAINS.

This is a handsome durable rock of which the Strassburg Cathedral and other public buildings in the city are constructed. The most interesting of the buildings is the Cathedral. The present structure was built in the eleventh and twelfth centuries, and is a mixture of Romanesque and Gothic. The most beautiful portion is the facade which is also the purest Gothic. The numerous statues of prophets, saints and apostles, and the fine carvings in the rock, like crystallized lace, show how the material is adapted to the most artistic kind of carving in stone. The tower is nearly five hundred feet in height and therefore one of the tallest structures in Europe. It is likewise Gothic and exquisitely carved. The rock is easily transported from the quarries in the mountains on the river Ill which bisects the city. The specimen was sent us by Professor Dr. H. Bücking, Professor of Mineralogy in the University of Strassburg, to whom we desire to express our hearty thanks. The analysis is as follows:

	Per cent.
$Si\ O_2$	77.57
$Al_2\ O_3$	14.45
$Fe_2\ O_3$	4.50
$Ca\ O$	1.62

Mg O	0.80
K_2 O	0.21
Na_2 O	0.45
H_2 O	0.45
Total	100.05

Manganese, titanium, and carbon dioxide were absent.

III. THE HARD JEWISH.

In the Proceedings of the Iowa Academy of Science for 1913, page 193, we described a rock from Solomon's quarries, Jerusalem, known as the "Royal". Mr. Herbert E. Clark of Joffa Gate, Jerusalem, kindly sent us another variety from another portion of the same quarries, known as "Hard Jewish". It is of a buff color, hard, brittle, fine-grained, compact, and to all appearances a very durable limestone. The specific gravity of 2.7, and also the fact of its breaking with a conchoidal fracture indicate its fineness of texture and compactness. It seems much harder than the "Royal", before mentioned and in color there is a marked contrast to the snowy whiteness of the "Royal". The analysis resulted as follows:

	Per cent.
Ca CO_3	87.84
Mg CO_3	7.10
Si O_2	3.51
Fe_2 O_3	0.32
Al_2 O_3	1.08
Total	99.85

We desire to record our thanks to Miss Bonnybel Artis, Ellery Botts, and John A. Cogswell for assisting in the analyses.

America doubtless has as fine and durable building stones as may be found in any quarter of the globe, but the high cost of labor has prohibited their widest use. As timber has greatly advanced in price in recent years, building stones may be destined to be more extensively used.

Chemical Laboratory,
Cornell College.

ACID POTASSIUM AND ACID SODIUM PHTHALATES AS STANDARDS IN ALKALIMETRY AND ACIDIMETRY.

W. S. HENDRIXSON.

Quite recently Francis D. Dodge[1] suggested acid potassium phthalate and acid sodium phthalate as standards in alkalimetry and acidimetry. His paper contains no analytical data and is largely theoretical, and so far as the writer can determine no such data are available. The two substances have certain very desirable features as standards, which Dodge has pointed out. The question is whether they are true acid salts. It seemed to me a matter of interest to subject them to a somewhat rigorous examination to determine whether they can be relied upon to give accurate results in standardization.

The primary solution used in the study of the acid phthalates was an approximately tenth normal solution of hydrochloric acid. It was made up according to the method of Hulett and Bonner,[2] and its concentration was further determined by means of silver chloride, and by comparison with two samples of benzoic acid, one made from the pure commercial acid and the other the standard benzoic acid from the Bureau of Standards.

Solution of Hydrochloric Acid.—Concentrated, chemically pure hydrochloric acid was distilled from a glass stoppered distilling flask till three-fourths of it had passed over. The distillate was then collected in a bottle placed in ice water. The end of the condenser tube extended well into the bottle. About three-fourths of what remained in the flask was distilled. The distillation was not interrupted from first to last, and bumping was controlled with platinum scrap.

The pressure being 740, according to Hulett and Bonner 17.9745 grams of this latter distillate should contain one mole. of HCl, (air weight). The amount weighed from a weight buret was 53.997 grams and it was made up to 3.00408 liters with pure water, by using the content, not the delivery of three calibrated liter flasks, whose total capacity was 3.0004 true liters as cali-

[1]Journal of Engineering and Industrial Chemistry, Vol. 7, p. 29.
[2]Journal of the American Chemical Society, Vol. 31, p. 393.

brated by myself by weighing when filled to the marks with water at 20°. The few centimeters remaining to be added were added with a buret.

In making up the hydrochloric acid solution and at all other essential points redistilled water was used. The boiler was of copper and it was fitted with a Kjeldahl distilling bulb to prevent the passage of spray. The condenser tube was of block tin and extended well into the receiving bottle. A seal of cotton between the tube and the neck of the bottle prevented currents of air. The collection of the water was begun only after about 500 c. c. of water had passed over, so as to eliminate carbon dioxide. The water was kept stored in glass stoppered, covered bottles till required.

The concentration of the hydrochloric acid solution thus prepared was further determined by means of silver chloride, filtered and weighed in platinum Gooch crucibles in the usual manner. In all precipitation and washing about 1 per cent of nitric acid was present. The filtrates were measured and usually amounted to about 500 c. c., and 1.4 milligrams of silver chloride was added to the weight for one liter of filtrate. The portions of the acid taken for precipitation were weighed.

In the early part of this work ordinary calibrated burets and flasks were used, but changing temperature, want of uniformity of drainage and the limit of volume in the case of burets to rather less than 50 cc. soon proved their inadequacy, and all results thus secured were rejected. In the determination of the hydrochloric acid and in all titrations here recorded weighing burets were used. They were made by the glass blower at the Chemical Laboratory, University of Illinois, at the instance of Professor W. A. Noyes to whom I am very greatly indebted. They are essentially the same as described by Washburn,[3] and used by him in his recent work on the value of the Farad. They weigh scarcely 50 grains, hold about 175 cc., and have long slender delivery tubes to insert into other vessels, and very small tips so as to give small drops.

The following are the results of the determination of the concentration of the acid by means of silver:

[3]Journal American Chemical Society, vol. 34, 1358.

	Grams of Solution. (Air weight.)	Weight of AgCl.	HCl to 1 Gram of Solution.
1.	64.215	.9221	.0036535
2.	57.318	.8232	.0036541
3.	63.945	.9185	.0036546
4.	107.876	1.5489	.0036532
5.	99.748	1.4323	.0036534
	Average of five determinations...........		.0036536

This value is for 1 gram of the HCl solution weighed in air. However, if the weight of the acid be reduced to vacuum standard the value becomes .0036497. The density of the solution was determined with a Sprengel picnometer at 20° as compared with water at the same temperature and was found to be 1.0018, and since the density of 1 cc. of water at this temperature is .9982, the density of the solution at 20°=.9982×1.0018=1.0000. Therefore one has also the value of 1 cc.=.0036497, of HCl.

Alkali Solution. Solutions of both barium and sodium hydroxides were prepared but the former seemed to have no advantage over the latter and had the disadvantage that the precipitates formed in titration interfered somewhat with judging the end points. It was soon discarded in favor of the sodium hydroxide.

Somewhat more than the required weight of sodium hydroxide, purified by alcohol, was weighed, sprayed with a little water to remove superficial carbonate and dissolved in about a liter of water. A slight excess of barium hydroxide solution was added to precipitate the carbonate and the excess of barium was precipitated with sodium sulfate. It was filtered rapidly, without waiting for all of it to pass through, into a large bottle which had been filled with air free from carbon dioxide. It was then made up to about four liters with the twice distilled water. The bottle was fitted with a glass stoppered buret which was filled through its side tube also provided with a glass stopper. Both buret and bottle were provided with long calcium chloride tubes filled with bits of solid potassium hydroxide. The tube connected with the bottle was in turn connected with a bottle containing a solution of concentrated caustic potash over which the air remained till drawn into the bottle containing the standard alkali, in filling the buret. Over the tip of the buret was kept a rubber cap. The weight buret was filled from the volume buret, the tip of the latter being inserted far into the neck of the weight buret. A small amount of carbonate in the alkali even if present, but if constant, would have mattered little, since in the series of titrations hydrochloric acid, sodium hydroxide, benzoic acid, for example, the influence of the carbonate would have been eliminated. For the same reason no correction was made for the error due to the fact that phenoltalein, which was used as the indicator, shows the pink color only after the hydroxyl ions are slightly in excess.

All titrations were made in air free from carbon dioxide. A small Erlenmeyer flask was fitted with a thin section cut from a two-hole rubber stopper. One hole received the long delivery tube of the weight buret, and through the other was a tube reaching to the bottom of the flask, and connected with an apparatus to purify the air. The compressed air was contained in a large steel cylinder and passed from it to a large storage bottle with a layer a few centimeters deep of strong caustic potash. It then passed through three gas-washing bottles containing potash, through a similar bottle with water and finally to the titration flask.

In titrating the acid against the alkali both were weighed in weight burets, and the alkali was run into the hydrochloric acid. The air was allowed to run through the flask a short time before the addition of alkali was begun. This stream of air also served to agitate the liquid, and so obviated any need of shaking or stirring. Five closely agreeing titrations gave the ratio in grams of alkali to acid as 1 to 1.10991. A second solution of sodium hydroxide was prepared in the same way and its ratio to the acid was 1 to 1.1859 grams. Which value applies in any series of titrations will be indicated.

Standardizing with Benzoic Acid. The benzoic acid used by Morey[4] in his investigation as to its reliability as a volumetric standard was fractionally sublimed in vacuo, which demands an amount of time and labor that might seem excessive in ordinary volumetric work. It seemed desirable, therefore, to make titration of the best acid on the market after purifying by crystallization only. A quantity of such acid was recrystallized from dilute alcohol and from water. The air-dried acid was fused in an oven heated at 130°. After fusion the platinum dish was placed in cold water which caused the cake of acid to crack loose. In weighing the acid for titration a platinum crucible was used since platinum is far less hydroscopic than glass. The

[4]Bureau of Standards, Bulletin 8, p. 643.

crucible was never handled with the bare hands. The weighed portions were dissolved in the titration flask in about 20 cc. of pure alcohol, whose neutrality had been tested, about an equal volume of water was added, and the titration was carried out as described under standardization of the sodium hydroxide. The following are the results, using the alkali having the relation to the acid 1 to 1.10991.

	Weight of NaOH.	Weighed benzoic acid.	Calculated HCl in 1 gram of solution of HCl.
1.	91.829	1.2470	.0036559
2.	82.139	1.1148	.0036547
3.	89.695	1.2169	.0036525
4.	79.778	1.0838	.0036574
	Average of all titrations............		.0036551

As under silver chloride reducing the weight of the HCl solution in air to volume, the HCl in 1 cc. is .0036511.

Another series of titrations was made using the special sublimed benzoic acid prepared by the Bureau of Standards for calorimetric and volumetric work. It was fused, weighed and titrated in the same way as the benzoic acid prepared by myself, but the more concentrated alkali having the ratio to the hydrochloric acid 1 to 1.1859 was used.

	Weight of NaOH.	Weighed benzoic acid.	Calculated HCl in 1 gram of solution of HCl.
1.	34.903	.5062	.0036544
2.	54.767	.7941	.0036536
3.	96.481	1.3990	.0036536
4.	139.791	2.0264	.0036526
5.	133.900	1.9410	.0036525
	Average of all determinations........		.0036533

Reducing the weight of the HCl solution to volume as explained under the silver chloride method, these results give the value of HCl to 1 cc., .0036494.

Acid Potassium Phthalate. This salt is anhydrous. It is moderately soluble in cold water, very soluble in hot water, and may be easily purified by repeated crystallization. Its molecular weight is high, 204.14, so that the amounts that may be weighed for titration are large, thus reducing the influence of the unavoidable errors in weighing.

Acid potassium phthalate was prepared by dissolving in hot water pure sublimed phthalic anhydride and a little more than the calculated weight of pure potassium carbonate necessary to form the acid phthalate. The salt was recrystallized five times from pure water in platinum. A second preparation was made with specially prepared potassium carbonate, made by repeated precipitation of the acid carbonate from the normal carbonate with carbon dioxide. After drying in the air each sample was heated in a platinum dish in an air bath for several hours at 125°.

The following are the titrations made with the first preparation. The first three were made with the solution of sodium hydroxide having the ratio to the hydrochloric acid 1 to 1.10991; all the remaining ones in this paper with the alkali having the ratio 1 to 1.1859.

	Weight of NaOH.	Weighed acid potassium phthalate.	Calculated HCl in 1 gram of solution of HCl.
1.	64.275	1.4583	.0036517
2.	68.479	1.5531	.0036503
3.	96.585	2.1933	.0036548
4.	59.670	1.4483	.0036565
5.	49.471	1.2000	.0036542
	Average of five determinations.......		.0036535

The data of the second series give practically the same value.

	Weight of NaOH.	Weighed acid potassium phthalate.	Calculated HCl in 1 gram of solution of HCl.
1.	71.7335	1.7380	.0036500
2.	56.660	1.3733	.0036513
3.	71.243	1.7287	.0036554
4.	78.108	1.8943	.0036535
5.	52.367	1.2692	.0036512
	Average.............................		.0036523

The amount of HCl in 1 cc. of the solution, calculated under silver chloride is .0036484.

Acid Sodium Phthalate. This salt has about the same solubility in hot and cold water as the acid potassium salt. It crystallizes with approximately one-half molecule of water. Its equivalent is also high, 188.04.

Three preparations of this salt were made by the same method and with the same care as described under the potassium salt. It was crystallized six times from hot water, and dried in the atmosphere of the laboratory. Many titrations were made to determine whether the hydrous salt would show sufficient constancy to serve as a standard. Three determinations of the water of crystallization were made using large quantities of the salt each time. All these determinations showed considerable variation depending apparently on the state of the atmosphere and conditions of crystallization. The titrations showed a variation of about 1 part in 700 too low to 1 part in 700 too high. The hydrous salt belongs to the same class as other hydrous substances used as standards such as oxalic acid and potassium tetroxalate. In this connection it may be stated that in the course of this study the writer prepared with great care samples of oxalic acid and potassium tetroxalate and made many titrations. The results were always too low. In the case of the tetroxalate the difference between the acidity found and the theory was so marked as to suggest some other reason than hygroscopic water. The potassium contained in the salt was therefor determined. Two determinations as sulfate and one as carbonate gave the per cents, 15.74, 15.77 and 15.73, while the theory requires 15.38. While not a perfect standard, hydrous acid sodium phthalate will give much more nearly correct results than either oxalic acid or potassium tetroxalate according to my experience. For this purpose, however, the salt should be dehydrated.

Dehydrated Acid Sodium Phthalate. Before the acid sodium phthalate was dehydrated for use in titration it was subjected to tests to ascertain its degree of stability when heated. A portion of it in a boat was heated in a tube through which passed a current of pure air, and the air then passed through a bottle of clear baryta water. The heat was gradually raised to 225°, the time occupying about two hours. No trace of carbon dioxide could be detected but a small amount of phthalic anhydride sublimed above 200°. The salt may, therefore, safely be heated much higher than the necessary temperature to dehydrate it within reasonable time, which is 120°. It was heated at that temperature and attained constant weight in about three hours, though the heating continued much longer. It was then used in the following titrations:

	Weight of NaOH	Weighed acid sodium phthalate.	Calculated HCl in 1 gram of solution of HCl.
1.	42.754	.9548	.0036524
2.	43.610	.9737	.0036515
3.	52.897	1.1824	.0036557
4.	51.337	1.1470	.0036540
5.	61.626	1.3758	.0036511
6	77.619	1.7354	.0036565
7.	51.479	1.1494	.0036516
	Average of seven titrations...........		.0036533

The value of HCl in 1 cc. of the hydrochloric acid solution is .0036494.

To summarize, we have the concentration of the solution of hydrochloric acid determined by five different methods and standards. The first three are of undoubted accuracy, though the method of Hulett and Bonner has the disadvantage that neither the boiling point of hydrochloric acid nor the distillate is perfectly constant at any concentration, though very nearly so. With these three old methods the acid phthalates are compared. The following are the concentrations for 2 cc. found by the different methods:

1. Method of Hulett and Bonner..................0036470
2. Silver chloride 0036497
3. Benzoic acid, series I and II..................0036502
4. Acid Potassium Phthalate, series I and II.......0036490
5. Acid Sodium Phthalate 0036494

It will be seen that these results agree within the limits of ordinary volumetric work. Leaving out the method of Hulett and Bonner whose slight defect has been mentioned and was fully recognized by its founders in their original publication,[3] the other results are almost identical.

From this study it would seem that benzoic acid, acid potassium phthalate and dehydrated acid sodium phthalate may with equal confidence be used as standards. The acid phthalates have the advantage of much higher equivalent weights, ready solubility in water and ease of preparation in the pure state.

LABORATORY OF GRINNELL COLLEGE.

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[3]Loc. cit.

THE FIRST COAL-WASHING PLANT IN IOWA.

GEORGE F. KAY.

For more than fifty years in Europe, coals have been subjected to washing to improve their quality. Between 1870 and 1880, coal-washing plants began to be erected in America, and today coal-washing plants are being operated in many of the coal-producing states of the United States. In Iowa there is but one plant, and this has been completed within the past three years, actual washing having been begun in July, 1912. This plant is located at Lakonta, about twelve miles west of Oskaloosa, in Mahaska county, which is one of the leading coal-producing counties of the state. The plant is owned by the Iowa Coal Washing Company, which has a capitalization of $40,000. The president of the company is F. C. Lofland, Oskaloosa, and the secretary, J. M. Timbrell, Lakonta.

In all coal washing a mechanical principle is applied, and water is the main material used in separating the impurities of the coal from the good coal. The chief impurities that it is possible to remove from coal are sulphur and ash. But not in all cases is it possible to remove these constituents from the coal. To insure success the impurities must be present in the proper relation to the coal. If the sulphur is present as organic sulphur or as finely disseminated pyrite in the coal, it can not be successfully removed by washing. On the other hand, if the sulphur is present in the coal chiefly as pyrite in flakes and lumps of appreciable size, it is possible by washing to separate a considerable part of the sulphur from the coal. The same statements may be made regarding the ash. If much of the ash is disseminated uniformly through the coal, washing will improve the coal but little. But if a considerable part of the ash is present as shale, slate, or bony coal the ash content can be decreased appreciably by washing. The successful separation of impurities from coal depends upon the difference in specific gravity between the coal and the impurities in the coal. Anything that is heavier than pure coal and is detached from the coal may be removed. Moreover, impurities that are attached to the coal in quantities sufficient to make the piece of coal and impurities together more than ten per cent heavier than coal can be separated from the coal, in which case the good coal attached to the impurity is lost in the operation. Considerable experimentation is necessary to determine the special treatment required for each variety of coal. In some plants the run-of-mine coal is washed, in other plants the screenings only are washed. When the run-of-mine coal is washed, it is necessary, to get the best results, to crush and size the coal, and, as a general rule, the smaller the ratio of reduction of the pieces of coal the more completely the impurities will be removed by washing.

The only coal that has been washed at the plant at Lakonta is screenings. These screenings have been obtained from mines which are being operated at no great distance from the plant. The largest tonnage, at present, is being furnished by the Consolidation Coal Company at Buxton. Some screenings are being taken from mines owned by the company which is operating the washing plant, and part of the screenings of the other mines adjacent to the Chicago & North Western Railway Company in this vicinity are being purchased by contract and washed at the plant. In the process of washing at the Lakonta plant, the screenings are elevated and then passed over jigs which are vertical in operation. These jigs are inclined and have one-fourth inch and one-half inch perforations. When the jigs are in operation 800 gallons of water a minute is used in each jig. The washed coal passes over the head of the jig, whereas the impurities, being heavier than the coal, seggregate at the bottom of the jig, and are removed through gates that open readily. The washed coal is next passed over two revolving screens which separate the coal into three sizes, one of which is below five-eighths inch in diameter, another between five-eighths inch and one and a half inch, and a third larger than one and a half inch. The coal is then elevated and sprayed over perforated screens to remove fine material adhering to the surfaces of the coal. After spraying, the clean coal is carried into bins where it is ready for shipment.

The effect of washing is well shown by comparing the coals before and after treatment. The unwashed screenings have been shown by analyses to have a sulphur, ash, and refuse content of from 25 to 35 per cent. During washing about 27 per cent of the total tonnage is removed, that is, the coal, after washing, constitutes only about 73 per cent of the gross tonnage subjected to the washing process. Analyses of the washed coals show that the ash content has been decreased greatly. For example, the average of 41 analyses from 41 car loads of the washed coal by Prof. C. O. Bates of Coe College, Cedar Rapids, and by reliable chemists in Chicago, was 12.75 per cent of ash. The average moisture content was 16.68 per cent. The lowest ash content was 7.62 per cent and the highest 18.43 per cent. The calorific value of the washed coals varies between 11,500 and 12,500 B. t. u. These results show that the washed screenings are not very different in composition from the average run-of-mine coal of Iowa, which has an ash content of 11.63 per cent, a moisture content of 15.07 per cent, and a calorific value of 11,754 B. t. u.[1]

The plant has a capacity of 1000 tons per day of nine hours. The average number of men employed is fifteen. The water used, about 125,000 gallons a day, is obtained from local wells which penetrate the sandstones of the Des Moines stage. In 1914, the amount of screenings washed was 98,587 tons from which 74,595 tons of cleaned coal was obtained.

Three grades of washed coal are sold. The grade of largest size, known as nut coal, is sold for domestic purposes, the other grades are sold for steam purposes. Mr. Timbrell states that these coals compete in the market chiefly with the washed coals of Kansas, Missouri, and Illinois, and not to any great extent with the unwashed coal of Iowa.

The plant at Lakonta has demonstrated very clearly that screenings of Iowa coals can be washed and marketed at a profit. Since much of the coal of Iowa, on account of its high ash and sulphur content, is not suitable for the manufacture of coal and water gas, is somewhat destructive to grates and fireboxes, and tends to disintegrate when stored, and since the evidence indicates that much of this ash and sulphur is so related to the coal that it can be removed by proper crushing and washing, is it not safe to predict that as the years go by more and more coal-washing plants, not only for screenings but for run-of-mine coal, will be established in this state?

GEOLOGICAL LABORATORY,
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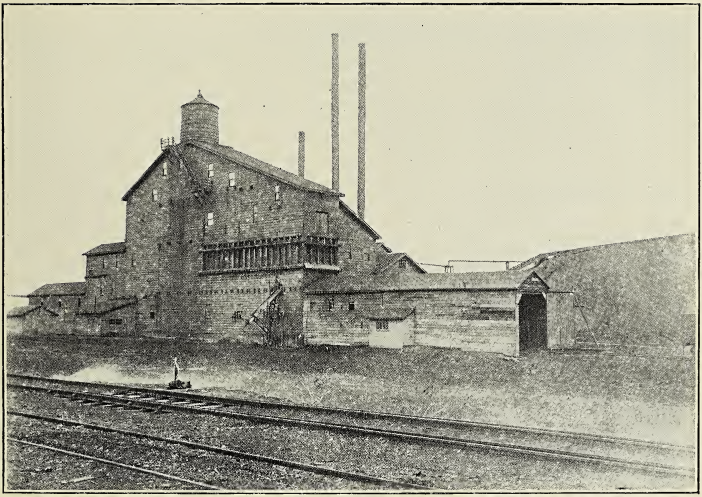
[1]Iowa Geol. Surv., Vol. XXIV, p. 737.

Plate XXII.

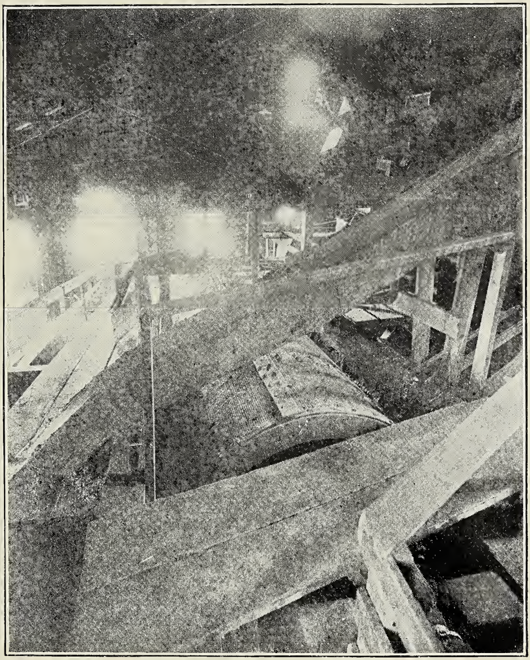


Iowa Coal-Washing plant, Lakonta.

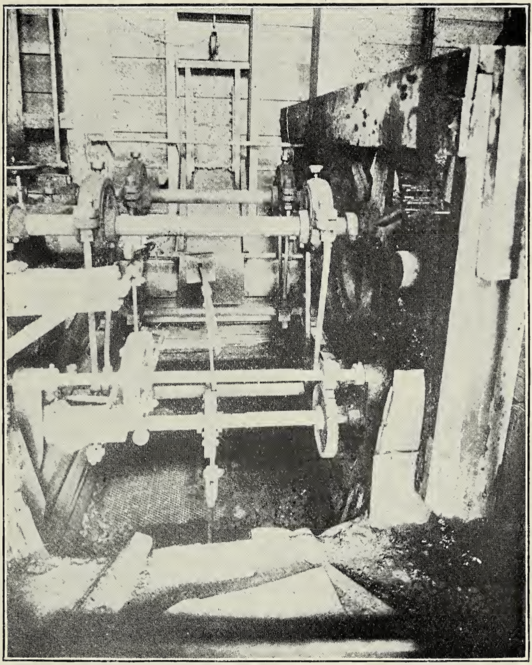
FIG. 1.—View of Iowa Coal-Washing plant, Lakonta.

FIG. 2.—Refuse dump at the Iowa Coal-Washing Company's plant, Lakonta.

Plate XXIV.



Revolving screens used by the Iowa Coal-Washing Company, Lakonta.



One of the three jigs of the plant of the Iowa Coal-Washing Company, Lakonta. Eight hundred gallons of water per minute passes through the jig when it is in operation.

THE EXTENSION OF THE WISCONSIN DRIFT SOUTHWEST FROM DES MOINES.

JOHN L. TILTON.

At the last meeting of the Academy I called attention to an extension of the Wisconsin drift south past Valley Junction into the region which was generally understood to be within the area of Kansan drift. It was with a view to extending observations further south in that direction than was possible in the time previously at my disposal that trips were made in 1914 extending the area examined east to the Army Post, west to the ravines in the southwest portion of Polk county, and as far south as Norwalk, Cummings and Orillia in Warren county and west to Madison county.

In addition to the district of Wisconsin topography described a year ago, another equally distinct area has been found two miles to the south, in section 35, Nw. qr. of the Se. ¼. Here the eastern one of two small ponds is partly drained, but the one a few rods to the west is as distinctly characteristic of Wisconsin drift topography as the one previously described in section 23. These two small ponds are faintly marked on the map of the Des Moines quadrangle. A mile to the west in section 34, Sw. qr. of the Ne. ¼ is another marshy area in the upland. This area is partly drained. The fact that the road extends across the outlet and that the small culvert is above the level of the pool suggests the suspicion that the water has been dammed back by the road. However, the bottom of the pool is slightly below the level that has been filled in, justifying the inference that here is a small upland pond that erosion had nearly but not fully drained. Several other ravines were noted headed in unusually dark soil along depressions in the upland. One is in the south central part of section 23, within a quarter of a mile of the section line. Another is half a mile to the south, in the north central part of section 26.

On the low ground in the eastern central part of section 22 the map locates a small pond that is of a very different character than the ones above mentioned. This pond is located in the line of drainage along the foot of the hills bounding the river valley on the east. Just to the north of this small pond is a rather large alluvial cone and fan composed of material washed out along ravines and deposited in such a way as to dam the drainage along the bluff. To the south of the pond a smaller deposit from smaller ravines determines the western limit of the pond, leaving a shallow, circular depression in which water accumulates in wet weather. The pond is not a bayou.

In the upland which bears evidence of Wisconsin drift topography several tests to determine the depth of weathering indicated an absence of lime. In many places along the road a substratum of stratified sand was observed through which water might transport lime leached from above. Had tests revealed the presence of lime in the upland the fact would have constituted additional evidence of Wisconsin drift; but the absence of lime in so thin and porous a surface deposit is not surprising. It is possible that deeper exposures than are to be found in the upland may still remain unleached. In the low divides a mile west of Valley Junction the effect of leaching was found to a depth of two feet and eight inches, effervescence occurring below that depth.

From the evidence now obtainable it appears that the area of Wisconsin drift extends through sections 23, 26 and 35, and probably into 36 on the east and 34 on the west. In all directions from this area the erosional topography of the Kansan drift area is conspicuous. If any Wisconsin drift were ever there it has been eroded away since, or its presence rendered inconspicuous by the complete drainage of the upland.

The stratified sand, so evident along the road, is beneath the Wisconsin drift, not an outwash from it.[1] Along the road in the southern part of section 14 it underlies a bed of loess. While it is possible that the sand may have been washed out from the Wisconsin drift prior to the extension of that drift sheet south of the river (in which case the loess would be post-Wisconsin) that is not probable. Similar deposits of sand are found in numerous places on the top of the Kansan drift where there is no evidence whatever that the Wisconsin drift or an outwash from it could have extended there.

[1]Is this sand continuous beneath the Wisconsin drift to the Iowan drift; and is it then continuous with sand above or below the Iowan drift? This is an important question, in view of recent discussions. Up to the present the question remains unanswered.

With a portion of the Wisconsin drift extending south from Valley Junction, did the deposit form an obstruction to drainage that ponded the water west along what is now the valley of the Raccoon river? Such a barrier, if it ever existed, was

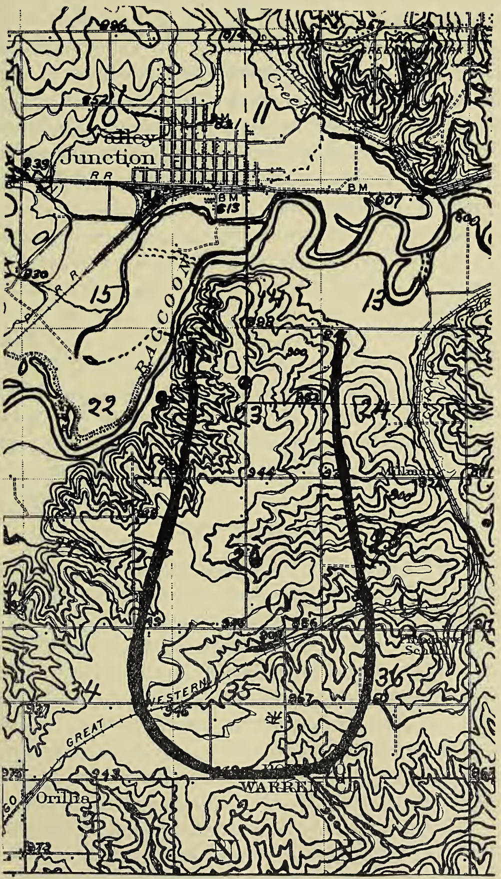


FIG. 5.—From evidence now obtainable it appears that the area of Wisconsin drift south of Valley Junction extends through sections 23, 26 and 35, and probably into 36 on the east and 34 on the west (township 78 north, range 25 west). (Topography taken from the Des Moines Sheet.)

too slight for the evidence of it to persist. The steep ends of the low divides a mile west of Valley Junction are in themselves not satisfactory evidence of an old shoreline; and nowhere else is any evidence noted that the flat on which Valley Junction is located is the old bed of ponded water. The border line between the flat with sand and gravel beneath it to a depth of at least thirty feet (at the pumping station of the Valley Junction water plant) and the low upland present an appearance of conditions similar to those observed in areas of Kansan drift further south. With absence of distinct evidence of ponding, this flat must be considered a portion of the terrace found along the rivers. The origin and age of this terrace I now wish to consider in a separate paper on that subject.

THE AGE OF THE TERRACE SOUTH OF DES MOINES, IOWA.

JOHN L. TILTON.

INTRODUCTION.

Along the Raccoon river in Polk county, along the Des Moines river, and along the tributaries of the Des Moines from Warren county there is a terrace, previously noted by geological workers. An important question with the writer has been this: Do the gravels in this terrace form one continuous deposit, or do they form two separate deposits, an upper of Wisconsin or post-Wisconsin age, and an underlying portion that is older than the upper deposit, and possibly of Aftonian age? This question was suggested by a division in the sand recorded in well records, and by the presence of fossils of large mammals that had been found at a depth of perhaps twenty-five feet below the surface of the sand. The identification of these fossils in the spring of 1914 by Professor Oliver P. Hay of the United States National Museum, and the publication of topographic maps of regions along the Des Moines river, make a review of local evidence seem desirable.

THE TERRACE.

The terrace, or second bottom, as it is locally called, is very noticeable along the valleys named in southern Polk and northeastern Warren counties, where it forms a low plain four or five feet above the flood plain of the rivers. It is less noticeable further southwest up the valleys of North, Middle and South rivers. Valley Junction southwest of Des Moines is built upon it, the low plain southwest of the fair grounds in Des Moines is a continuation of it, and the railroad stations at Avon and Levey are built upon it. The topographic maps of this portion of the state: the Des Moines, Milo, Knoxville and Pella sheets, give as good evidence of the terrace as it seems possible to represent with a contour interval of twenty feet; and farmers all through the area recognize the terrace by the location of houses and buildings upon it, and not upon the lower ground of the first bottom, or flood plain. Along the Mississippi river a simi

Topography taken from the following named sheets.

Des Moines, Iowa. Milo, Iowa.

Pella, Iowa. Savanna, Iowa-Illinois.

FIG. 6.—Topographic maps showing river terraces.

larly related terrace is very evident;[2] found not only along the river itself but also along the tributaries.

THE TERRACE DEPOSITS.

Near Avon the surface deposits of the terrace are very sandy; but farther up the valleys of the tributaries the surface of the terrace is composed of a dark material, frequently without evident stratification, and always without pebbles. Evidently it has been washed from the upland and deposited along the valleys. Indeed the process is very evident in the spring time where the drainage has been disturbed by the winter's ice. This "gumbo" is like material in the upland, but should not be confused with it. The undisturbed deposit in the upland is a

[2]Note the location of Sabula. See also, S. Calvin, "Geology of Winneshiek county," Iowa Geological Survey, Vol. XVI (1906), pp. 55-56. The depth of sediment in the valleys of northeastern Iowa is stated by James H. Lees in the Proceedings of the Iowa Academy of Science, Vol. XXI (1914), p. 176, and by A. C. Trowbridge in the same volume, p. 209.

portion of the ground moraine of the Kansan drift sheet. The washed material from this source may be traced down along the floors of the ravines toward the lowland. Beneath this surface deposit along the sides of the river valleys water-bearing sands are found universally. Inspection of excavations for a tunnel at the Des Moines water works revealed no perceptible plane of separation in the sand; and inquiry at the Valley Junction pumping station likewise brought no evidence of a plane of separation in the sand. At Carlisle there are numerous ''driven wells'', the sandpoints on the pipes resting in the sand at a depth of forty-two feet. At Avon the sand and gravel has been extensively excavated by the Chicago, Rock Island and Pacific Railway to ballast the lines to Allerton, to Indianola, and to Winterset. Here a test-boring is reported as giving continuous sand and gravel to a depth of thirty feet below the surface of the terrace. Beneath this sand and gravel was found two feet of a blue clay without pebbles (silt?). Beneath the clay ''quicksand'' was found, but the depth of it was not ascertained.

The sand as exposed in the excavations reveals stratification, and numerous pebbles up to an inch in diameter among which greenstones[3] are very abundant. One small feature observed in the gravel pit west of the railroad bears upon the question of climate. In a fresh exposure there was a small mass of brownish, unconsolidated sand about four inches in diameter, containing a pebble of greenstone in the lower part of it; as if a small mass of frozen sand, with the lower portion weighted by the greenstone, had sunk to the bottom of the water.

Aside from the record of the test-boring at Avon but one other evidence was found of a division in the sand. A farmer reported that at his well on the edge of the upland there was a resistant, impervious stratum dividing the sand which his well penetrated. This condition part way up a ravine, though suggesting a division in the sand along the valley, may well exist while the sand along the valley forms one continuous deposit. The deposit of clay (silt?) over quicksand reported in the record of the test-boring, may easily have formed in the silting up of a valley. The gravel at the surface of the deposit is finer than that at a depth of six feet; and the gravel from the west

[3]A complete analysis of the kinds of pebbles found in the gravel has not been made. In general appearance they look like any assemblage of pebbles of equal size that has been washed from Kansan drift.

end of the excavation west of the track is reported coarser than that from the east end of the excavation, which end is farther away from the edge of the upland.

FOSSILS.

In the old gravel pit east of the Chicago, Rock Island and Pacific railroad at Avon a tusk and several large bones thought to be of a mastodon or an elephant are reported by one who saw them. Several other bones found there later are now in the collection at Simpson College. These last specimens were studied by Professor Oliver P. Hay of Washington in 1914 with the following result: "The metapodial and astragalus belong to Bison. The piece of lower jaw and the vertebra are those of a caribou (Rangifer). The tooth is one of *Rangifer muscatinensis*. The atlas is that of a musk-ox (*Symbos cavifrons*)."

I had previously expressed to Professor Hay my doubt as to whether the lowest portion of the gravel was really Aftonian in age of deposition, and my reasons for that doubt. After identifying the specimens he wrote, "It seems to me you are right in doubting the Aftonian age of those gravel beds. They are probably Wisconsin or early post-Wisconsin." Later he adds that the bones of the reindeer and musk-ox indicate an ice age, though it "might be later with these bones washed out of a glacial deposit."[4]

SUMMARY.

1. The gravels are in a low terrace along the southern margin of the Wisconsin drift and even extending into valleys in the Wisconsin drift area.

2. From the area above described a low terrace is found along the Des Moines river to the Mississippi. Northward along the Mississippi river a terrace is conspicuous to within the area of Wisconsin drift in Wisconsin, where the terrace is referred to the flooded condition of the streams at the melting of the Wisconsin ice sheet.

3. The fossils are not pre-Wisconsin; they are Wisconsin in age, or derived from Wisconsin drift. The gravel itself contains an evidence of the presence of ice.

CONCLUSION.

It therefore appears that the sand and gravel in the river valleys and forming a low terrace at Valley Junction, Des Moines, Avon and Carlisle (and elsewhere in this part of the state) were laid down in the closing stages of the Wisconsin ice age. The surface of the terrace has since been modified both by erosion and by deposition.

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Simpson College.

[4]Published with Professor Hay's consent.

View east from near the railroad bridge north of Carlisle, Iowa. The flood plain (with bayou) of North river is in the foreground on the left, that of Des Moines river in the background on the left, and that of Middle river between the white house on the right and the distant high ground. The railroad and all of the houses are on the terrace. The low terrace cliff extends in an irregular line from left to right just beyond the houses.

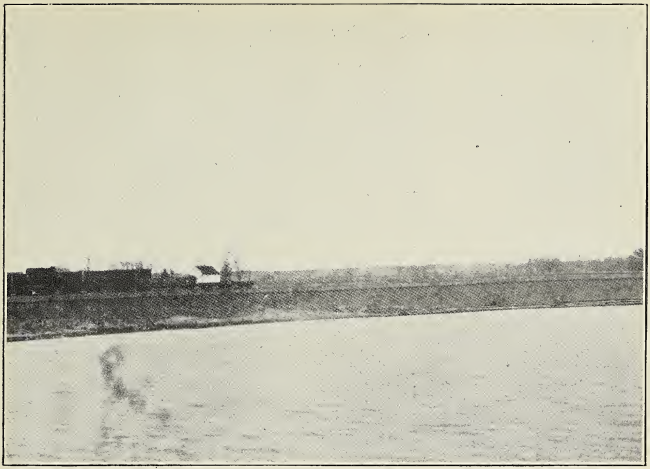


FIG. 1.—View of the recent excavation west of the track at Avon, Iowa, looking northeast across the valley of the Des Moines river. The water in the excavation is said to be eighteen feet deep. A test boring is reported to have revealed continuous sand and gravel to a depth of thirty feet below the surface of the terrace.

FIG. 2.—View of a portion of the old excavation east of the track at Avon, Iowa. Here the water is but three to four feet deep. The stratification of the sand and gravel is very evident in the foreground.

THE OCCURRENCE OF BARITE IN THE LEAD AND ZINC DISTRICT OF IOWA, ILLINOIS AND WISCONSIN.

W. D. SHIPTON.

INTRODUCTION.

According to the reports of the Iowa, Illinois, and Wisconsin Geological Surveys natural crystals of barite are found rarely in the Lead and Zinc District of Iowa, Illinois, and Wisconsin. On account of the rarity of distinct crystals, considerable interest attaches to the finding of these crystals in this region at Hanover, Illinois. In the possession of Mr. T. D. Shipton of Hanover, are sixty or more well defined crystals of barite; it is to him that the writer is indebted for the material from which this paper was prepared.

OCCURRENCE.

Keyes refers to barite as commonly associated with the lead and zinc ores in the Dubuque region. He reports good crystallization of tabular form, and bluish tints as of not infrequent occurrence.[1] White refers to barite as having been found only in minute quantities in Iowa. It was detected in the lead caves of Dubuque.[2] Cox reports that no well defined crystals have been found in the lead and zinc district of Illinois, although barite has been found at all horizons from the bottom of the oil rock to the top of the Maquoketa shale.[3] Henry W. Nichols, Assistant Curator of Geology in the Field Museum, Chicago, reports these crystals from Hanover as being the first that he had ever seen from the state of Illinois. According to Volume I, page 213, of the Wisconsin Geological Survey, barite or heavy-spar is found occasionally with calcite in the lead-bearing crevices; but only a small amount of this mineral has ever been found, and there are comparatively few places where it occurs at all. At one locality, near Scales Mound in Illinois, in a position where no lead has been found, and at the very summit of the Galena limestone, there is a thin bed of dolomite with numerous geodic cavities in which, in connection with pyrites and

[1] Iowa Geological Survey, Volume I, page 194.
[2] Iowa, Geology of, Volume II, 1870, page 305.
[3] Illinois Geological Survey, Bulletin 21, page 38.

brown spar, well formed crystals of barite are found. They are small and few of them are as much as an inch in length. Grant has noticed that barite, where it occurs at all, appears in the main in the vicinity of the oil rock. It is not common, but in certain of the mines it is abundant.[4] A. J. Williams of the Department of Geology of the University of Iowa reports having found one well defined crystal of barite in a quarry well within the southwest city limits of Dubuque. He also reports crystalline barite, which has been much water worn, as having been found in the stream beds in the vicinity of Dubuque. The crystals upon which this paper is based are found, perfectly developed, at or just below the contact of the Maquoketa shale and the upper thin bedded member of the Galena dolomite.

CHARACTERISTICS OF THE BARITE FROM HANOVER, ILLINOIS.

General Character.—The specimens of barite examined by the writer occur in three different forms. The first is the white massive form, which is embedded in a matrix of hard compact dolomite. It is opaque to transparent and shows good cleavage. The second form occurs as an aggregate of crystals. The third form is present in distinct crystals varying from seven-tenths of an inch to three inches in length along the c-axis. These crystals are in some cases found embedded in the limestone, and since this is harder than the barite the crystals of the latter are removed with difficulty. Or they are found in small pockets or cavities, from which they are readily removed. Upon examination of the crystals several striking features are noticed. First is their drusy appearance and paralled growth. In some specimens the entire crystal is studded with numerous fine crystals. In other specimens the drusy appearance is seen only on certain faces, and in such cases the macropinacoid faces usually are free from the minute crystals. The parallel growths are very common and are present in the form of tabular or platy crystals parallel to the macropinacoid face. These crystals are exceedingly thin and show domes and prisms. The prisms are usually very long and linear. Their edges have a crested or cocks-comb-like appearance, due to the projection of distinct crystals; in a few specimens this form of edge may make up the entire prism face. Another interesting feature of the crystals

[4]U. S. Geol. Survey Bulletin 294, Lead and Zinc Deposits of the Upper Mississippi Valley, page 52.

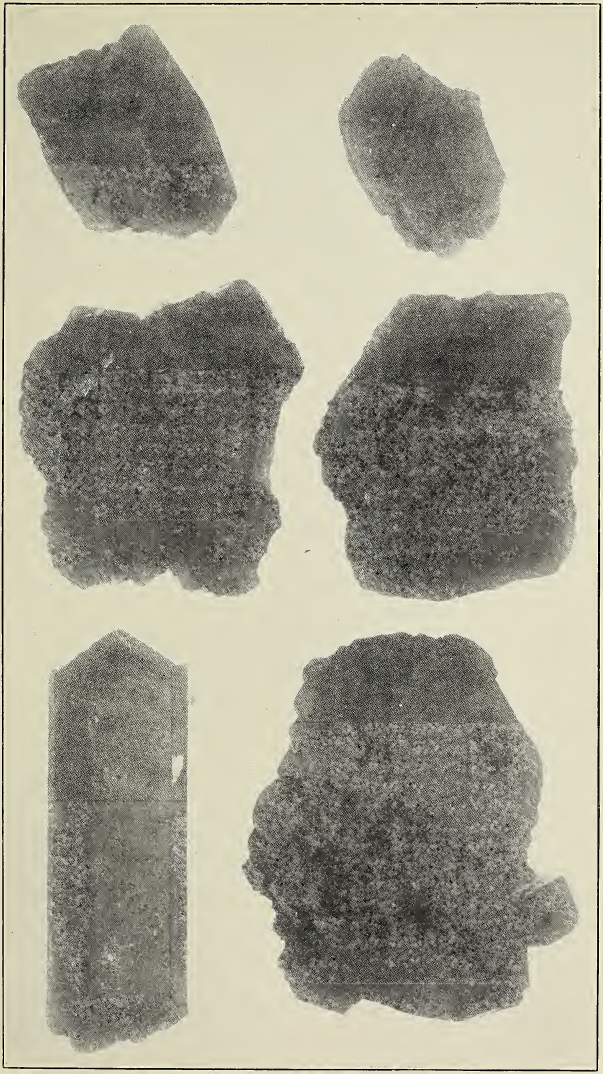
is their splendid play of colors. Many of the crystals are very iridescent and the light reflected from their surfaces is of many colors, due to the fine cleavage-lamellae, in the light reflected from which interference of the incident and reflected waves takes place.

Crystallography of the barite.—The general characteristics of the barite have been given. The faces represented on the crystals are as follows:

- Pinacoids
  - Macropinacoid
  - Brachypinacoid
  - Basal pinacoid
- Prism
  - Brachyprism
- Domes
  - Macrodomes
  - Brachydomes
- Pyramid
  - (not common)

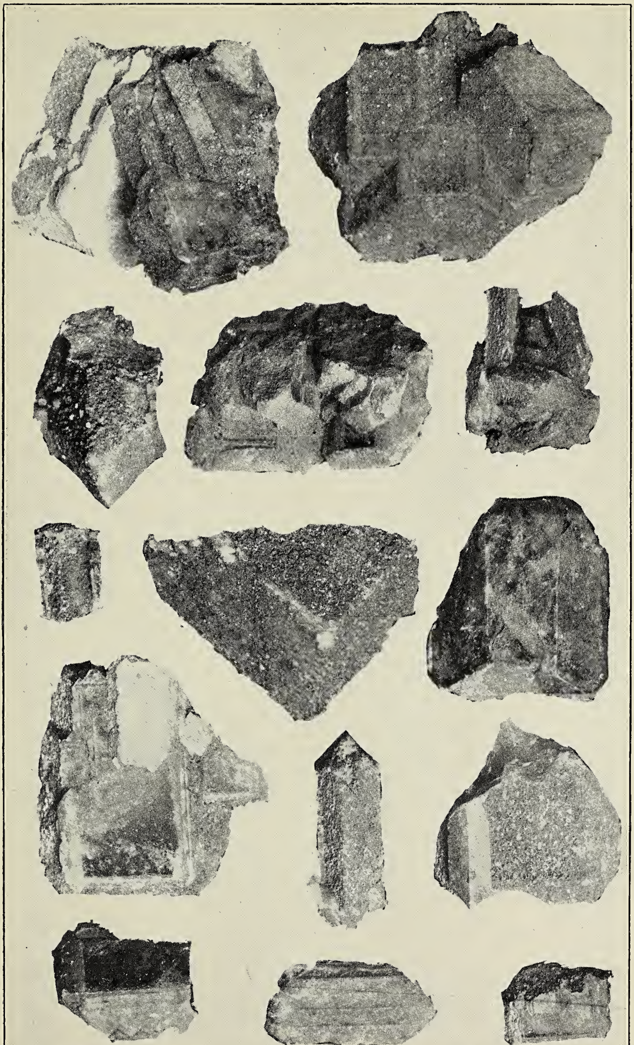
These faces occur in several common combinations. The macropinacoid, brachydome, macrodome, and brachyprism forms are the most common combinations. Another form consists of the macropinacoid, brachypinacoid, brachyprism, macrodome, and brachydome. The macropinacoid, brachyprism, and macrodome forms also occur. Other more uncommon forms are present. The habit of the crystals is very variable. There seems to be no relation between the size of the faces and the size of the crystals.

Geological Laboratory,
University of Iowa.



Crystals of barite from Hanover, Illinois.

Crystals of barite from Hanover, Illinois.



Crystals of barite from Hanover, Illinois.

THE STE. GENEVIEVE FORMATION AND ITS STRATIGRAPHIC RELATIONS IN SOUTHEASTERN IOWA.

STUART WELLER AND FRANCIS M. VAN TUYL.

In his report on the geology of Lee county[1] Keyes described a fine-grained, compact limestone at the top of the St. Louis formation, resembling lithographic stone in texture. Gordon[2] reported a similar limestone characterized by *Spirifer littoni* (=*Spirifer pellaensis* Weller) and *Pugnax ottumwa* at the same horizon in Van Buren county. Bain[3] subsequently recognized this member in Keokuk county and named it the Pella because of its typical development at the town of this name in the neighboring county of Marion. This name has been adopted by Savage in his geology of Henry county[4] and by Miller in the Marion county report.[5] Until 1900, when Nickles and Bassler[6] referred the Pella to the Ste. Genevieve upon the basis of its bryozoan fauna, the St. Louis age of the formation was accepted without question. Weller[7] subsequently pointed out the Ste. Genevieve affinities of the Pella fauna in 1909, and recent field studies have now likewise demonstrated that the Pella is formationally distinct from the underlying St. Louis, it being separated from that formation by a disconformity and by a characteristic basal sandstone in every Iowa locality which has come under observation.

Areal Distribution.—In general, the exposures of the Pella beds in Iowa are confined mainly to the southeastern part of the state. In the belt of Mississippian rocks, which extends northwestward from this region, the higher formations of the system are concealed by the Coal Measures, except for locally exposed areas in Story, Webster and Humboldt counties, where the overlying beds have been removed by erosion. Little is known as to the extent of the Pella in this direction, but the finding of a good Pella fauna by Wilder[8] in certain marls overlying the St. Louis limestone in Webster county indicates that the Pella seas extended at least as far northward as Fort Dodge.

[1]Ia. Geol. Survey, Vol. III, 1893, p. 349.
[2]Ia. Geol. Survey, Vol. IV, 1894, p. 217.
[3]Ia. Geol. Survey, Vol. IV, 1894, p. 282.
[4]Ia. Geol. Survey, Vol. XII, 1901, p. 265.
[5]Ia. Geol. Survey, Vol. XI, 1900, p. 143.
[6]U. S. Geol. Survey Bull. 173, pp. 166 and 188.
[7]Jour. Geol., Vol. XVII, p. 278.
[8]Ia. Geol. Survey, Vol. XII, 1901, p. 78.

In southeastern Iowa, Coal Measures strata also frequently cap the Mississippian. But this higher formation has been long since stripped off in many areas. In this region the Pella is preserved mainly in the form of local outliers due to both pre-Pennsylvanian and post-Pennsylvanian erosion. Small scattered exposures occur in Lee, Des Moines, Henry, Washington and Keokuk counties, and outcrops appear at intervals along the Des Moines river and its tributaries in Van Buren, Wapello, Mahaska and Marion counties. It is best known to the writers as developed in Van Buren county.

Lithologic Characters and Stratigraphic Relations.—Lithologically the Pella is very variable, and it is impossible to give a general description of its character which will hold in all cases. For this reason, it seems desirable to present a number of detailed sections, in order that its variability may be better understood. These sections will also show the stratigraphic relations and thicknesses of the formation at those points where it has been most carefully studied.

SECTION I.

Section along bed and banks of a small creek emptying into the Des Moines river in the lower part of the town of Croton, Lee county, Iowa.

	FEET.	INCHES.
PENNSYLVANIAN:		
15. Sandstone, yellowish, soft. (disconformity)		
PELLA:		
14. Limestone, compact, light gray above but dark gray below, containing a bed of calcareous shale 2½ feet thick in middle portion, about	9	
13. Sandstone, yellowish, fine-grained, sometimes soft and shaly in lower portion; contact with bed below uneven; bearing large fucoid-like markings on surface of layers (disconformity)	4	3
UPPER ST. LOUIS:		
12. Limestone, gray, granular to compact, locally slightly oölitic in part; middle portion cross-bedded, a layer in lower portion bearing conspicuous wave marks on its upper surface	10-13	
11. Limestone, bluish, dolomitic, thinly bedded, somewhat shaly, slightly fossiliferous, resting on the undulating surface of the bed beneath	2	

	Feet.	Inches.
10. Limestone, compact, gray, consisting of moundlike masses of a conglomeratic limestone flanked by more evenly bedded, less disturbed layers.................... (disconformity)	13	
LOWER ST. LOUIS:		
9. Limestone, massive, compact, dolomitic, gray when fresh but weathering yellowish. The *Lithostrotion canadensis* zone	0-2	
8. Limestone, buff, dolomitic, massive, flaking off obliquely, fossiliferous in lower portion	4½-5	
7. Limestone, gray when fresh but weathering buff, dolomitic, locally grading wholly or in part into dark gray, non-dolomitic, conglomeratic limestone	7	6
6. Limestone, bluish when fresh but weathering buff, fucoidal	3	6
5. Limestone, brownish, dolomitic, tough, with discontinuous seams of unaltered gray limestone in upper portion.		
4. Limestone, drab, compact, brittle, with numerous rounded chert concretions, arching up over moundlike masses of bed beneath, about	2	
3. Limestone, conglomeratic, consisting of mingled blocks of gray compact limestone; gray subcrystalline limestone; brownish dolomitic limestone, and soft bluish limestone either in a shaly or a calcareous matrix	12-13	
2. Limestone, gray, compact, dense, dolomitic in basal portion, with thin wavy and concretionary stratification................ (disconformity)	1	6
WARSAW:		
1. Shale, bluish, argillaceous (exposed)......	5	10

The Pella beds are again well exposed at an abandoned quarry on the south bank of Indian creek, 3½ miles west of Farmington (N. W. ¼ N. E. ¼ Sec. 5, T. 67 N., R. 8 W.). The succession in this quarry and in the creek below is as follows:

SECTION II.

	Feet.	Inches.
12. Drift, yellowish, sandy	0-8	
PELLA:		
11. Limestone, light gray, dense, lithographic-like, breaking with conchoidal fracture, becoming coarser-grained and slightly crinoidal in the upper portion; in rather heavy layers separated by thin partings of shaly limestones, locally seamed with calcite veinlets following fractures; some layers exhibiting stylolytic structure....	8	6

	FEET.	INCHES.
10. Shale, bluish, argillaceous, with calcareous seams bearing many pelecypods near top	3	5
9. Limestone, gray, subcrystalline, with thin discontinuous seams of fine-grained sandstone in thin, undulating layers, bearing a few small pelecypods..................		9
8. Sandstone, fine-grained, rather soft, light gray when fresh but weathering yellowish; in some places with angular chert fragments in basal portion.............. (disconformity)	0-2	
UPPER ST. LOUIS:		
7. Limestone, gray, subcrystalline, in rather heavy layers; upper surface irregular....	2½-4½	
6. Limestone, dark gray, subcrystalline, compact; often filled with small sinuous, tubular, branching fucoids; bearing large rounded calcareous algae................		2-6
5. Shale, fissile, bluish when fresh but weathering drab, becoming more calcareous in upper portion	1	5
4. Limestone, gray, compact, grading up into the bed above	1	10
3. Limestone, gray, compact, exhibiting fine wavy stratification		6
2. Limestone, gray, compact, thin-bedded.....	1	8
1. Limestone, gray, granular to compact, locally cross-bedded in part, bearing large rounded calcareous algæ in upper portion	12	6

A few rods below the point of the foregoing section, an exposure in the north bank of the creek along the Chicago, Burlington and Kansas City railway shows twenty-one feet of Pella beds overlain disconformably by five feet of Pennsylvanian sandstone.

Other important exposures of the Pella beds appear in the bluffs of the Des Moines river and along its tributary, Reed creek, northwest of Farmington.

In a section exposed in the northeast bluff of the Des Moines river and in the railway cut of the Chicago, Rock Island and Pacific Railway two miles north of Farmington (S. W. ¼ Sec. 23, T. 68 N., R. 8 W.) the Pella is seen to rest directly upon the Lower St. Louis.

SECTION III.

	FEET.	INCHES.
PELLA:		
4. Limestone, compact, gray, brecciated, capping brow of bluff......................	3	4
3. Concealed. Slope strewn with loose blocks of compact gray limestone..............	31	

	FEET.	INCHES.
2. Sandstone, fine-grained, light gray above but yellowish below, soft, bearing rounded and subangular blocks of gray dolomitic limestone .... (disconformity)	21	6
LOWER ST. LOUIS:		
1. Limestone, brecciated, gray to buff, imperfectly dolomitized, exposed to level of track	16	

In the exposures on Reed creek the Pella beds are exceptionally well developed. A remarkable section exhibiting both the Pella and the whole of the St. Louis as developed in Iowa, appears in the south bluff of the creek about three-fourths of a mile above its mouth (N. E. ¼, N. E. ¼, Sec. 14, T. 68 N., R. VIII W.). The succession, as measured near the middle of the bluff, is as follows:

SECTION IV.

	FEET.	INCHES.
11. Drift.		
PELLA:		
10. Limestone, light gray, compact to subcrystalline, some layers lithographic-like and breaking with conchoidal fracture; layers 1 inch to 1½ feet thick, separated by shaly partings which are locally highly fossiliferous; in places exhibiting stylolytic structure; becoming shaly in lower portion and grading downwards into the bed below; locally brecciated in part....	21	6
9. Shale, bluish, argillaceous to calcareous, of variable thickness due to mashing.......	3-6	
8. Limestone, light gray, compact, in thin, irregular layers with shaly partings......		9
7. Sandstone, bluish, fine-grained, rather soft, bearing rounded and subangular pebbles of compact gray limestone..............	6	
6. Limestone, gray, compact in middle but subcrystalline above and below..........		4
5. Sandstone, bluish, fine-grained, calcareous, massive, bearing rolled chert fragments (disconformity)	3	
UPPER ST. LOUIS:		
4. Limestone, buff, dolomitic, arenaceous.....	6	
3. Limestone, buff, dolomitic, massive........	2	9
2. Limestone, buff, dolomitic with small irregular remnants and blocks of compact gray limestone, slightly brecciated...... (disconformity)	9	
LOWER ST. LOUIS:		
1. Limestone, buff, dolomitic, badly mashed and brecciated, shaly in lower portion...	28	

Other sections measured nearby in the same bluff showed considerable variation from that given above, owing to differential erosion of the St. Louis prior to the deposition of the Pella and to the variable character of the basal beds of the Pella itself. The section presented, however, may be regarded as typical.

In another bluff on the opposite side of Reed creek, about 300 yards above the location of the preceding section, the Pella beds are seen to rest upon somewhat lower beds of the Upper St. Louis. At this point, bed No. 10 of the foregoing section is represented by 18 feet of limestone; bed No. 9 by 3½ feet of shale; and beds 5, 6, 7 and 8 collectively by a continuous bed of sandstone varying from 24 to 34 feet in thickness. The underlying St. Louis is badly mashed for the most part, and towards the top the matrix of the brecciated limestone is abundantly filled with sand grains derived from the overlying formation. The basal sandstone of the Pella attains a similar development in the vicinity of Keosauqua, whence the name Keosauqua sandstone as applied by Gordon.[9] It there in many places includes discontinuous, lenticular masses of compact, sparsely fossiliferous limestone.

Fauna.—As regards the fauna of the Pella beds, at least two distinct faunal zones are distinguishable. These are represented in the thin shale bed which usually follows the unfossiliferous basal sandstone and in the overlying limestone member which normally caps the formation in southeastern Iowa. The shale member is characterized predominantly by a pelecypod fauna, but the brachiopod, *Pugnoides ottumwa,* and a small ostrocod, *Leperditia* sp., are also common. In the Indian creek section (Section II, bed 10), this bed yields the following forms:

Pugnoides ottumwa (White)
Sphenotus (several undescribed species)
Nucula illinoisensis Worthen?
Leda curta M and W.?
Myalina sp. undet.
Schizodus (several undescribed species)
Aviculopecten sp.
Modiola sp.
Allorisma (species undescribed)
Solenospira sp.
Leperditia sp. undet.

A collection from the same bed on Reed creek (Section IV, bed 9) yielded the following species:

Pugnoides ottumwa (White)
Solenomya? iowensis Worthen?
Sphenotus (several undescribed species)
Glossites (species undescribed)
Edmondia (species undescribed)

[9]Ia. Geol. Survey, Vol. IV, 1894, p. 217.

Nucula? sp.
Leda curta M. and W.?
Pinna (species undetermined)
Myalina? sp.
Myalina (species undetermined)
Schizodus (several undescribed species)
Aviculopecten (species undetermined)
Allorisma (species undetermined)
Leperditia (species undetermined)

The limestone following the shale bears a fauna consisting almost entirely of brachiopods, the pelecypods so characteristic of the underlying shale being almost entirely wanting. The following list of species identified from a collection made from this bed as developed along Indian creek (Section II, bed 11) is representative:

Rhombopora (species undetermined)
Productus ovatus Hall
Pugnoides ottumwa (White)
Girtyella indianensis (Girty)
Spirifer pellaensis Weller
Composita trinuclea (Hall)?
Allorisma sp.
Bellerophon sp.
Phillipsia? sp.

Of the above forms *Spirifer pellaensis* ranks first in abundance, while *Pugnoides ottumwa* is a close second.

A comparison of these Iowa collections with those which have been made from the typical exposures of the Ste. Genevieve limestone in Ste. Genevieve county, Missouri, and from exposures in Monroe county, Illinois, demonstrates the identity of the faunas. A number of the undetermined pelecypods of the Iowa collection are clearly undescribed, and are identical with species which have been collected in the Missouri and Illinois localities. As in Iowa, so in Illinois and Missouri, *Pugnoides ottumwa* is the most persistent index fossil of the fauna, and on the basis of these faunal resemblances the correlation of the Pella beds of Iowa with the Ste. Genevieve limestones may be considered as being fully established.

Walker Museum,
University of Chicago.

FOUNDATION OF EXACT GEOLOGIC CORRELATION.

CHARLES KEYES.

In the last generation or two there appears to have been little advancement made along lines of general geologic correlation. Two controlling reasons stand out prominently. On account of the fact that the criterion of fossils is so largely misused and is so generally unchecked by other critical criteria it is continually losing much of its former precedence. The adoption of the lithologic formation as the cartographic unit is also almost a complete failure for the reason that no account is taken of the change, replacement and effacement of its essential characters from place to place. All this confusion gives rise to an interminable synonymy which even a specialist in a circumscribed region cannot always satisfactorily make out without detailed review of the original sections on the ground.

When the mania for proposing new titles for geologic formations becomes so acute as it has in the case of the collector of fossils there is little real hope of simplifying stratigraphy so that the average worker going into a district may easily understand, and without undue expenditure of time and effort, acquire fundamental insight into the problems presented. In the last quarter of a century there appears to be not a single systematic effort on the part of the geological surveys of the country to accomplish what should have been done years and years ago. Instead matters in this respect are growing rapidly worse instead of better. In no field of science is there presented so chaotic a state of nomenclature as that relating to stratigraphy.

In casting about for the proper area for which to construct a suitable generalized section of local rocks the quadrangle as ordinarily selected appears to be much too small to be of any real service. The county is likewise too limited in extent. In size the state seems most satisfactory for trial-tests in continental correlations. A comprehensive section of the Iowa rocks was given last year in the Proceedings of the Academy. This year a similarly constructed section of the Missouri rocks is annexed for comparison. Later, sections of Kansas, Oklahoma, Western

Texas, New Mexico and Arizona will be presented, as parts of a broad but exact scheme of general correlation.

As fundamental elements in the upbuilding of the North American continent the areas of Iowa and Missouri present some exceptionally instructive contrasts. In the geological sections of these two states the record of each physical event is accentuated and paralleled with those of others.

Several notable features first deserve enumeration. In the one area certain phases of unconformity are represented by tremendous sections of sediments. At one time a great and lofty mountain range stretched across the northern area, while in the south remained a lowland plain. In its present aspect the Ozark dome did not exist until very recent times. These circumstances have an important bearing upon the proper interpretation of the regional stratigraphy.

For many years the two sections have appeared to be so unlike that little exact comparison was possible. This apparent discrepancy arisés from several causes. First, there is small attempt to assign to the several geologic formations recognized their proper taxonomic ranks. Second, different names for the same terranes are used in the two states. Third, state lines prevent workers in the one province from extending their investigations into adjoining districts and thus making exact stratigraphic correlations. Fourth, terranes are represented in one state which have no exact depositional equivalent in another. Fifth, change in lithologic character of formations tend to confuse the delimitation of formations.

The similarities of the two sections are as important as are their differences. The former are the more apparent since the taxonomic values of the several formations, the usage of the same nomenclature, and the positions of the terranes in the time-scale are made to harmonize in a way never before attempted. To the detailed differences attention is specifically called in another place.

Of the larger differences between the two sections the most notable may be briefly enumerated. First of these are those which relate to the Cambric rocks. The Croixan series, which in Iowa is scarcely exposed above stream-level, is well differentiated in Missouri and widely outcrops around the Ozark dome. Although the successions in the two states have nearly the same thickness no equivalents of the subdivisions recognized in the south can be suggested for Iowa, where the rocks are mainly known only from the records of deep-well sections.

Of the Ozarkian series the Jefferson dolomite appears to be very nearly the exact equivalent of the Shakopee dolomite of the north. The Roubidoux sandstone corresponds to the New Richmond sandstone of the same region. The Gasconade dolomite probably represents somewhat more than the Oneota dolomite. The Gunter sandstone is a local deposit.

In the Ordovicic division the Early part of the sequence, represented by the Yellville dolomite, does not appear to be found in the north. Early Siluric sedimentation is not represented in Iowa by deposits. Early and Mid Devonic terranes, which have no sedimentative representatives in Iowa, are well developed in the south.

The Tennessean series, which is so poorly developed in Iowa, reaches in southern Missouri a quite remarkable thickness and attains great diversity in lithologic character. In its geographic distribution it extends far southeastward into Alabama; while the Mississippian series extends southwestward. The two series therefore, really belong to quite distinct geographic provinces, the sedimentation of which overlaps somewhat along one edge. The importance of this distinction is not generally recognized.

The Arkansan series in both Missouri and Iowa is represented by a marked hiatus. The plane of unconformity bevels all older strata in such a manner as to indicate a long period of erosion, if not one of complete planation. On the south side of the Ozark dome in southern Missouri appears the feather-edge of the great Arkansan formation comprising coal-bearing shales and sandstones. This attains in central Arkansas an enormous thickness of more than 15,000 feet. This series is the depositional equivalent of the unconformity which characterizes the base of the coal measures in both Missouri and Iowa. The entire Carbonic succession appears so important terranally and has so many marked division lines that Chamberlin and Salisbury propose to assign a taxonomic rank to each of its two principal divisions equivalent to that of Devonic or Cambric. This procedure is not believed to have sound stratigraphic foundation; and it is difficult to see how the proposal is any distinct advance over our prior conceptions.

Another notable difference between the Missouri and Iowa general sections is the presence in the first named state of marine Tertiaric beds; and in the last mentioned state of continental deposits of the same age. The correlation of both of these sections with the great Southwest standard section is also given.

GENERAL GEOLOGIC SECTION OF MISSOURI.

Eras	Periods	Sub-P.	Series	Terranes	Thick	Rocks
CENOZOIC	QUATERNARIC	Late			25	Loess
				Interval		Unconformity
		Mid	*Pleistocene*	Wisconsin	25	Gravels
				Peoria	25	Loess
				Interval		Unconformity
				Kansas	50	Till
		Early		Interval		Unconformity
	TERTIARIC	Late	*Poinsettan*	Lafayette	50	Gravels
		Mid		Interval		Unconformity
		Early	*Crowleyan*	Wilcox	100	Shales
				Porter	50	Clays
				Interval		Unconformity
MESOZOIC	CRETACIC	Late	*Ripleyan*	Egypt	150	Sands
				Interval		Unconformity
		Mid	*Dakotan*	Nishnabotna	20	Sandstones
		Early	*Comanchan*	Interval		Unconformity
	JURASSIC			Interval		Wanting
	TRIASSIC			Interval		Wanting
PALEOZOIC	CARBONIC	Late		Unrep'sented		
		Mid	*Missourian*	Atchison	300	Shales
				Forbes	35	Limestones
				Platte	125	Shales
				Plattsmouth	50	Limestones
				Lawrence	250	Shales
				Stanton	30	Limestones
				Parkville	100	Shales
				Iola	40	Limestones
				Thayer	100	Shales
				Bethany	75	Limestones
			Des Moines	Marais des C.	300	Shales
				Henrietta	75	Limestones
				Cherokee	225	Shales
			Arkansan	Sonora	100	Shales
		Early	*Tennessean*	Chester	100	Shales
				Kaskaskia	125	Limestones
				Aux Vases	150	Sandstones
				Genevieve	150	Limestones
				St. Louis	200	Limestones
				Interval		Unconformity
			Mississippian	Spergen	100	Limestones
				Warsaw	65	Shales
				Keokuk	75	Limestones
				Burlington	125	Limestones
				Interval		Unconformity
			Waverlyan	Chouteau	80	Limestones
				Hannibal	75	Shales
				Louisiana	50	Limestones
				Saverton	50	Shales
				Grassy	40	Shales

ERAS	PERIODS	SUB-P.	SERIES	TERRANES	THICK	ROCKS
PALEOZOIC	DEVONIC			Interval		Unconformity
		LATE	*Chemungan*	Snyder	125	Shales
			Senecan	Callaway	50	Limestones
		MID	*Erian*	Interval		Unconformity
				Wittenberg	30	Shales
				Interval		Unconformity
				Grand Tower	150	Limestones
		EARLY	*Oriskanian*	Clear Creek	225	Limestones
			Helderbergian	Interval		Unconformity
				Bailey	160	Limestones
	SILURIC	LATE	*Goweran*	Interval		Unconformity
				Sexton	50	Dolomites
		MID	*Niagaran*	Interval		Unconformity
				Bowling Gr.	40	Dolomites
		EARLY	*Alexandrian*	Interval		Unconformity
				Noix Girardeau	30 50	Limestones Limestones
	ORDOVICIC	LATE	*Maquoketan*	Bufallo Thebes	60 75	Shales Sandstones
		MID	*Mohawkian*	Interval		Unconformity
				McCune	50	Limestones
				Interval		Unconformity
				Bryant Joachim	150 150	Limestones Dolomites
		EARLY	*Minnesotan*	St. Peter	125	Sandstones
			Canadian	Interval		Unconformity
				Yellville	150	Dolomites
	CAMBRIC	LATE	*Ozarkian*	Interval		Unconformity
				Jefferson Roubidoux Gasconade Gunter	200 150 250 100	Dolomites Sandstones Dolomites Sandstones
		MID	*Croixan*	Interval		Unconformity
				Proctor Eminence Potosi Doe Run Derby Davis LeSueur Fredericktn'n LaMotte	60 200 300 60 40 150 250 200 250	Dolomites Dolomites Dolomites Dolomites Dolomites Shales Dolomites Limestones Sandstones
		EARLY		Interval		Unconformity
PROTER-OZOIC	SUPERIORIC	EARLY	*Animikian*	Ironton Pilot Knob	200 50	Slates Conglomerates
	SELKIRKIC			Interval		Unconformity

ERAS	PERIODS	SUB-P.	SERIES	TERRANES	THICK	ROCKS
ARCHEO-ZOIC	ALGOMIC	LATE	*Francoisian*	Skrainka Iron Mount'n Knob Lick	 300 500	Diabases Porphyries Granites
AZO-IC				Not exposed.		

SEQUENCE OF ROCK FORMATIONS IN KANSAS.

Eras	Periods	Sub-P.	Series	Terranes	Thick	Rocks
CENOZOIC	QUATERNARIC	Late	*Recent*		25	Alluvium
				Interval		Unconformity
		Mid	*Pleistocene*	Wisconsin	100	Loess
				Kingsdown	150	Adobes
				Pearlette	25	Volcanic ash
				Meade	40	Gravels
				Interval		Unconformity
				Kansas	50	Tills
				Afton	25	Clays
				Interval		Unconformity
		Early			10	Clays
	TERTIARIC			Interval		Unconformity
		Late	*Texhoman*	Blanco	100	Sands
				Goodnight	150	Clays
				Interval		Unconformity
		Mid	*Loupian*	Ogalalla	300	Sands
				Arikaree	500	Clays
		Early				Not exposed
MESOZOIC	CRETACIC	Late	*Montanan*	Interval		Unconformity
				Pierre	400	Shales
		Mid	*Coloradan*	Niobrara	300	Chalks
				Hays	50	Limestones
				Victoria	150	Shales
				Carlile	100	Shales
				Greenhorn	100	Limestones
				Graneros	150	Shales
			Dakotan	Cawker	50	Shales
				Brookville	150	Sandstones
				Pete	50	Shales
				Interval		Unconformity
		Early	*Comanchan*	Mentor	100	Sandstones
				Interval		Unconformity
				Kiowa	150	Shales
				Cheyenne	60	Sandstones
				Interval		Unconformity
	JURASSIC	Late	*Morrisonian*	Chaquaqua	75	Shales
				Travester	50	Shales
				Interval		Unconformity
	TRIASSIC	Early	*Dockuman*	Trujillo	75	Shales
				Tecovas	50	Shales
				Interval		Unconformity

Eras	Periods	Sub-P.	Series	Terranes	Thick	Rocks
PALEOZOIC	CARBONIC	Late	*Cimarronian*	Quartermaster	300	Sandstones
				Greer	100	Gypsums
				Woodward	300	Shales
				Blaine	75	Gypsums
				Enid	100	Shales
				Interval		Unconformity
		Mid	*Oklahoman*	Wellington	200	Shales
				Marion	150	Shales
				Winfield	100	Shales
				Riley	60	Limestones
				Matfield	75	Shales
				Wreford	50	Limestones
				Neosho	125	Shales
				Cottonwood	10	Limestones
			Missourian	Atchison	500	Shales
				Forbes	30	Limestones
				Platte	200	Shales
				Plattsmouth	50	Limestones
				Lawrence	300	Shales
				Stanton	125	Limestones
				Parkville	100	Shales
				Iola	30	Limestones
				Thayer	100	Shales
				Bethany	225	Limestones
			Des Moines	Marais de C.	400	Shales
				Henrietta	100	Limestones
				Cherokee	300	Shales
			Arkansan	Interval		Unconformity
		Early	*Tennessean*			Unrepresented
			Mississippian	Keokuk	75	Limestones
				Burlington	100	Limestones

EXPLANATORY NOTE.

The carbonic section of Kansas soon comes in for detailed discussion in another connection. There are several cogent reasons for not adopting here the subdivisions suggested by the Kansas geologists. As the divisional lines followed well show they are not materially different from Broadhead's arbitrarily chosen and "convenient" groups of half a century ago.

That Kansas geologists should not agree among themselves upon what formations their several subdivisions should include, that those in neighboring states should not agree among themselves or with the Kansas workers, and that none of these should agree with the Federal representatives and others who have visited the region is not passing strange because none of the expressed opinions take into account genetic bases. Until the laws of priority in names, the canons of nomenclature, the basic principles of stratigraphy, and the essential influences of regional diastrophic movements are recognized confusion and disagreement must continue to prevail in the simplest matters.

GENERAL GEOLOGICAL SECTION OF NEW MEXICO.

Eras	Periods	Sub-P.	Series	Terranes	Thick	Rocks
CENOZOIC	QUATERNARIC	Late	*Jornadan*		25	Abode
		Mid	*Palomasan*		200	Till
		Early	*Gilan*		250	Gravels
				Interval		Unconformity
	TERTIARIC	Late	*Pecosian*	Llano Estacado	300	Sands
				Interval		Unconformity
		Mid	*Arriban*	Sante Fe Galesteo	500 800	Clays Sands
				Interval		Unconformity
		Early	*Chaman*	Chaco Canyon Largo	1000 700	Clays Sandstones
				Interval		Unconformity
			Nacimientan	Torrejon	300	Marls
				Interval		Unconformity
				Puerco	500	Clays
				Interval		Unconformity
			Aztecan	Archuleta	250	Conglomerate
				Interval		Unconformity
			Ratonan	Maxwell Houten Maya	800 600 100	Shales Sandstones Conglomerate
				Interval		Unconformity
MESOZOIC	CRETACIC	Late	*Laramian*	Navajo Pictured Cliffs	1000 150	Shales Sandstones
				Interval		Unconformity
			Montanan	Lewis Chacra Mesa Verde Pina Vititos	600 200 800 250	Shales Sandstones Shales Sandstones
				Interval		Unconformity
		Mid	*Coloradan*	La Jara Apishapa Timpas Gallinas	1000 500 300 200	Shales Shales Limestones Shales
			Dakotan	Glorietta	300	Sandstones
				Interval		Unconformity
		Early	*Comanchan*	Kiowa Garrett	100 50	Shales Conglomerate
				Interval		Unconformity
				Washita Fredericksburg	500 200	Limestones Limestones

Eras	Periods	Sub-P.	Series	Terranes	Thick	Rocks
		Late		Interval		Unconformity
				Chaquaqua	150	Shales
				Travester	100	Shales
	JURASSIC	Mid	*Morrisonian*	Exter	75	Sandstones
				Interval		Unconformity
MESOZOIC		Early	*Zunian*	McElmo	300	Shales
				La Plata	300	Sandstones
				Wingate	900	Sandstones
		Late	*Doloresian*	Le Roux	800	Shales
				Shinarump	600	Conglomerate
	TRIASSIC	Mid		Interval		Unconformity
				Trujillo	300	Shales
		Early	*Dockuman*	Tecovas	200	Shales
				Interval		Unconformity
				Quarter-master	150	Shales
			Cimarronian	Greer	125	Shales
				Chaves	425	Shales
		Late		Interval		Unconformity
				Capitan	2500	Limestones
			Guadaloupan	Eddy	1000	Sandstones
				Interval		Unconformity
				Torrance	500	Shales
				Yeso	600	Shales
			Bernalillan	Manzano	500	Sandstones
				Interval		Unconformity
				Tellera	300	Limestones
	CARBONIC		*Maderan*	Gallegos	100	Sandstones
				Antonito	200	Limestones
		Mid		Mosca	200	Limestones
PALEOZOIC			*Lunasan*	Coyote	75	Sandstones
				Montosa	400	Limestones
				Sandia	250	Shales
				Interval		Unconformity
			Ladronesian	Alamito	200	Shales
			Tennessean	Interval		Unconformity
				Modoc	200	Limestones
			Mississippian	Sierra	50	Limestones
		Early		Lake Valley	150	Limestones
				Grande	25	Limestones
			Waverlyan	Interval		Unconformity
		Late	*Martinian*	Berenda	50	Limestones
				Interval		Unconformity
	DEVONIC	Mid	*Perchan*	Bella	250	Shales
				Silver	200	Shales
		Early		Interval		Unconformity
		Late				Wanting
	SILURIC	Mid	*Santa Ritan*	Naiad	250	Limestones
				Cibola	175	Limestones
		Early		Interval		Unconformity

Eras	Periods	Sub-P.	Series	Terranes	Thick	Rocks
PALEOZOIC	ORDOVICIC	Late	*Mimbresian*	Cristobal	165	Limestones
		Mid	*Montoyan*	Frondosa	100	Limestones
		Early	*El Pasan*	Armendaris	300	Limestones
				Interval		Unconformity
	CAMBRIC	Late	*Chiricahuan*	Lone	300	Quartzites
			Chloridian	Carrasco	75	Limestones
		Mid	*Dragoonan*	Burro	500	Quartzites
				Hawkins	50	Limestones
				Mangas	100	Quartzites
		Early		Interval		Unconformity
PROTEROZOIC	SUPERIORIC		*Valencian*	Graphic Sandoval	1000	Lavas Granites
				Interval		Unconformity
	SELKIRKIC		*Albuquerquan*	Ysidro	1500	Shales
				Tijeras	250	Quartzites
				Interval		Unconformity
			Garnuan	Antonio	2000	Slates
	ANIANIC			Interval		Unconformity
ARCHEOZOIC			*Pecurisan*	Truchas	900	Slates
				Penasco	400	Quartzites
				Serna	1500	Schists
				Interval		Unconformity
			Taosan	Solitario	800	Slates
				Rociada	250	Limestones
				Sapello	300	Quartzites
				Ninos	1000	Schists
				Interval		Unconformity
AZOIC						Slates Gneisses Schists

NOMENCLATURE AND SYNONYMY.

Abo Sandstones, Lee. (Bull. U. S. Geol. Surv., No. 389, p. 12, 1909.) Term exact synonym of Manzano sandstones as defined by C. L. Herrick.

Alamito Shales, Keyes. (Journal of Geology, Vol. XIV, p. 154, 1906.) Probably representative of some part of the Arkansan coal series of the Mississippi valley.

Albuquerquan Series. The great sequence of argillaceous beds, with some quartzites, exposed to the extent of more than 2,000 feet in the Tijeras canyon, east of Albuquerque.

Antonio Slates. Thick, somewhat metamorphosed, argillaceous beds which lie beneath the Tijeras quartzite, and are well displayed at the north end of the Manzano mountains. They are underlain by other but as yet undetermined sediments.

Antonito Limestones. Lowermost of the heavy gray limestones exposed in fine sections at the southern extremity of the Sandia range.

Apishipa Shales, Gilbert. (Seventeenth Ann. Rept., U. S. Geol. Surv., Pt. ii, p. 567, 1896.)

Archuleta Shales. The title is here proposed for that of Animas Formation of the San Juan region, which is preoccupied.

Armendaris Limestones. Main body of the Early Ordovicic limestones well displayed in the Sierra de los Caballos.

Arriban Series, Keyes. (Proc. Iowa Acad. Sci., Vol. XIII, p. 226, 1908.) Essentially the entire Miocene section as represented around the southern end of the Rocky Mountains.

Aztecan Series. A thick, post-Laramian succession of Cretacic sediments in the San Juan region.

Bella Shales, Keyes. (Trans. American Inst. Mining Eng., Vol. XXXIX, p. 147, 1909.)

Berenda Limestones, Keyes. (Trans. American Inst. Mining Eng., Vol. XXXIX, p. 147, 1909.) Late Devonic section of the Mimbres region, which possibly represents the attenuated eastward extension of the thick Martinian limestones of eastern Arizona.

Bernalillan Series, Keyes. (Rept. Governor New Mexico to Secretary of Interior, for 1903, p. 341, 1904.) Term originally proposed for the Mid Carbonic red-beds below the Cimarronian series.

Bliss Quartzites, Richardson. (Bull. Texas Univ. Min. Surv. No. 9, 1904.) Basal member of the Mid Cambric section of the Franklin mountains; and the sole representative of the Dragoonan series of that area.

Burro Quartzites. Main body of the Mid Cambric quartzites which immediately overlie the Chloridian series of limestones near Silver City.

Canyon Largo Sandstones, Newberry. (Macomb's Exped. Green River, Geol. Rept. p. 1, 1876.)

Capitan Limestones, Richardson. (Bull. Texas Univ. Min. Surv., No. 9, 1904.)

Carrasco Limestones. Main calcareous member of Late Ordovicic age well displayed back of the Carrasco smelter property near Silver City.

Cenocene Series. Latest formed deposits of the Quaternaric age.

Chaco Clays, Keyes. (Proc. Iowa Acad. Sci., Vol. XIII, p. 225, 1908.) Main body of clays, shales and sands heretofore referred to the Wasatch sequence of the San Juan basin.

Chacra Sandstones. Massive sandstone layers forming the upper member of the Mesa Verde coal formation and constituting a prominent relief feature in the southeastern part of the San Juan region.

Chaquaqua Shales. Section of alternating red sandstones and shales, finely exposed in the Chaquaqua canyon, in northeast New Mexico.

Chaman Series, Keyes. (Proc. Iowa Acad. Sci., Vol. XIII, p. 224, 1908.) Main body of so-called Wasatch section, in the San Juan district.

Chaves Shales. Lowermost section of red shales which rest on the great Capitan limestones in the Guadaloupe mountains.

Chiricahuan Series. Late Cambric limestone succession well developed in the Chiricahua and Caballos ranges.

Chloridian Series. Mid Cambric limestone succession extensively exposed in Grant county; and probably the eastern attenuation of the Abrigo sequence of limestones of Bisbee.

Cibola Limestones. Important Mid Siluric limestone member outcropping at the Cibola mill at Silver City.

Cimarronian Series, Cragin. (Colorado College Studies, Vol. VI, p. 18, 1896.)

Coloradan Series, Endlich. (U. S. Geol. and Geog. Surv. Terr., Ninth Ann. Rept., p. 126, 1877.)

Comanchan Series, Hill. (Am. Jour. Sci. (3), Vol. XXXIII, p. 298, 1887.)

Coyote Sandstones, Herrick. (Bull. Hadley Lab. Univ. New Mexico, Vol. II, fascicle 3, p. 4, 1900.)

Cristobal Limestones. Main body of Late Ordovicic limestone section in the Franklin, Caballos, Fra Cristobal and Mimbres ranges.

Dakotan Series, Meek and Hayden. (Proc. Acad. Nat. Sci. Philadelphia, Vol. XIII, p. 410, 1862.)

Dragoonan Series, Dumble. (Trans. American Inst. Mining Eng., Vol. XXXI, p. 1902.) Mid Cambric section finely exposed in the vicinity of Silver City. Originally defined in the Dragoon range of southeastern Arizona.

Dockuman Series, Hill. (Texas Geol. Surv., First Ann. Rept., p. 189, 1890.)

Doloresan Series, Cross. (U. S. Geol. Surv., Folio 57, p. 2, 1899.)

Eddy Sandstones, Keyes. (Journal of Geology, Vol. XIV, p. 154, 1906.) The term Delaware proposed by G. B. Richardson for this formation is preoccupied.

El Pasan Series, Keyes. (Science, Vol. XXIII, p. 922, 1906.) Term is restricted to the Early Ordovicic section of the Franklin, Caballos and Mimbres ranges.

Epicene Series, Keyes. (Proc. Iowa Acad. Sci., Vol. XXI, p. 186, 1914.) Early, or pre-Glacial, section of the Quaternaric succession.

Exter Sandstones, Lee. (Journal of Geology, Vol. X, p. 45, 1902.)

Fredericksburg Limestones, White. (Proc. Acad. Nat. Sci., Philadelphia, 1887, p. 40, 1887.) Part of Cretacic section well exposed in the Sierra de los Muleros west of El Paso.

Frondosa Limestones. Main body of Mid Ordovicic series in Franklin mountains, which carries a Galena-Trenton fauna.

Fusselmann Limestones, Richardson. (Am. Jour. Sci. (4), Vol. XXV, p. 474, 1908.) Includes the entire Siluric section of the Franklin mountains.

Galisteo Sandstones, Hayden. (U. S. Geol. and Geog. Surv. Terr., Third Ann. Rept., p. 167, 1873.)

Gallegos Sandstones. Thick sandstone beds in the middle of the Maderan limestones in the Sandia range.

Gallina Shales. Basal member of the Coloradan series, well developed on Gallina Creek, near Las Vegas.

Garnuan Series. Thick argillaceous sequence which lies below the Tijeras quartzite in the Tijeras and Coyote canyons at the north end of the Manzana mountains. Still other sediments underlie it.

Garrett Conglomerate. Basal member of the Early Cretacic section in northeastern New Mexico and southwestern Kansas.

Gilan Series. Early Quaternaric section widely developed in the Gila River valley.

Glorietta Sandstones. Main body of the Dakotan series around the southern end of the Rocky mountains.

Grande Limestones, Keyes. (Trans. American Inst. Mining Eng., Vol. XXXIX, p. 148, 1909.) Formation is best shown at Lake Valley; and is perhaps the southwestern representative of the Chouteau limestone of the Mississippi valley.

Graphic Lavas. Bedded volcanic sequence superposed on pre-Cambric rocks of the Magdalena mountains.

Greer Shales, Gould. (Water Supply and Irrig. Pap., U. S. Geol. Surv., No. 148, p. 39, 1905.) Western extension of the Cimarronian red-beds of western Texas and Kansas.

Guadaloupan Series, Girty. (Am. Jour. Sci. (4), Vol. XIV, p. 363, 1902.)

Hawkins Limestones. Important calcareous beds of Mid Cambric age which are intercalated in the basal section of quartzites exposed in Grant county.

Houten Sandstones. Middle sandy portion of the Raton series in northeastern New Mexico.

Jornadan Series. Principal intermont plains soils and surface deposits.

Kelly Limestones, Herrick. (American Geologist, Vol. XXXIII, p. 310, 1904.) Synonymous with Lake Valley limestones.

Kiowa Shales, Cragin. (Colorado College Studies, Vol. V, p. 49, 1894.) Main body of Comanchan shales well exposed in northeastern New Mexico and southwestern Kansas.

Ladronesan Series, Keyes. (Journal of Geology, Vol. XIV, p. 154, 1906.) Remnant of coal-bearing formation which is to be correlated with the Arkansan series of the Mississippi valley.

La Jara Shales. Thick, uppermost black shales section of the Coloradan series around the southern end of the Rocky mountains.

Lake Valley Limestones, Keyes. (Rept. Governor of New Mexico to Secretary of Interior, for 1903, p. 341, 1904.) Main body of Early Carbonic section exposed typically at Lake Valley and elsewhere in the Mimbres region.

La Plata Sandstones, Cross and Spencer. (U. S. Geol. Surv., Folio 60, p. 3, 1889.)

Laramian Series, White. (Bull. U. S. Geol. and Geog. Surv. Terr., Vol. III, p. 625, 1877.)

Le Roux Shales, Ward. (Am. Jour. Sci. (4), Vol. XII, p. 401, 1901.)

Lewis Shales, Cross and Spencer. (U. S. Geol. Surv., Folio 60, p. 4, 1899.)

Llano Estacado Sands, Hill. (Bull. Geol. Soc. America, Vol. III, p. 87, 1892.) Mainly the Pliocene deposits of eastern New Mexico and western Texas.

Lone Quartzite. Late Cambric section of alternating quartzites and metamorphosed limestones well displayed in Lone mountain, near Silver City.

Lunasan Series. Main limestone sequence in the Manzano mountains.

Maderan Series, Keyes. (Rept. Governor of New Mexico to Secretary of Interior, for 1903, p. 341, 1904.) Uppermost gray limestone sequence below the red-beds in the Sandia mountains.

Magdalena Group, Gordon. (Journal of Geology, Vol. XV, p. 805, 1907.) Synonymous with Maderan and Lunasan series, little of either of which appear to be represented in the Magdalena range.

Mangas Quartzite. Basal silicious member of the Mid Cambric section exposed near Silver City.

Manzanan Series, Keyes. (Rept. Governor of New Mexico to Secretary of Interior, for 1903, p. 341, 1904.) Exact synonym of Lunasan series, which term is proposed for it.

Manzano Sandstone, Herrick. (Bull. Hadley Lab. Univ. New Mexico, Vol. II, Pt. i, fascicle 3, p. 4, 1900.) Title as originally used appears to have been restricted to the lowermost red sandstones to which W. T. Lee later gave the designation Abo sandstones.

Martinian Series; Ransome. (Prof. Pap. U. S. Geol. Surv., No. 21, p. 33, 1904.) Late Devonic limestone succession of Bisbee, Arizona, Silver City, and Lake Valley.

Maya Conglomerate. Basal member of the Tertiaric section in northeastern New Mexico.

McElmo Shales, Cross and Spencer. (U. S. Geol. Surv., Folio 60, p. 4, 1899.)

Mesa Verde Shales, Holmes. (U. S. Geol. and Geog. Surv. Terr., Ninth Ann. Rept., p. 245, 1877.)

Mimbresan Series, Keyes. (Rept. Governor of New Mexico to Secretary of Interior, for 1903, p. 341, 1904.) Term restricted to Late Ordovicic section in Mimbres, Caballos and Franklin ranges that carries the Richmond fauna.

Mississippian Series, Winchell. (Proc. American Philos. Soc., Vol. XI, p. 79, 1869.) Term again restricted to its original signification and to the middle part of the Early Carbonic succession.

Modoc Limestones, Lindgren. (Prof. Pap. U. S. Geol. Surv., No. 43, p. 69, 1905.) Part of the Early Carbonic section extending eastward to the Mimbres range from Clifton, Arizona.

Montanan Series, Eldridge. (Proc. Colorado Sci. Soc., Vol. III, p. 93, 1888.)

Montosa Limestones, Keyes. (Journal of Geology, Vol. XIV, p. 154, 1906.) One of the distinctive members of the Lunasan section of the Manzana and Sandia ranges.

Montoyan Series. Mid Ordovicic section of the Franklin, Caballos and Mimbres mountains.

Morrisonian Series, Cross. (U. S. Geol. Surv., Folio 7, p. 2, 1894.)

Mosca Limestones, Keyes. (Journal of Geology, Vol. XIV, p. 154, 1906.) Uppermost member, carrying a distinctive fauna, of the Lunasan series in the Manzano mountains.

Nacimientan Series, Keyes. (Proc. Iowa Acad. Sci., Vol. XIII, p. 224, 1908.) Includes the main body of Puerco marls of E. D. Cope, and other argillaceous beds.

Naiad Limestone. Main ore-bearing formation at Georgetown, Silver City and elsewhere in these districts.

Navajo Shales. Thick, upper member of the Laramian series in the San Juan region.

Ninos Schists. Lower and principal schistose section above the Azoic gneisses in Solitario mountain, northwest of Las Vegas.

Palomas Series, Gordon. (Prof. Pap. U. S. Geol. Surv., No. 68, p. 237, 1910.) Term restricted to the Mid Quaternaric, or Pleistocene, section.

Pecosan Series, Keyes. (Proc. Iowa Acad. Sci., Vol. XIII, p. 227, 1908.) Includes essentially all of the Pliocene section of the Llano Estacado region.

Penasco Quartzite. Main body of silicious section exposed near Pecuris, north of Santa Fe.

Perchan Series, Gordon. (Am. Jour. Sci. (4), Vol. XXIV, p. 58, 1907.)

Pictured Cliffs Sandstones, Holmes. (U. S. Geol. and Geog. Surv. Terr., Ninth Ann. Rept., p. 246, 1877.)

Picurisan Series. A thick section of highly tilted sediments of Archeozoic age widely exposed on the west side of the Rocky mountains north of Santa Fe. They strike northwest and southeast, and are best exposed near the village of Pecuris.

Pino Vititos Sandstones. Basal member of the Montanan coal-bearing series around the southern end of the Rocky mountains.

Pleistocene Series. Term here restricted to the Mid Quaternaric section.

Puerco Clays, Cope. (Rept. Secretary of War to Forty-fourth Cong., Vol. II, Pt. ii, p. 1012, 1875.)

Quartermaster Shales, Gould. (Water Supply and Irrig. Pap., U. S. Geol. Surv., No. 148, p. 39, 1905.)

Rociado Limestones. Main body of Archeozoic limestones in the Solitario Mountain district, northwest of Las Vegas.

Ratonan Series, Knowlton. (Am. Jour. Sci., (4), Vol. XXXV, p. 527, 1913.)

San Andreas Limestones, Lee. (Bull. U. S. Geol. Surv., No. 389, p. 9, 1907.) Upper part of Maderan series.

Sandia Shales, Herrick. (Journal of Geology, Vol. VIII, p. 115, 1900.)

Sandoval Granites. Red granites penetrating all pre-Cambric rocks of the Sandia, Magdalena and other ranges.

Santa Fe Clays, Hayden. (U. S. Geol. Surv. Terr., Prelim. Field Rept., p. 66, 1869.)

Santa Ritan Series. Mid Siluric section as repesented around Fort Bayard, and in the Caballos and Franklin ranges; it carries the Niagaran fauna.

Sapello Quartzites. Main body of Archeozoic quartzites below the thick limestone section in the Solitario peak region, northwest of Las Vegas.

Serna Schists. Basal part of the Archeozoic section near Picuris, north of Santa Fe, on the west flank of the Rocky mountains.

Shandon Quartzites, Gordon. (Prof. Pap. U. S. Geol. Surv., No. 68, p. 225, 1910.) Basal quartzites in the Caballos mountains, probably belonging to the Dragoonan series.

Shinárump Conglomerates, Powell. (U. S. Geog. and Geol. Surv., Geol. Uinta Mts., p. 41, 1876.)

Sierra Limestones, Keyes. (Trans. American Inst. Mining Eng., Vol. XXXIX, p. 149, 1909.) Uppermost member of Early Carbonic sequence at Lake Valley.

Silver Shales, Keyes. (Trans. American Inst. Mining Eng., Vol. XXXIX, p. 147, 1909.) Mid Devonic black shales, weathering brown or red, of the Mimbres region.

Solitario Slates. Extensive section of tilted Archeozoic beds lying above the main limestone exposed in Solitario mountain, northwest of Las Vegas.

Taosan Series. Tilted Archeozoic sediments exposed in Solitario peak. They strike N. 50 degrees W., across Taos county, and dip about 60 degrees SW.

Tecovas Shales, Gould. (Water Supply and Irrig. Pap., U. S. Geol. Surv., No. 191, p. 231, 1907.)

Tellara Limestones. Thick, uppermost gray limestone member of the Maderan series exposed on the east flank of the Sandia range.

Tijeras Quartzites. Thick quartzitic beds best exposed in the great Tijeras arch of pre-Cambric rocks at the south end of the Sandia range.

Timpas Limestones, Gilbert. (Seventeenth Ann. Rept., U. S. Geol. Surv., Pt. ii, p. 566, 1896.)

Torrance Shales. Upper, or vermillion section of the Bernalillan series of Carbonic red-beds in the Manzano mountains.

Torrijon Clays, Dall. (Eighteenth Ann. Rept. U. S. Geol. Surv., Pt. ii, p. 347, 1898.)

Truchas Slates. The upper slate section of the Archeozoic succession at Picuris, north of Santa Fe.

Travester Shales. Variegated beds lying immediately above the Exter sandstones well displayed in Travester canyon in northeastern New Mexico.

Trujillo Shales, Gould. (Water Supply and Irrig. Pap., U. S. Geol. Surv., No. 191, p. 26, 1907.)

Valencian Series. Latest pre-Cambric succession of volcanics and granites.

Vermejo Shales, Knowlton. (Am. Jour. Sci., (4), Vol. XXXV, p. 527, 1913. Probably exact equivalent of Mesa Verde shales.

Washita Limestones, Shumard. (Trans. St. Louis Acad. Sci., Vol. I, p. 583, 1857.)

Wingate Sandstones, Dutton. (Sixth Ann. Rept. U. S. Geol. Surv., p. 136, 1885.)

Yeso Shales, Lee. (Bull. U. S. Geol. Surv., No. 389, p. 9, 1909.) Term restricted to middle section of Bernalillan series.

Ysidro Shales. The thick argillaceous member of Proterozoic sediments lying above the great quartzite, which is best exposed in the sharp, truncated arch in Tijeras canyon between the Sandia and Manzano ranges.

Zunian Series, Dutton. (Sixth Ann. Rept. U. S. Geol. Surv., p. 137, 1885.)

REMARKABLE PRAIRIE SYNCLINORIUM.

CHARLES KEYES.

Geotectonics of great plains regions seldom offer very much attraction for structural studies. Large plains are almost universally tracts especially notable for their deep soils. Rock-exposures are few in number and unimportant. There are no marked contrasts of relief. These lowlands are frequently true peneplains the surfaces of which are either still lying near sea level or are but recently raised only slightly above it.

The upper Mississippi basin is just such a region as that postulated. Its surface is so deeply covered by glacial debris, wind-borne loess, and fine soils that the bedrock of entire counties is hardly mapable even approximately. The superficial inequalities are so small, the slopes of the streams so slight, and much of the substructure so soft that rock outcrops are infrequent and give little clue to the attitude of the bedded terranes beneath. Beyond the expressed belief that the strata of the substructure are flat-lying or only slightly inclined mention is seldom made of the regional tectonic features.

Recent years witness a great relief to the difficulties of interpretation of the geologic structures of this region. Numerous deep-wells put down in quest of good water supplies sufficient for municipal purposes indicate clearly the larger features of tectonics. Many of these borings go down distances of 2,000 feet or more. Inasmuch as the principal aquifer of the Iowa region is the St. Peter sandstone deep-borings endeavor to sink to this horizon. By connecting the various boring records along different lines the formations between the St. Peter sandstone and other well known layers are also more or less readily and accurately determined. The resulting sections disclose the fact that there is well-defined flexing that is far from being so simple and so slight as is commonly supposed.

As elucidating some of the broader tectonic features of the prairie region certain of these geologic cross sections are particularly instructive and suggestive. The line of one section connecting two insular outcrops of very old rocks, or pre-Cambric formations, passes entirely across the western part of our state. It extends from Sioux Falls, South Dakota, southward or southeastward to the crest of the Ozark dome, in southeast Missouri. This is a section about 600 miles long. From the north end to a point east of Kansas City the section coincides closely with the course of the Missouri river, affording the best surface exposures in all the region. Along this line are an unusual number of deep-wells having good records of the formations penetrated.

This cross section presents the form of a great trough, ending at each extremity in an old mountain ridge. Something of an adequate conception of the grand proportions of this structure is gained from the statement that the middle of the syncline is depressed a distance of more than two miles below the ends. Each of the raised extremities of the section is a part of a notable mountain ridge which in early Mesozoic times trended northeast and southwest across the Upper Mississippi Valley region.

The northern one of these ranges is now designated as the Siouan mountains. Its features are figured forth in a recent paper read before this Academy. The geologic history of this remarkable orogenic elevation is, briefly, this: Since all 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 portion of the continent was a land area, the country was again completely base-leveled, 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 their decline. At the time of their highest stage their crests 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.

A similar history obtains for the Ozarks. In early Mesozoic times they too were notable positive features of landscape. As in the case of the Siouan mountains they were in Comanchan time completely leveled and worn down nearly to the level of the sea. Unlike the instance of the Siouan elevation the Ozark perfectly peneplained area was in Tertiary times again elevated, the summit of the great dome attaining a height above the sea of more than 2,000 feet. This is the elevated region which we see today, modified from its original condition only by the trenching of modern rivers.

To us in Iowa the features of the broad trough and its vast economic consequences concerning our welfare are of first importance.

This great trough is not a simple flexing of strata on a large scale; but a bending of a section already affected by numberless foldings and faultings. It is, therefore, a true synclinorium, and, withal, one of the most typical known.

One of the most notable, as well as one of the most unexpected features connected with this synclinorium is the presence of a number of extensive dislocations. Two of these faults have displacement values of 125 and 350 feet respectively. The lines of fracture have a northeast and southwest direction—parallel to the axial trend of the Siouan and Ozark mountain ridges. These faults appear to be members of a system of sub-equally spaced stratigraphic breaks, 25 miles apart, that traverse nearly, if not quite, the entire width of the state. Since the presence of such a fault-system is foreshadowed indications of other notable faults are made known at the expected intervals. The recognition of these great faults in Iowa where they are wholly unlooked for, explains a host of anomalies concerning the areal distribution of the Paleozoics beneath the deep covering of till that have long puzzled Iowa geologists.

The geologic date of this regular spaced faulting is fixed by a number of circumstances. It appears to be Mid Tertiary, and hence coeval with the last uprising of the Ozark dome. This association of the two events is especially significant in that it immediately supplies an adequate reason for their presence at the points at which they are actually found. In eastern Missouri the orogenic strain seems to have been relieved mainly by a single dislocation; and the famous Cap au Grès fault which intersects the Mississippi river at the mouth of the Illinois river has a throw of more than 1,000 feet. The faulting is, of course, an event long subsequent to those of the Siouan and older Ozark mountain building. Both the latter and the production of the great synclinorium belong to Early Cretacic, or Comanchan time.

The later physiographic features of the region are also not without great interest. With the planing down of the mountains and the peneplanation of the entire region in Comanchan times the Mid Cretacic deposits were laid down over the old land area not only where they are found outcropping today, in northwestern Iowa and southeastern Missouri but they doubtless once extended unbrokenly over the whole country intervening. This surmise is substantiated by the recent discovery, in Mercer county, Missouri, far beyond the southernmost known extension of the Nishnabotana sandstone in Iowa, of undoubted ledges of typical Dakotan sandrock.

Below the floor of the Cretacic formation, the Comanchan baselevel, more than 2,000 feet of Late Carbonic sediments appear to have been removed from the Iowa area. This section includes besides about 200 feet of the Missourian series, 700 feet of the Oklahoman series, and 1,000 feet of the Cimarronian series.

To the downward bending of the rocks in the great tract between the Siouan and Ozark mountain regions we owe the preservation of our vast stores of mineral fuel. Were it not for this circumstance we would not have within the borders of our state a single workable deposit of coal. Our entire commonwealth would be as barren of coal as now are northeastern Iowa, northern Illinois, Wisconsin and Michigan—vast areas over which the productive coal measures without question originally extended, but which were removed during the prodigious denudation which took place over all this region during Comanchan times.

CONTRAPOSED SHORE-LINES ON STRAITS OF JUAN DU FUCA.

CHARLES KEYES.

(*Abstract.*)

Among the many novel geologic phenomena to which was directed the attention of those who took part in the trans-continental excursions of the Twelfth International Geological Congress, convened in Canada a year ago, were some remarkable examples of the exhuming of old and buried shores of the Pacific ocean in the vicinity of Puget Sound.

In late geological times there has been more or less constant rising and sinking of the coast. In a previous geographic cycle a very resistant igneous rock had been cut into by the waves so as to form a low sea-cliff. By subsequent slight sinking this cliff and shore were carried below tide-level, and covered by sands and gravels. Today, with marked coastal uprising, a new shore line is being developed, the old shore line being uncovered at the same time.

As a special term to express the idea of the development of this type of shore line, which is in every way analogous to the formation of the superposed river valley Clapp has proposed the title "Contraposed Shore-lines". On the borders of the straits of Juan du Fuca, which separate the island of Vancouver from the state of Washington the phenomenon is so clearly displayed that photographs show every characteristic.

THE PALEONTOLOGY AND STRATIGRAPHY OF THE UPPER CARBONIFEROUS OF IOWA.

GEO. L. SMITH.

The object of this paper is to give the results of field observation and paleontologic study of the Upper Carboniferous of southwestern Iowa, extending over several years, as opportunity offered. It has been necessary that portions of the adjacent states of Missouri and Nebraska be included in this investigation, to complete and confirm the results obtained by studies of the stratigraphy of Iowa. Good exposures of outcrops in Iowa are infrequent and widely scattered; correlations are therefore difficult to make without the information to be derived from the examination of outcrops in adjacent territory.

As the result of his investigation of the stratigraphy in this geological field, the writer has been convinced of the accuracy of the "General Section of the Strata Exposed on the Missouri River," by J. E. Todd in his paper "Some Varient Conclusions in Iowa Geology," published in "Proceedings of the Iowa Academy of Science," Vol. XIII, page 183. All the outcrops examined by the writer can be easily correlated with this general section. Todd's long familiarity with the geology in this field enables him to interpret correctly the stratigraphy of this portion of Iowa. This section is the type section with which all other sections will be compared.

As far as possible sections of natural outcrops will be given, correlated and combined with each other and the type section. These sections are selected from many others as the most adapted to give the true sequence of strata. They will be given, commencing with the lowest strata and following each other in order until the highest strata east of the Missouri river are included.

"GENERAL SECTION OF THE UPPER CARBONIFEROUS ROCKS OF IOWA."

J. E. TODD.

No.		Feet
16	Blue, red and ash-colored clays with two layers of limestone, two and four feet thick..........	19
15	Yellow micaceous sandstone.....................	10
14	Drab, ash, lead and chocolate-colored clays or shales with a thin limestone layer.............	39

13.	Limestone in thin layers, light yellow and gray..	12
12.	Shales, mostly gray, some red and blue, with five thin layers of limestone and four of sandstone	185
11.	Bluish limestone, interstratified with black shales and one foot of coal near center................	12
10.	Drab clays enclosing three strata of limestone, two to four feet thick	30
9.	Compact limestone, mostly thin bedded, and some layers stylolitic	20
8.	Blue clays, carbonaceous at two levels, and with two thin limestones	12
7.	Soft, fine-grained, yellow sandstone..............	12
6.	Clays and shales, bluish and gray, with three or four limestones, one much the thickest, sometimes seven feet thick......................	45
5.	Limestone, yellow and gray, with many Fusulina	20
4.	Clays, ash and red, with black shale in middle....	5
3.	Yellowish, soft sandstone	4
2.	Limestone, very fossiliferous	10
1.	Greenish and chocolate clays above, and shales below to level of Missouri river at Plattsmouth	25
	Total	460

Number eleven of the above includes the cap and bottom rocks of the Nodaway coal, and the limestone in number fourteen is the cap rock of the Nyman coal.

This series of strata has been divided into different formations by the Iowa Geological Survey as follows, commencing with the uppermost:

McKissick's Grove shales.
Tarkio limestone.
City Bluffs shale.
Braddyville beds.
Forbes limestone.
Platte shales.
Plattsmouth limestone.
Andrew shales.

COMPOSITE SECTION OF THE OUTCROPS RECORDED IN THIS REPORT.

	Feet	Nos. of Todd's Section
McKissick's Grove shales.............	80	14, 15, 16
Tarkio limestones	12	13
City Bluffs shale.....................	200	12
Nodaway coal	1½	*11
Braddyville beds	45	10
Forbes limestone	20	9
Platte shales	70	6, 7, 8
Plattsmouth limestone	20	5
Total	448½	

*Includes cap and bottom rocks.

All the following outcrops have been examined by the writer, and most of them in company with the late Doctor Calvin. They will be given in the order most favorable for explaining the relations of the different outcrops.

OUTCROP EXPOSURE AT ROCK BLUFF, NEBRASKA.

No.		Feet
14.	Yellow limestone; Forbes	15
13.	Yellow shale	1½
12.	Gray limestone	1
11.	Shale, carbonaceous	2
10.	Gray limestone	2
9.	Concealed	30
8.	Limestone, gray	3
7.	Concealed	10
6.	Limestone, disintegrated	5
5.	Limestone, gray	1
4.	Shale, blue, weathered	8
3.	Limestone, chips, weathered	5
2.	Shale with bands of limestone, weathered	10
1.	Limestone, yellow and gray; Plattsmouth	20
	Total	113½

This is the only known outcrop showing the full thickness of Platte shales. It is not in good condition at the present time, as much of it is concealed by slides and talus.

WILSON SECTION, TWO MILES NORTH OF THURMAN, IOWA.

No.		Feet
26.	Shale, black	1
25.	Limestone, with a shale	2½
24.	Shale, yellow	1¼
23.	Shale, black	1¾
22.	Shale, gray, calcareous	1½
21.	Shale, black	1
20.	Shale, gray, calcareous	1½
19.	Coal, Nodaway	1
18.	Shale, blue	2
17.	Limestone, blue	4
16.	Shale, gray, calcareous	6
15.	Limestone, gray	4
14.	Shale, gray	6
13.	Limestone, blue	1½
12.	Shale, gray, calcareous	4
11.	Limestone, yellow, cherty	2½
10.	Shale, gray	3
9.	Limestone, gray	1
8.	Shale, yellow	2
7.	Limestone, gray, in four benches; Forbes	21
6.	Shale, carbonaceous	2½
5.	Limestone	¾
4.	Shale, carbonaceous	2½
3.	Limestone, blue	2
2.	Shale, blue	4
1.	Sandstone, micaceous	1
	Total	83½

This is the only known locality in the state of Iowa, where a complete section of the Braddyville beds is shown in outcrop. It includes numbers eight to eighteen, inclusive, in this section.

At the present time the base of the outcrop is concealed by talus, and the section given above is that described by Chas. A. White in Iowa Geological Survey Report of 1870, slightly modified.

COMPOSITE SECTION OF OUTCROPS IN THE VICINITY OF STENNETT, IOWA.

No.		Feet
12.	Limestone, residual	5½
11.	Shale, gray, calcareous	½
10.	Limestone, gray	1¾
9.	Shale, gray, argillaceous	3½
8.	Limestone, variable	5
7.	Shale, yellow	1
6.	Limestone, blue, cherty	6
5.	Shale, parting	
4.	Limestone, variable	5
3.	Shale, argillaceous	1½
2.	Shale, carbonaceous	3
1.	Limestone, shaly	2
	Total	34¾

The Forbes limestone is represented by numbers four to eight, inclusive. The carbonaceous shale number two is universally present, underlying this limestone, and has been prospected for coal both at Wilson section and near Stennett.

The Missouri Geological Survey has correlated the Forbes limestone with the Deer Creek limestone of Kansas, and uses this term for the Forbes limestone. As the Iowa outcrops of this limestone are upwards of one hundred miles distant from the type section of the Forbes limestone, it is by no means certain they represent the same horizon. Under these circumstances, the Missouri Geological Survey having abandoned the use of the term Forbes, it is proposed that this limestone be named the Stennett limestone. Until the different formations of Iowa have been actually traced in the field to those of Kansas, it is preferable that they be designated by local names rather than by those of formations several hundred miles distant.

The City Bluffs beds of Broadhead are situated two miles northwest of Burlington Junction, Missouri.

SECTION AT WEST END OF BRIDGE OVER NODAWAY RIVER.

No.		Feet
16.	Sandstone, ferruginous	1
15.	Shale, blue	10
14.	Shale, yellow, concretionary	2
13.	Shale, blue	3
12.	Shale, yellow, concretionary	1½
11.	Shale, blue	1
10.	Sandstone, ferruginous	½
9.	Shale, arenaceous, septaria	10
8.	Sandstone, ferruginous	2
7.	Limestone and sandy shale in alternate layers	5
6.	Shale, gray, many septaria	30
5.	Shale, dark blue	25
4.	Shale, below level of water in river	30
3.	Limestone, cap rock	2
2.	Shale	4
1.	Coal, Nodaway	1½
	Total	128½

The forty-seven feet of strata in numbers six to nine, inclusive, comprise the septarian zone of the City Bluffs shales. Some of these septaria reach a diameter of two feet. This outcrop is the City Bluffs beds described and named by Garland C. Broadhead in the Missouri Geological Report of 1872.

COMPOSITE SECTION OF DIFFERENT OUTCROPS SOUTH OF THE I. O. O. F. CEMETERY, NEAR ELMO, MISSOURI.

No.		Feet
8.	Shale, gray, weathered yellow	25
7.	Limestone, blue, weathered yellow, cap rock	1
6.	Shale	½
5.	Coal, Elmo	1
4.	Underclay	½
3.	Shale, weathered yellow	13
2.	Shale, yellow, with nodules of impure limestone	2
1.	Shale, weathered yellow, with many large septaria	15
	Total	58

Number one is the upper member of the septarian zone of the City Bluffs shale. The coal, number five, has been named the Elmo coal by the Missouri Geological Survey. It is an irregular coal, only rarely present, and has long been known in Iowa, being first described by E. H. Lonsdale in the Montgomery County Report of 1894.

COMPOSITE SECTION OF DIFFERENT OUTCROPS ON TARKIO CREEK, PAGE COUNTY, IOWA.

No.		Feet
11.	Limêstone, yellow, cap rock	3
10.	Coal, Nyman	1
9.	Shale, variable	30
8.	Limestone, yellow	1

7.	Shale, gray, calcareous	3
6.	Limestone, blue, weathered yellow and brown	2
5.	Shale, blue	12
4.	Limestone, gray	2
3.	Shale, gray, calcareous	3½
2.	Limestone, gray	2
1.	Shale, blue, with thin layers of sandstone	35
	Total	94

The lower limestones, numbers two and four, are not constant as they often grade into a very calcareous shale. Numbers six to eight, inclusive, are the Tarkio limestone. The lower limestones with the interbedded shale should be included in the City Bluffs shale. This section does not reach down to the upper shale, exposed in the outcrop on the wagon road south of the cemetery near Elmo, leaving a hiatus of probably not to exceed twenty feet, not known in outcrop in Iowa or Missouri. As shown by outcrops and drillings the thickness of the City Bluffs shale is one hundred and eighty to two hundred feet.

SECTION AT WEST END OF RAILROAD BRIDGE OVER THE MISSOURI RIVER AT NEBRASKA CITY, NEBRASKA.

No.		Feet
12.	Thin bedded limestone with shale partings	4
11.	Sandstone, yellow, micaceous	4
10.	Shale, blue	5
9.	Limestone, gray, single layer, thickens to the south, Nyman coal cap rock	2
8.	Shale, coaly, black, Nyman	¼
7.	Shale, blue, arenaceous, and micaceous in places	40
6.	Limestone, yellow	2
5.	Shale, weathered	6
4.	Limestone, yellow	1
3.	Shale, weathered	1
2.	Limestone, yellow, in two layers	1
1.	Shale	5
	Total	71¼

This outcrop is one mile below the Nebraska City landing section described by Fielding B. Meek over forty years ago. Numbers two to six, inclusive, are the Tarkio limestone. This section is nearly the same as that on Tarkio creek, but in addition it reaches higher in the General Section of Todd.

SECTION IN FIRST RAVINE SOUTH OF ROSE BRANCH, NORTHWEST OF ROCKPORT, MISSOURI.

No.		Feet
11.	Shale, red	5
10.	Sandstone, brown, micaceous, irregularly bedded	10
9.	Shales and sandstone with one foot of limestone in upper part	35

8.	Limestone, yellow	1
7.	Limestone, shaly	3
6.	Limestone, blue	1¼
5.	Coal, shaly; Nyman	¼
4.	Shale, arenaceous	24
3.	Limestone, gray	1½
2.	Shale, calcareous	1½
1.	Limestone, brown	4
	Total	86½

This outcrop includes in its higher members the latest strata found in the Carboniferous in the states of Iowa and Missouri.

The Tarkio limestone includes one to three, and the McKissicks Grove shale comprises all the section above this limestone. The different outcrops, sections of which have been given, are the best and most extensive known and show a nearly complete succession of strata from the Plattsmouth limestones to the uppermost of the Carboniferous east of the Missouri river.

PALEONTOLOGY.

Nearly all the fossils listed were obtained at the mine dumps at Coin and New Market, and at different outcrops on Tarkio creek in Page county, Iowa. The under shale of the Nodaway coal is included, its fauna being in fact part of that of the Nodaway coal. In the mines this shale is excavated to a depth of about two feet in constructing the entries. The coal is underlain directly by a gray shale, no under clay being present. All material excavated in sinking shafts and mining operations is promiscuously dumped and it is impossible to discriminate closely between horizons. An attempt is made to give the fauna and flora of the roof and under shales of the Nodaway coal. It is a matter of regret that the cap rock of the Nodaway coal cannot be included, but this is not practicable as this limestone is very seldom seen in outcrop and is inaccessible in the mines. Paleontologic studies of other formations in southwestern Iowa are in progress and the result of such investigation will be given in a future paper. As a whole the characteristic of the fauna is the predominance of the Molluscoida, while the Pelecypoda are but meagerly represented. The limestone and the calcareous shales are usually prolific in fossils, but the blue shales and the sandstones are well nigh barren. While by far the greater part of the different species range throughout the whole series of strata there is a certain expression of the fauna that enables a close approximation to be made of the different horizons.

Although the study of the Bryozoa has been difficult and unsatisfactory it is believed all precise correlation must be done by a close discrimination of the different species of the Bryozoa and their horizons. There has been great difficulty in identifying the smaller Productidae. Although several hundred ventral valves of Marginifera, *Productus longispina* and *P. muricatus,* have been examined, but few detached dorsal valves have been found, and none of these show the submarginal ridge that characterizes the genus Marginifera. A small brachiopod that is especially difficult to identify is found in the City Bluffs shale and the Tarkio limestone. At first sight it appears to be a Strophalosia. However, it is without a cardinal area and has no attachment scar on the ventral valve, which definitely removes it from the genus Strophalosia. It is probably an undescribed species of Productus. The feature most evident in the fauna of the Tarkio limestone is the great abundance of the different species of Myalina to be found in this limestone.

At Coin the outstanding feature of the City Bluffs fauna is the abundance of Bellerophon, Chonetes, and Spiriferina present. At New Market in this same shale the species most frequent are Marginifera, *Productus muricatus,* and *Orthothetes crassa.* Bryozoa are far more abundant at Coin than at New Market. The most common fossils of the roof and under shales of the Nodaway coal are *Euomphalus catilloides* and a small variety of *Orthothetes crassa.* In the City Bluffs shale are found specimens of the marine plant, *Conostychus ornatus,* identification by Calvin. Moreover a few specimens of *C. broadheadi* have been positively identified. It is a surprise that these algae should be found so high in the Carboniferous when they were originally described as found at the very base of the Coal Measures of Missouri. The gymnosperm *Carpolithes granulosa* is found in great abundance in the City Bluffs shale, both at Coin and at New Market. As this shale is a marine deposit plant remains are rarely found in it. The only plant remains so far found are Conostychus, Carpolithes, and Neuropteris.

The calcareous shales and partings in the limestones carry an abundance of Bryozoa. Detached stem fragments of crinoids are abundant in all the different strata except the sandstones. Several indeterminata have been found which are under further study. Grabau and Shimer, "North American Index Fossils," has been the principal authority used in the identification of the fauna and in terminology.

TARKIO LIMESTONE.

FAUNA.

Foraminifera—
- Fusulina secalica.

Bryozoa—
- Rhombopora lepidodendroides.

Brachiopoda—
- Ambocelia planoconvexa.
- Chonetes glaber.
- Chonetes granulifer.
- Chonetes verneuilana.
- Enteletes hemiplicata.
- Meekella striatocostata.
- Productus cora.
- Productus costatus.
- Productus nebrascensis.
- Productus pertenuis.
- Productus semireticulatus.
- Pugnax utah.
- Seminula argentea.
- Spirifer cameratus.
- Spiriferina kentuckiensis.

Pelecypoda—
- Allorisma terminale.
- Aviculopecten white.
- Myalina kansasensis.
- Myalina subquadrata.
- Myalina swallovi.

Gastropoda—
- Bellerophon pericarinatus.
- Bucanopsis montfortiana.
- Naticopsis altonensis.
- Orthonema subœniatum.
- Phanerotrema grayvillensis.
- Platyceras parvum.

Cephalopoda—
- Orthoceras rushense.

Trilobita—
- Phillipsia major.

CITY BLUFFS SHALE.

FAUNA.

Foraminifera—
- Fusulina secalica.

Anthozoa—
- Lophophyllum profundum.
- Lophophyllum westi.

Crinoidea—
- Ceriocrinus hemisphericus.
- Erisocrinus typus.
- Eupachycrinus tuberculatus.
- Hydreionocrinus acanthroporus.
- Hydreionocrinus mucrospinus.

Vermes—
- Serpula insista.

Bryozoa—
- Fenestella perelegans.
- Fistulipora nodulifera.
- Pinnatopora trilineata.
- Polypora crassa.
- Polypora elliptica.
- Polypora submarginata.
- Rhombopora lepidodendroides.
- Septopora biserialis.
- Stenopora carbonaria.

Brachiopoda—
- Ambocelia planoconvexa.
- Chonetes glaber.
- Chonetes granulifer.
- Chonetes variolatus.
- Dielasma bovidens.
- Enteletes hemiplicata.
- Hustedia mormoni.
- Marginifera (Productus) longispina.
- Marginifera (Productus) muricatus.
- Meekella striatocostata.

Orthothetes crassa.
Productus cora.
Productus costatus.
Productus nebrascensis.
Productus pertenuis.
Productus punctatus.
Productus semireticulatus.
Pugnax utah.
Rhipodomella pecosi.
Seminula argentea.
Spirifer cameratus.
Spiriferina kentuckiensis.

Pelecypoda—
Allorisma terminale.
Allorisma granosum.
Aviculopinna peracuta.
Aviculopecten occidentalis.
Aviculopecten whitei.
Edmondia nebrascensis.
Myalina peratenuata.
Myalina subquadrata.
Myalina swallovi.
Nucula ventricosa.
Leda bellistriata.

Gastropoda—
Bellerophon percarinatus.
Bucanopsis montfortiana.
Euomphalus catilloides.
Euphemus carbonarius.
Phanerotrema grayvillensis.
Soleniscus brevis.
Soleniscus paludinæformis.
Worthenia tabulata.

Cephalopoda—
Orthoceras rushense.
Tainoceras occidentale.

Trilobita—
Griffithides scitula.

Vertebrata—
Pisces.
Agassizodus variabilis.
Peripristis semicircularis.

Flora.

Algæ—
Conostychus broadheadi.
Conostychus ornatus.

Pteridophyta—
Neuopteris scheuchzeri.

Cordaitales—
Carpolithes granularis.

NODAWAY COAL: ROOF AND UNDER SHALES.

Fauna.

Anthozoa—
Lophophyllum profundum.

Bryozoa—
Rhombopora lepidodendroides.

Brachiopoda—
Ambocoelia planoconvexa.
Chonetes granulifer.
Orthothetes crassa.
Marginifera (Productus) longispina.
Productus pertenuis.
Seminula argentea.
Spiriferina kentuckiensis.

Gastropoda—
Bellerophon percarinatus.
Euomphalus calliloides.
Euphemus carbonarius.
Phanerotrema grayvillensis.

Flora.

Pteridophyta—
Alethopteris grandini.
Annularia sphenophylloides.
Asterophyllites equisetiformis.
Calamites suckowii.
Neuopteris ovata.
Neuopteris scheuchzeri.
Pecopteris cyathea.

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SHENANDOAH.

THE LOESS OF PECZEL, HUNGARY.

B. SHIMEK.

Péczel is located a half-hour's ride by rail east of Budapest. Extensive exposures have been made east of the town in a brick-yard lying just north of the railway. For two hundred yards interrupted exposures face the railway. Eastward the line of exposures sweeps around the end of a ridge, and is continued northward, on the north side of a narrow valley, along the side of an upland which borders another valley extending in a northerly direction. The entire region lies south of the southern boundary of the European drift sheets.

Practically all the sections show two very distinct deposits: a lower stratified deposit which is evidently aqueous in origin; and an upper aeolian loess.

THE STRATIFIED SECTION.

This is regularly horizontally stratified, and consists of alternating bands of silt and sand, the latter with small pebbles in some places. There is little or no cross-bedding, and the deposit appears to have been formed in rather slack water. It is marked *b* in figures 1 and 2 of Plate XXXI.

The prevailing color is yellow, but there are frequent darker bluish or brown bands, and the upper part, along the line of contact with the loess, is commonly strongly oxidized. Occasional horizontal oxidized lines also appear in the body of the deposit.

The greater part of this deposit contains only a few scattered fragments of the shells of mollusks, but at one point, near the eastern extremity of the cut which is represented in figure 1, a larger number of shells was discovered. This was at and near the point marked *c* in figure 1. The lower portion of this part of the bank contains sand which appears to be more or less in pockets. The species which were found in this sandy portion are checked in the first column of the table of mollusks which is here presented. The upper part of the stratified portion at *c* consists largely of silt which seems to be formed chiefly of loess materials. This also contained some shells, and these are marked in the second column of the table. As this part of the exposure is near the end of the bank it is possible that there has been a shifting of a part of the materials at this point since the main deposit was formed. However, at least fragments of several of the species given in the table are scattered throughout this stratified member of the series.

It will be noticed that *Lymnaea truncatula* and *Valvata piscinalis* are aquatic, while the remaining species are terrestrial, though *Vertigo pygmaea* and the larger species of *Succinea* are found usually in very wet places. This deposit was evidently formed in water, but adjacent to bodies of land on which the rather numerous land shells developed.

THE LOESS SECTION.

The prevailing loess is yellow, and in its physical characters closely resembles the heavier yellow loess which is common in Iowa. It is sometimes streaked with bluish gray, especially in its lower part, and usually shows the horizontal cleavage and the disposition to break into vertical columns which mark our own loess. It is also more or less fossiliferous, and contains a few calcareous nodules. In the Péczel sections this loess is not exposed to a greater depth than fifteen feet, but it probably is somewhat thicker. The sections *a* in figures 1 and 2 show yellow loess only, and this rests directly upon the stratified layer below. Fossils seem to be scattered throughout the yellow loess, but by no means uniformly. The species from two of the sections of yellow loess are checked in columns 3 and 4 of the table of mollusks. All are terrestrial.

A lower gray loess, very similar to that which is found at many points in Iowa and other parts of the Mississippi valley, is also found in the Péczel exposures, and must be quite widely distributed as specimens of it in the museum of the Geological Institute at Budapest show. At Péczel the best exposure is that which lies immediately south of that figured in Plate XXXI, figure 1. It is on the opposite side of a narrow ridge from the latter, and faces south. In this exposure the upper yellow loess is exposed to a depth of seven to eight feet, and below it four to five feet of gray loess appear. This closely resembles the gray (or bluish gray) loess of Iowa in color and texture, in its oxidized root lines, and in its wholly terrestrial fossils. The latter are checked in the fifth column of the table of mollusks.

Usually the yellow and gray loesses are quite sharply separated, but at some points they intergrade within a band a few inches in width. It is significant that they occupy the same relative position as our yellow and gray loesses, the gray being the lower, and evidently the older. Indeed, the resemblance of these two loesses to our own is very striking throughout.

In the following table of mollusks the columns are numbered as follows:

1. Shells from the sandy part of the exposure shown in figure 1 at *c*.
2. Shells from the upper fine silt near *c*.
3. Shells from the first cut at the Péczel end of the series. These are from yellow loess.
4. Shells from the yellow loess of the cut south of the one shown in Plate XXXI, figure 1.
5. Shells from the lower gray loess in the same cut.
6. Modern habitats of the species.

TABLE OF MOLLUSCA.

	1	2	3	4	5	6
Helix arbustorum L....	+	+	+	+	+	Woods, etc.
Hygromia hispida L....	+	+	+	+	+	Woods, etc.
Vallonia costata Muell..	+	+	+	+		In grass, under stones, etc.
Vallonia tenuilabris A. Br.	+	+	+			
Patula ruderata Stud...	+		+			Under stones, bark, etc.
Helicella candidula Studer	+					Dry, grassy slopes.
Vitrea hammonis (Ström.) Pils.......	+		+			Woods, meadows, banks.
Vitrea crystallina (Muell.)	+					Woods, under leaves, etc.
Euconulus fulvus (Drap.) Reinh.......	+	+	+	+		Woods, under leaves, etc.
Cochlicopa lubrica (Muell.) Fer.........	+			+		Under stones, etc.
Cochlicopa lubrica exigua Mke............	+		+		+	Rocky woods, etc.
Chondrula tridens (Muell.)	+	+	+			Grassy slopes, brush, etc.
Clausilia dubia carpatica Drap.	+	+		+		Woods, under leaves, etc.
Clausilia sp............		+				
Pupa muscorum Muell..	+	+	+			Under stones, etc., dry slopes.
Pupa frumentum Drap..	+		+			Grassy slopes.
Vertigo pygmæa Drap...	+					Moist meadows, etc.

TABLE OF MOLLUSCA—Continued

	1	2	3	4	5	6
Vertigo sp............	+					
Sphyradium edentulum (Drap.) Sterki......	+	+				Woods, under leaves, etc.
Succinea oblonga Pfr...	+	+	+	+	+	Under wood, etc., often in dry places.
Succinea putris L......	+	+		+	+	Damp woods, meadows, etc.
Succinea pfeifferi Rossm.	+				+	Low, wet places.
Lymnæa truncatula Muell.	+					Small streams and stagnant waters.
Valvata piscinalis Muell.	+	+				Small streams and ponds.

All of these species now live in the same general region.

EXPLANATION OF PLATE XXXI.

Fig. 1. Cut in brickyard at Peczel, Hungary, showing the following:
- *a.* Yellow loess, resting unconformably on *b*; 12-15 feet.
- *b.* Horizontally stratified deposit consisting of alternating bands of silt and sand with small pebbles.
- *c.* The portion of *b* in which the largest number of shells was found, chiefly in sand pockets.
- *x-x.* The line between *a* and *b*.

Fig. 2. Cut east of the preceding:
- *a.* Yellow loess; 8-12 feet.
- *b.* Silt and sand, horizontally stratified, containing fragments of shells.

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State University of Iowa.

Fig. 1.

Fig. 2.

A NEW CRINOID FAUNA FROM MONTÍCELLO, IOWA.

A. O. THOMAS.

The purpose of this paper is two-fold: first, to bring briefly before the members of the Academy the story of the discovery and a general description of an interesting but little known crinoid or sea-lily found some years ago near Monticello, and second, to call attention in a few words to some new inadunate crinoids recently collected by the writer in an outcrop of Silurian rocks at the same locality.

The first-mentioned crinoid is the wonderful petal-crinoid, *Petalocrinus mirabilis* Weller, and is the most remarkable member of this new fauna. It was first collected near Monticello, Jones county, by Mrs. A. D. Davidson and was named and described by Professor Stuart Weller[1] of the University of Chicago. Two years later Dr. F. A. Bather[2] of the British Museum, London, published a most exhaustive and excellent paper on the same crinoid and its relatives.

Petalocrinus instead of having arms with free branches has all the divisions of each arm united into a solid fan-shaped piece. The calyx is depressed globular in shape and is about the size of a small slightly flattened pea; its plates are minute and firmly joined together. In life it was united below to a slender, jointed stem perhaps several inches in length and this was fastened by its lower end to the sea bottom. The five arm-fans, when attached, form a circle around the calyx at the same level near its top. On their upper or ventral surfaces the fans are ridged and grooved while their lower surfaces are smooth. Since the fans are curved dorsally or downwards instead of being flat a complete specimen may be likened somewhat to a tiny umbrella with the stem for its handle or perhaps to a small rose with five drooping petals.

In the fossil state the arm-fans are usually detached and scattered and may be found highly silicified and adhering firmly to masses of fossiliferous chert scattered over the nearly driftless, thin-soiled hills of the region. Mrs. Davidson and also Dr.

[1]Jour. Geol., Vol. iv, (1896) pp. 166-173.
[2]Quart. Jour. Geol. Soc. London, Vol. 54 (1898), pp. 401-441.

Weller found not only detached arms but also a few specimens in which the five arm-fans are still attached to the calyx. Two or three years later, in 1899, the late Professor Samuel Calvin found a very fine specimen retaining the arm-fans; this at present is the most perfect specimen in the University collection.

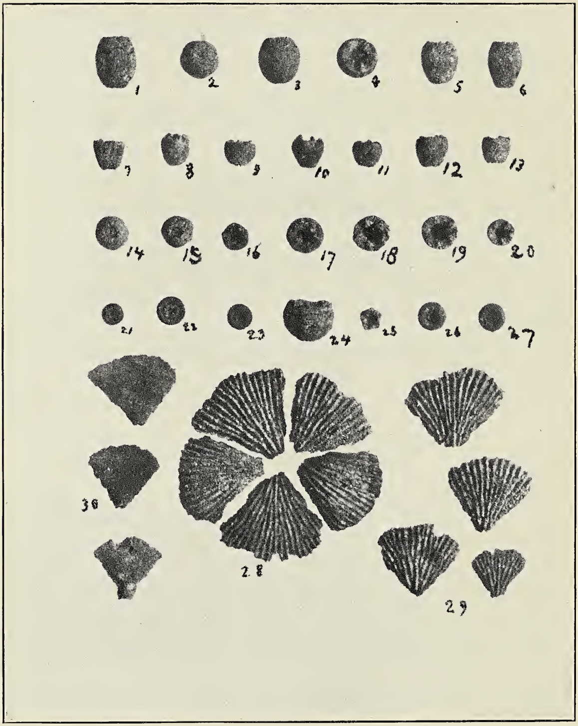
The description of the complete crinoid by Weller gave Bather a clue to some similar arm-fans which had been collected in the Silurian on the island of Gotland in the Baltic Sea and which are in the Riksmuseum at Stockholm, Sweden. The Gotland arm-fans, together with a part of the Weller-Davidson collection and other material from Jones county, as well as a single arm-fan from St. Paul, Indiana, furnished the basis for Bather's paper cited above. From this material six species were described; three from Gotland, two, including Weller's species, from Jones county, and one from Indiana. It is interesting to note that only at these widely separated localities have specimens of Petalocrinus ever been found.

Several other fossils associated with Petalocrinus in Iowa are associated also with its relatives in Gotland. That the shore line along which this fauna lived and migrated in Silurian times was continuous from the Baltic across the present Atlantic to Iowa is very probable.

It was while searching for specimens of Petalocrinus that the writer came upon a small area of residual soil unusually rich in fossils. In origin the soil is the "product of secular rock decay" as expressed by Calvin[3] who has written an excellent description of the fossiliferous geest of Jones county. This particular stony plot, its lean soil filled with chips and nodules of chert, proved a collector's bonanza. Weathered-out corals, brachiopods, crinoids, and other forms were common. The region, as far as known, had never yielded an arm-fan of Petalocrinus free from the stony matrix, but here scores of them lay on the surface, many of them practically perfect.

The finding of so many weathered-out arm-fans inspired the hope that by close search some of the calyces might be secured and though none were found the search was not in vain for in all some thirty or forty dorsal cups of other small crinoids were obtained. They are well preserved although silicification has largely obscured the sutures between the plates; fortunately, a few individuals preserve these diagnostic features quite well.

[3]Iowa Geol. Surv., Vol. v (1895), pp. 62, 63.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They belong chiefly to the genus Pisocrinus, the pea crinoid. This genus has not been reported before from the Silurian of Iowa but it is significant that it is abundantly represented in the Silurian fauna of Gotland[4] and also in the Silurian at St. Paul and vicinity, Indiana.[5] It will be recalled that these are the only localities, except at Monticello, where Petalocrinus has been found. The finding of Petalocrinus and Pisocrinus together in Iowa is only what reasonably might have been expected.

It is quite likely when this new material has been studied carefully and some comparisons have been made that other genera will be recognized and that some of them will include more than one species. The writer hopes to have ready for publication soon a detailed description of the species represented in the new material. A photograph of some of the specimens found is appended to this paper but complete identification has not been attempted.

PLATE XXXII.

NEW CRINOIDS FROM MONTICELLO.

Figures are Natural Size.

Figs. 1-5. Several views of an oval, cask-shaped species.
Fig. 6. Quite similar to numbers 1 to 5, but pyriform.
Figs. 7-13. Side views of several individuals of the genus Pisocrinus.
Figs. 14, 15. Basal view of Pisocrinus sp.
Figs. 16-20. Cups of Pisocrinus sp., seen from above.
Figs. 21-23, 26, 27. Segments of a small stem.
Fig. 24. Side view of a broad, bowl-shaped cup; probably Pisocrinus.
Fig. 25, A small pentangular cup seen from above.
Fig. 28. *Petalocrinus mirabilis* Weller. Ventral view of five arm-fans, from different individuals, arranged in a relation similar to that which they retained in life.
Fig. 29. Four fans of Petalocrinus, ventral aspect, showing different sizes.
Fig. 30. Three fans of Petalocrinus, dorsal aspect, showing the smooth surfaces.

[4]F. A. Bather. The Crinoidea of Gotland. Part I, the Crinoidea Inadunata (1893), pp. 22-35.
[5]C. S. Beachler, Amer. Geol., Vol. 7 (1891), p. 178.

SOME UNIQUE NIAGARAN CEPHALOPODS.

A. O. THOMAS.

Among the paleontological collections at the State University of Iowa are some unique cephalopod remains. It is the purpose of this paper to call attention to a few of them and it is hoped that at some later time the rich Niagaran fauna of which these are a part shall receive more extensive treatment.

The specimens at hand consist chiefly of the siphuncles of several orthoceracone species. They are of the nummuloidal type and are usually strongly silicified. They occur at nearly all horizons in the Niagaran but most frequently in the Hopkinton or Delaware stage. Specimens are never abundant.

The beautiful and rare pearly nautilus of our modern seas is the nearest living relative of these extinct species. From our study of zoology it will be recalled that the coiled shell of the nautilus is divided by transverse partitions (the septa) into chambers. The septa are concave, their concave surfaces facing the opening or aperture of the shell. The animal lives in the body chamber, a cuplike cavity above the last septum. An extension of the body, known as the siphon, passes backward from the body chamber through perforations in the septa. In the modern nautilus the perforation in the last septum is but a millimeter or two in diameter and becomes gradually smaller as it is traced back through earlier and earlier septa. On the convex or posterior surface of each septum the shell substance is built out into a short tube around the siphonal perforation. This series of disconnected tubes is called the siphuncle. In the modern nautilus each segment of it extends only about one-third the distance across the air chamber into which it projects.

The Niagaran cephalopods which are here considered were straight-shelled tapering forms much as our coiled pearly nautilus would make were it possible to uncoil it into the form of a straight cone. Curved, loosely coiled, and even closely coiled species were contemporaries of the straight-shelled ones but a few of the straight species only will be discussed in this paper.

The slender discontinuous siphuncle of the pearly nautilus is but a vestige of the large continuous siphuncle of its extinct Niagaran ancestors. Moreover, it is quite likely that the siphon occupying the large siphuncle of the Niagaran cephalopod played a far more important function in the life of the animal than does the slender remnant in the nautilus, the real function of whose siphon is not known with certainty.

Fragments of these large siphuncles constitute the chief part of the record left by the straight nautiloids which thrived in the Niagaran seas of east-central Iowa. In rare cases a part of the shell and a few of the septa have been preserved with the siphuncle; more commonly it is a cast of the shell that is found. Such specimens show the relation of the siphuncle to the shell and septa but several of the species are known only from a few segments of the siphuncle alone. The occurrence of such remains in Iowa has been noted by Calvin[1] in the Dubuque and in the Delaware county reports and also by Savage[2] in the Jackson county report. Some of the specimens described in this article were doubtless collected during the prosecution of the field work in the counties named.

A paleogeographic map[3] of North America during the Niagaran epoch shows that the rocks of this age in Iowa are but a part of a series of disconnected outcrops extending east into Illinois then north along the west shore of Lake Michigan then east again in the upper peninsula of Michigan and across the north end of Lake Huron into Ontario and on into New York.

The Niagaran outcrops just pointed out have yielded several species of these interesting cephalopods and they have been known to scientists for nearly a century. As early as 1823, Dr. John J. Bigsby read before the Geological Society of London a paper entitled "Notes on the Geography and Geology of Lake Huron."[4] This paper, published the following year at London, contains a description and figures of several species of straight-shelled cephalopods from Drummond and Thessalon islands in the north end of the lake. Of one genus Bigsby had only the siphuncles and it is not surprising that their actiniform lamellae led him to describe them as species of corals having "in their general appearance a considerable resemblance to vertebrae". Mr. Charles Stokes, a fellow of the Geological Society, undertook to name the supposed corals for Bigsby. He gave then the

[1]Iowa Geol. Surv., Vol. X, p. 454, also Vol. VIII, pp. 152 and 158.
[2]Iowa Geol. Surv., Vol. XVI, p. 616.
[3]See Chamberlin and Salisbury, "Introductory Geology," 1914, p. 390 or Charles Schuchert, "Paleogeography of North America," Bull. G. S. A., 1910, Plate 67.
[4]Trans. Geol. Soc. London, second series, Vol. i, pt. ii, pp. 175-209, Plates xxv, xxvi, xxviii, xxx.

generic name, Huronia, and assigned specific names to the five species which Bigsby had separated on "variations of external form". Stokes recognized the other cephalopods in Bigsby's paper as "Orthocerae", but no names were suggested.

It may be of interest at this point to recall that Drummond Island was formerly the site of a British garrison and fossil remains were first collected there by a Mr. White of the Army Medical Staff. By the treaty of Ghent the island was ceded to the United States and the British garrison was withdrawn. Dr. Bigsby, an ardent Englishman, laments in his paper, page 202, that "as it will not be held as a military post by its present owners, it will be long, probably, ere its fossils again become the object of research." Fourteen years, however, after the reading of Bigsby's paper, Stokes read an article before the same society "On some Species of Orthocerata"[5] in which he corrected his former view as to the coral nature of Huronia and interpreted the fossils as the siphuncles of orthoceracones.

It would extend this paper to an unwarranted length were the writer to mention, even briefly, the work of later geologists and paleontologists who have contributed to our knowledge of the Niagaran cephalopods. Reference will be made to a few of them in the descriptions which follow but no attempt will be made to give a complete bibliography of each species.

For the sake of taxonomic clearness it may be stated here that Hyatt[6] makes Huronia a sub-genus of Actinoceras while Eastman in the second edition of Zittel's Textbook of Paleontology, 1913, page 609, treats it as a genus of equal rank with Actinoceras in the family Actinoceratidae. The latter will be followed in this paper.

DESCRIPTION OF SPECIES.

Huronia vertebralis Stokes.

Plate XXXIII, figure 1; Plate XXXIV, figure 5.

1824. *Huronia vertebralis* Stokes. Trans. Geol. Soc. London, second series, Vol. i, pt. ii, p. 202, Pl. xxviii, fig. 2.

1851. *Huronia vertebralis* Hall. Rept. on the Geol, of the Lake Superior Land Dist., by Foster and Whitney, part ii, p. 221, Pl. xxxiv, fig. 1.

1857. *Orthoceras canadense* Billings. Rept. of Progr. Geol. Surv., Canada, p. 321.

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[5]Trans. Geol. Soc. London, second series, Vol. v, pt. iii, pp. 705-714, Pls. lix, lx.

[6]Proc. Boston Soc. Nat. Hist., Vol. xxii, 1884.

Shell straight, gradually tapering, slightly elliptical in transverse section. Surface of the shell and character of the septa not preserved in the material at hand.

Siphuncle smooth, conspicuously segmented, sub-central in position, and round in cross-section. Each joint or segment fits down a short distance into the swollen and deflected summit of the one next older; the proximal edge of the septum passed between this expanded top and the contracted base of the joint above; the groove for its reception is very narrow and it extends inward for a distance of about one-fifth the radius of the segment's base. Fragments of the septa still remaining in the grooves are very thin. The plane of contact between two segments is more or less oblique to the longitudinal axis of the siphuncle; the amount of obliquity depends on the eccentricity of the siphuncle,—in the specimens at hand the large siphuncular fragments show the greatest obliquity.

Endosiphuncle central, its diameter about one-sixth that of the smaller end of the segment; in some of the specimens it is open and in others filled with foreign matter. Between the endosiphuncle and the inner surface of the segments radiate vertical lamellae which in cross-section resemble the septa of some cyathophylloid coral. At the constrictions between the segments the lamellae seem to be replaced by short cylindrical rings arranged concentrically between the endosiphuncle and the base of the septal groove.

Measurements: specimen (a) diameter, greatest, 33 mm., least, 26 mm.; length, 31 mm.; obliquity, 97°.

Specimen (b) three successive segments; diameter, greatest, 30.2, 29.9, 27.0 mm.; least, 26.0, 25.2, 25.0 mm.; length, 25 mm. each; obliquity 92°.

Specimen (c), four successive segments; diameter, greatest, 20.1, 20.1, 19.0, 18.5 mm.; least, 17.3, 16.5, 16.0, 15.2 mm.; length, 16.0, 16.0, 15.5, 15.2 mm.; obliquity, 92°.

One very fine specimen in the university museum lies in a slab of cherty dolomite; only a cast of the shell remains, while dolomitization has entirely effaced all traces of the septa. On being removed from the quarry the slab was broken in such a way as to show the siphuncle in its relation to the original shell or conch. Seventeen segments are present. The specimen is ninety millimeters in diameter at the larger end and fifty at the smaller, and is approximately 420 mm. long. The rate of tapering indicates that it was at least twice this length when whole. The thirteen posterior segments average twenty-two millimeters in length. It was obtained at the Farley Quarry, North Farley, Dubuque county.

Occurrence and Locality: In Niagaran dolomite at Hopkinton, Delaware county, and at Farley, Dubuque county, Iowa. In collection of the State University.

Huronia obliqua Stokes.

Plate XXXIII, figure 2.

1824. *Huronia obliqua* Stokes. Trans. Geol. Soc. London, second series, Vol. i, pt. ii, p. 203, Pl. xxviii, fig. 4.

Siphuncle straight, smooth, tapering at the rate of a little over one millimeter for each segment length. Transverse section circular. Segments short in proportion to their lengths—seven having a total length of one hundred millimeters while their average greatest diameter is 37.4 mm. The obliquity of the plane passing through the line of contact of any two joints is 97°. This exceeds the obliquity of any other species of this genus with the exception of some of the gerontic siphuncles of *H. vertebralis.*

Endosiphuncle central and proportionately smaller than in the preceding; the actiniform lamellae well developed.

Occurrence and Locality: The only specimen in the University collection is labelled Niagaran, northeastern Iowa.

Huronia subcylindrica sp. nov.

Plate XXXIV, figure 4.

Siphuncle straight, round in cross section, sides parallel, or nearly so; the specimen consists of seven segments, four of them whole. It shows no appreciable tapering.

The segments are about one-half as long as their average diameter and their nearly parallel sides give them a cylindrical appearance. The anterior end of each segment is partly set off from its main body by a sort of uneven contact which somewhat resembles the epiphyseal surface in the limb bones of young mammals. The contact between two segments is slightly oblique.

The endosiphuncle is six to eight millimeters in diameter, is out of the center by about one-half this amount, and its wall is wrinkled and irregular. The lamellae are strong, more or less convoluted, and are irregularly arranged.

Fragments of the thin proximal edges of the septa are present between all the joints; they enter between them at an angle of nearly 45° from the vertical.

Measurements: Greatest diameter (aver.) 40 mm., least (aver.) 38.1 mm.; length of segments (aver.) 21 mm.; obliquity, 95°.

Occurrence and Locality: The type specimen is in the University collection and is labelled Niagaran, Delaware county, Iowa.

Huronia hopkintonensis sp. nov.

Plate XXXIII, figure 3.

Siphuncle large, straight, tapers very gradually. The type specimen consists of four partly broken segments and a fragment of a fifth segment. Transverse section apparently circular. The segments are strikingly short and broad and are about two-fifths as long as wide; their sides slope gradually and the upper one-third of each is moderately swollen; the top of each turns abruptly inward then obliquely downward beneath the segment above. The obliquity of the segmental contact is small.

A fragment of the septum between the two lower segments is double; this is an actinoceran character not present, as far as observed, in any other specimen of Huronia at hand.

The endosiphuncle is central and is two millimeters in diameter. The actiniform lamellae are very numerous and more crowded than in any of the other species here described.

This species differs from *H. vertebralis* in its larger size, in the proportions of the segments, and in the much less swollen anterior ring.

Measurements: Greatest diameter, (aver.) 55 mm., least (aver.) 46 mm.; length of segments (aver.) 20.6; obliquity, 93°.

Occurrence and Locality: The type specimen is in the University collection and is labelled Niagaran, Hopkinton, Iowa.

Huronia turbinata Stokes.

Plate XXXIII, figure 4.

1824. *Huronia turbinata* Stokes. Trans. Geol. Soc. London, second series, Vol. i, pt. ii, p. 203, Pl. xxviii, fig. 3.

Siphuncle straight, round, and tapering gradually. Our specimen consists of four segments, the upper and lower imperfect, the two middle ones nearly whole.

The segments are notably turbinate in shape; the swollen part of each is prominent and a circle passing along its greatest periphery is quite well back from the anterior end. The upper half of each segment is convex while the lower half is slightly concave and smoother than the upper. The maximum and minimum diameters of the segments are in proportion of approximately thirteen to nine while the height to the width is about three to five. Two segments meet along a slightly oblique plane. The endosiphuncle is central and small. The lamellae are few and rather obscure in our specimen.

Fragments of the septa preserved with this bit of siphuncle indicate that the septum on emerging from the septal groove turned abruptly upward and adhered to the lower half of the segment; from this position it deflected outward to unite with the conch. The smoothness of the lower half of each segment seems to be due to the fact that it was covered and thus protected from weather and wear for some time after the destruction of the enveloping conch. It is worthy of note that the lower half of the segments in *H. obliqua* also is smoother and strongly suggests, in our material, a similar relation of septa and siphuncle in that species.

Measurements: Greatest diameter, three successive segments, 27.0, 26.0, 25.8 mm.; least diameter, three successive segments, 18.5, 18.0, 17.2 mm.; average length, three segments, 14.5 mm.; obliquity, 95°.

Occurrence and Locality: The only specimen in the University collection is from the Niagaran, "northeastern Iowa."

Discosorus (?) biconoideus sp. nov.

Plate XXXIV, figures 1 and 2.

Compare *Discosorus conoideus* Hall, 1852. Pal. N. Y., Vol. ii, p. 99, Pl. xxviii, figs. 13a, b, c.

Siphuncle of the nummuloidal type, straight, transverse section circular; tapers both posteriorly and anteriorly giving the specimen a biconoid appearance. The anterior cone is the shorter due to more rapid tapering in this direction.

Segments disc-like, edges rounded, septal groove deep, opposing faces flat and smooth; anteriorly the segments become thinner at the extreme end showing that the air chambers in senility become shallower. The obliquity of the plane passing between the joints is as high as 105° which is greater than in any species of Huronia.

Endosiphuncle central; internal character of the segments obscure but where broken small fragments of crinoid or cystoid stems and hollow molds of minute fossils tend to indicate that they were empty. Hall in the reference to *D. conoideus,* cited above, mentions similarly included remains.

These siphuncles evidently belonged to some ovoid brevicone type of cephalopod. In the university collection is a fragment of a cast of a conch with part of the siphuncle in place. The siphuncle is broken in such a way that it can not be referred to this species with absolute certainty but the following points can be seen clearly; seven camerae are present on the antisiphonal side; the sutures undulate slightly; the uninjured surface of the specimen preserves impressions of longitudinal ridges; the surface along these ridges is a gently convex curve; the siphuncle is nummuloidal and tapers in both directions.

This species is referred to the genus Discosorus with some doubt. Many fragments of siphuncles in the collection taper in one direction only; these conform to Hall's description of the genus as given in the reference cited at the head of this description, but a redefinition of the genus is necessary in order to include biconoid or doubly tapering siphuncles.

The specific name is also offered with some hesitation, for it may be possible that the siphuncles at hand are but more complete specimens of Hall's *D. conoideus.* However, it seems unlikely that good observers like Bigsby, Hall, Whitfield, Barrande, Hyatt and others should have failed to notice biconoid forms or at least to have suspected the biconoid character of the siphuncle if such was originally the complete form of the specimens they studied.

Occurrence and Locality: Occur as dolomitic casts in the Niagaran at Maquoketa, Jackson county, and also at Hopkinton and vicinity in Delaware county, Iowa. One silicified specimen is labelled Niagaran, Delaware county. State University collection.

Actinoceras cf. richardsoni Stokes.

Plate XXXIV, figure 3.

1840. *Actinoceras richardsoni* Stokes. Trans. Geo. Soc. London, second series, Vol. v, pt. ii, p. 708, Pl. lix, figs. 2, 3.

Siphuncle nummuloidal, straight, round in cross section; the fragment at hand shows little or no tapering.

Segments discoidal, outer edges evenly rounded, surface of upper half curved more abruptly than the lower to which fragments of the septa still adhere as in *H. turbinata.* The obliquity of the segments makes an angle of 105° with the vertical axis.

The internal characters of the siphuncle are wholly obscured by excessive silicification.

The high obliquity of the segments of this fragmentary specimen makes its reference to Stokes' species rather doubtful, while the highly silicified condition of the interior makes even generic determination uncertain.

Occurrence and Locality: The specimen is in the University collection and was found in the Niagaran, Hopkinton, Iowa.

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EXPLANATION OF PLATE XXXIII.

(All Figures Natural Size.)

HURONIA VERTEBRALIS Stokes.

Fig. 1. Two large segments showing unusual obliquity for this species.

HURONIA OBLIQUA Stokes.

Fig. 2. A series of nine segments, the terminal ones imperfect. The greatest obliquity is at right angles to the side shown. Note that the concave surface of each segment is smoother than the convex.

HURONIA HOPKINTONENSIS sp. nov.

Fig. 3. The type specimen. Greatest obliquity not shown.

HURONIA TURBINATA Stokes.

Fig. 4. Portion of the siphuncle showing the obliquity of the segments, also a fragment of the turned up part of the septum adhering to the concave surface of the upper segment. The smoothness of the concave part is not well brought out in the photograph.

EXPLANATION OF PLATE XXXIV.

(All Figures Natural Size.)

DISCOSORUS (?) BICONOIDEUS sp. nov.

Fig. 1. The paratype. A large incomplete siphuncle showing the obliquity of the segments, the amount of their separation, and their thinning toward the anterior end.

Fig. 2. A more complete siphuncle of a smaller individual, the holotype, showing tapering toward each end.

ACTINOCERAS cf. RICHARDSONI Stokes.

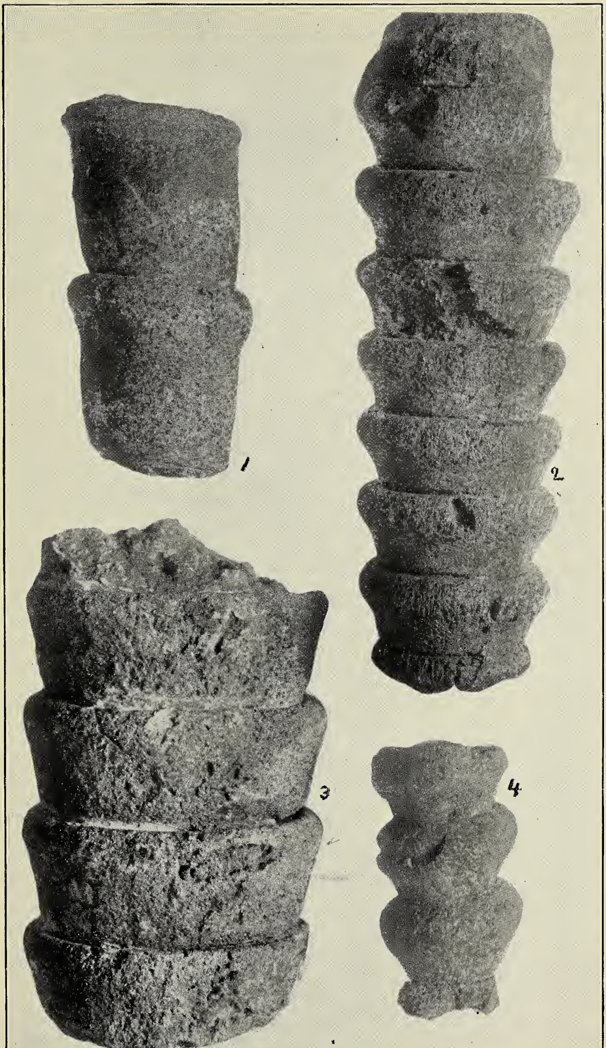
Fig. 3. View of a fragmentary specimen showing its nummuloidal character and the septal remnants attached to the posterior surfaces of the segments. Note the high obliquity of the segments.

HURONIA SUBCYLINDRICA sp. nov.

Fig. 4. The type specimen. Shows the nearly cylindrical character of the segments, the low anterior ring, and the narrow septal groove. The view is at right angles to the greatest obliquity.

HURONIA VERTEBRALIS Stokes.

Fig. 5. A typical specimen showing a slight amount of tapering, segments with subparallel sides, and rounded evenly-inflated anterior rings.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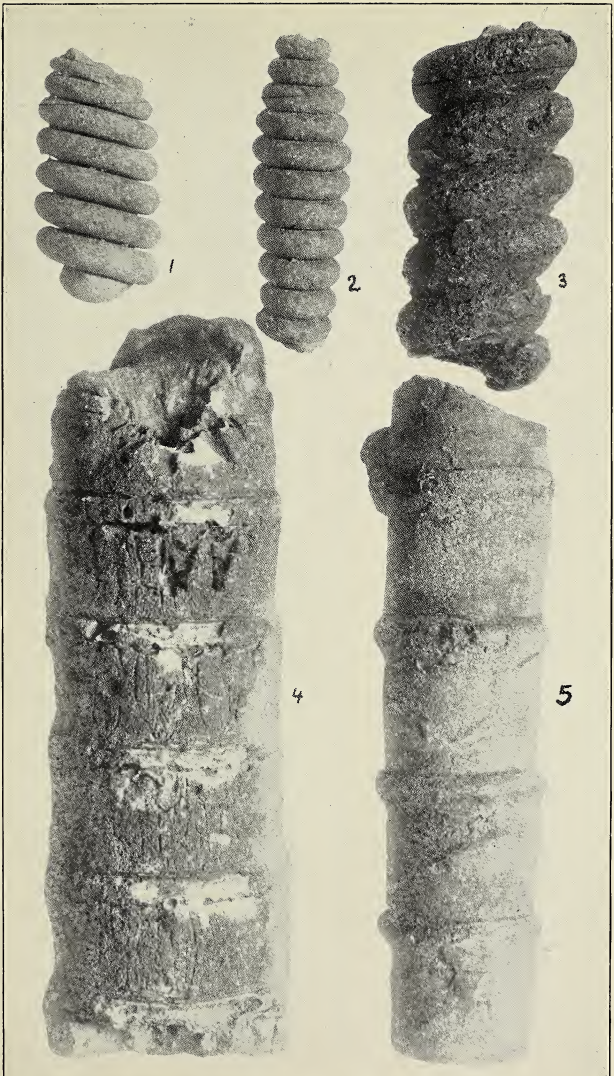
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A DESIGN FOR ELECTRICAL REGULATION OF HIGH TEMPERATURE OVENS.

W. E. TISDALE.

In growing Tellurium crystals, a temperature within a few degrees of 450 centigrade must be maintained constantly. The electrical oven available consisted of a porcelain tube five centimeters in diameter and thirty centimeters long, covered with asbestos. The need for making a regulator arose from the fact that nowhere in the catalogues available was there a regulator advertised that would be contained within the tube without completely closing it. Nearly all temperature regulators for electrically heated apparatus break the heating current when the temperature rises to a given point, and make it when the apparatus cools, and the difference between these two temperatures is the regulation of the device. It requires 10 amperes to heat this particular oven to 500 degrees centigrade, and simple expansion could not be relied upon to make a gap sufficiently wide to prevent sparking and at the same time give any very close regulation.

Any device using electricity to break the heating circuit must operate with a very small current because of sparking across the gap made by the contraction of the contacts. This contraction should be as great as possible, and in the oven for which this device was made there was not sufficient room to use levers to increase the gap. A mercury-in-glass device was first used, in which the circuit through a storage cell and relay was completed by the rising surface of the mercury coming in contact with a platinum point. This was discarded because the oxide and vapor formed at each contact made it necessary to keep vigilant watch to assure its working. Another device consisting of a strip of brass and copper riveted together, and using the unequal expansion of the two to bend the strips and make contact against a suitably placed point was discarded because of its lack of fine regulation. The present device utilizes the geometric principle that if the base of a right triangle be kept constant, the perpendicular increases more rapidly than the hypotenuse, and especially for small increments.

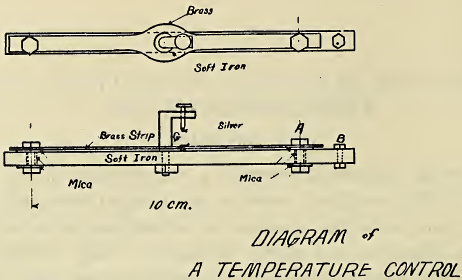

FIG. 11.—Apparatus for temperature control.

Thus, in the apparatus shown in figure 11, in which the base is made of soft iron, and the flexible part of brass, for each degree rise in temperature for each centimeter of length, there is a difference in expansion of .000007 centimeters. By making the length of the metal between rivets to be 10 centimeters, the half length which forms the triangle is five centimeters, and for 400 degrees rise in temperature,
the brass is $5 + .000019 \times 400 \times 5 = 5.038$ cm. in length, and the iron is $5 + .000012 \times 400 \times 5 = 5.024$ cm. in length. This gives a rise of $\sqrt{(5.038)^2 - (5.024)^2} = \sqrt{.14} = .375$ cm. or 3.75 mm., which is equivalent to the expansion of 50 centimeters of brass. The device operates on one-fourth ampere of current, and regulates to one degree. Its action is clearly shown in the diagram, figure 12.

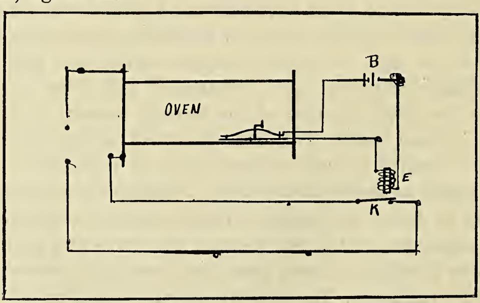

FIG. 12.—Diagram of apparatus installed.

NOTES ON THE PRODUCTION AND SOME ELECTRICAL PROPERTIES OF TELLURIUM CRYSTALS.

W. E. TISDALE.

This report deals with the production of Tellurium crystals, and the effect of temperature on their electrical properties. An investigation of Tellurium was undertaken primarily to settle the question of its change of resistance with light, or its light-sensitiveness. It occurs in the periodic table in the same column with Selenium, and in the same row with antimony, which elements show an effect on light sensitiveness. Adams in 1876 made some experiments on Tellurium cells and reported "a distinct though very slight influence of light on their conductivity". Siemens, Knox, and Saunders report that there is no effect of light that can not be explained as the effect of heat. Selenium crystals differ in certain ways from Selenium cells, and it was this fact that suggested the idea of securing Tellurium crystals for the tests.

Tellurium is a non metal of atomic weight generally accepted at 127; it has its melting point at 452 C., and crystallizes in but one system, the hexagonal. Commercial Tellurium in stick form is sealed in a tube of heavy glass through which dry air and dry hydrogen gas have been passed a half hour in turn, and which is then placed in an electric oven where the temperature is kept constant—the crystals forming by the process of sublimation. The lengths of the crystal axes seem to be a function of the pressure under which they form. In an atmosphere of Hydrogen gas, under a pressure of three centimeters of mercury, the crystals form with nearly equal axes—from one to two millimeters. Under a pressure of three atmospheres in Hydrogen, the length of the crystal is from twenty to thirty times its diameter, and the longest one produced here was 3.2 cms. long, requiring two weeks' time to grow. The crystals form much more slowly in low pressure than in high—in the latter case they are evident in twenty-four hours, and have grown to more than one centimeter in three days.

These crystals of Tellurium are exceedingly brittle, and it is not possible to solder them. If they are mounted for electrical experiments using pressure to secure contacts, it is impossible to get results that can be duplicated, and it was deemed inadvisable to use Mercury contacts because of the uncertain action of it on Tellurium. This difficulty of contacts was eliminated by a method of welding Tellurium crystals and Platinum wires. The process is rather delicate, but crystals as small as .02 cm. in diameter have been used, with Platinum wire .015 cm. in diameter. These fine wires bend very readily and relieve any small strains before the crystal is stressed to the breaking point, and because of this fact it was found to be inadvisable to use larger Platinum wires because of their stiffness. The crystals were put in circuit by welding the free ends of the Platinum to Copper wires.

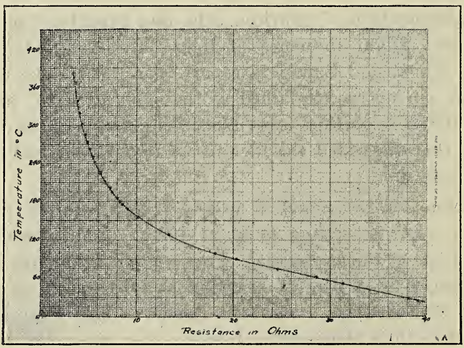

Fig. 13.—Curve showing resistance of tellurium crystals.

For temperature adjustments in producing the curve shown in figure 13, the crystals were immersed in paraffin, and the experiments taken from room temperature to 380 degrees centigrade. From this curve two temperature coefficients are obtained, for use in the formula $R^t = R^o (1 + at)$. The first is from 20° C. to 150° C., and is $a_1 = -.00584$. The second is from 200° C. to 400° C., and is $a_2 = -.00298$.

In obtaining the curve, figure 14, the same sort of mounting was used as before, except that the crystal remained in air. The peculiar shape of the E-I curve is due entirely to the negative heat coefficient in the resistance formula. No attempt was made to regulate the temperature, and the heating was due to the current through the crystal. A voltmeter was connected across the crystal, and the current regulated by an adjustable resistance in series with the crystals. The increase of the conductance curve with current is very similar to that shown in figure 13, showing decrease of current with temperature.

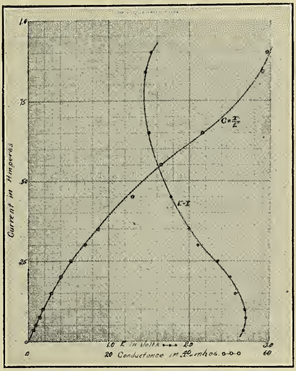

FIG. 14.—Curves showing electrical properties of tellurium crystals.

A series of tests was made to establish the question of light-sensibility, all of which showed that there was no change in the conductance of Tellurium crystals under the action of light.

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THE ABSENCE OF LIBERATION OR ABSORPTION OF ELECTRONS DURING A CHANGE FROM THE CONDUCTING TO THE NON-CONDUCTING STATE.

L. E DODD.

Metallic selenium in the crystalline form is an electrical conductor. In the amorphous form, which may be produced by melting a selenium crystal, the substance is an electrical insulator. If, as supposed, electrical conductivity in metals is due to free electrons, then in the change from the conducting to the non-conducting state there must be a disappearance of free electrons. This disappearance could be accounted for by a liberation of electrons into the space surrounding the substance, or by a recombination of free electrons with positive residues to form the neutral molecules of the insulator. In this paper is described an experiment to test the question of liberation of electrons during a change from the conducting to the non-conducting state.

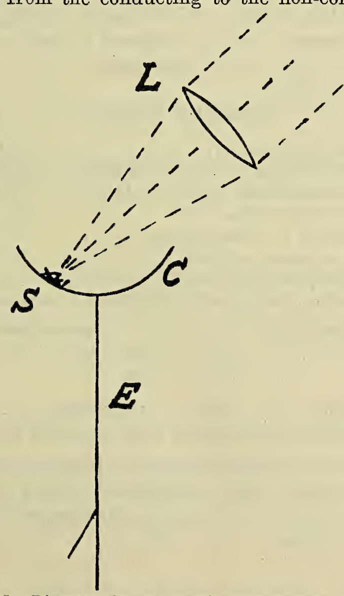

FIG. 15.—Diagram showing melting of selenium crystals.

Crystals of metallic selenium, S, figure 15, were placed in a metallic cup, C, attached to the vertical rod of a delicate electroscope, E. To melt the selenium a lens, L, for focussing the sun's rays on the crystals, was employed; a flame would have been undesirable in this experiment because of its high ionizing power. With the rays shut off the electroscope was negatively charged. The focus of rays was then applied to the crystals, which soon began to melt, and in a short time fully 80% of the crystal mass had changed to the amorphous form. The time required and the change of electroscope deflection were carefully noted. The cup was then cleared of the whole mass, the electroscope again negatively charged, and the sun's rays focussed as before, this time falling on the metal of the cup. The change in deflection was noted for the same time as previously required for the change of state. This was done also a second time. Thus there were two values for change in deflection to compare with the first result. If no important difference should appear between these last two deflection changes and the change during the melting of the crystals, the conclusion would naturally follow that the change in state contributes of itself no appreciable charge to that already on the electroscope.

NUMERICAL RESULTS.

Total mass of crystals	0.0142 grams.
Mass of Se changing to amorphous form	0.01136 grams.
Time consumed during change of state	3½ mins.
Readings of electroscope scale:	
At beginning of change of state	62 divs.
At end of change of state	21 divs.
Difference in deflections	41 divs.

Readings of scale after removal of crystals from cup:

First Trial.		Second Trial.	
Beginning	61	Beginning	37
End	27	End	—2
Difference	34	Difference	39

(Time during these trials, 3½ min., as in the first case.)

The two trial readings indicate no important difference in change of deflection from that obtained during the change of state. Hence the conclusion that the state change has contributed no appreciable charge.

EXPECTED MAGNITUDE OF LIBERATED CHARGE.

In this connection it is of value to deal numerically with the question as to the magnitude of the charge that might be expected to be liberated by the change of state. In the light of present knowledge of electrons there are reasons for assuming that in a conductor at least one free electron exists for every atom. (See Jeans, Electricity and Magnetism, Second Edition, p. 545.) If in the change from a conductor to an insulator by a change of state the free electrons disappear by escaping from the parent matter entirely, rather than by recombination with the positive residues distributed throughout the mass of matter, we should look for a liberated charge corresponding to one free electron for every atom. Referring to the present experiment we are therefore justified in considering a liberation of at least one free electron for every ten atoms. We proceed with computations as follows:

No. atoms per gr-atom any element...... 6.02×10^{23}
Atomic weight of selenium............ 79
For selenium there are................. 7.6×10^{21} atoms/gr.
7.6×10^{21} atoms/gr. X 0.01136gr.......... $= 8.6336 \times 10^{19}$ atoms.
Assuming 1 free electron for
each 10 atoms,...................... $n = 8.6336 \times 10^{18}$ electrons
Total charge is ne ($e = 4.65 \times 10^{-10}$ e.s.u.).... $= 4.0146 \times 10^{9}$ e. s. u.
Since 3×10^{9} e.s.u $= 1$ coulomb, we have..... 1.3 coulombs

Considering the small capacity of the electroscope, this charge of 1.3 coulombs, or even a very small fraction of it, could not have escaped notice.

CONCLUSION.

With a choice of metallic selenium as a suitable substance for experimentation, there is found no experimental evidence that matter either liberates or absorbs electrons during processes incident to a change from the conducting to the non-conducting state.

The result of the experiment throws emphasis upon the theory of recombination between "free" electrons and parent atoms in metallic conductors, which process must be supposed to take place in a manner somewhat similar to the known recombination following after ionization of gases. Initial conceptions of "free electrons" in metallic conductors rather inclined to the view that they are permanently free, as far as the individual atoms in the metallic masses are concerned, although retained within these masses. Recent developments, especially regarding the metal selenium, (Dr. F. C. Brown, Physical Review, May, 1915, p. 395) lead to the view that the ''free'' electrons are only temporarily and probably only to a limited degree free. It appears that under different conditions of pressure and intensity of illumination, the electrons taking part in electrical conduction have different degrees of freedom from the parent atomic structure. The present experiment was suggested in the light of Dr. Brown's results. (Loc. cit.) Its outcome appears to support the particular view to which he has been led, of the action of conducting electrons in metals.

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A RESONANCE METHOD FOR MEASURING THE PHASE DIFFERENCE OF CONDENSERS.

H. L. DODGE.

It is a well known fact that when an alternating electromotive force is impressed upon a condenser the resulting current does not lead the electromotive force by the theoretical ninety degrees. This is particularly noticeable in the case of paper condensers of the telephone type so often used in laboratories for the study of the alternating current circuit. When an attempt is made to interpret such experiments by graphic methods it is sometimes found that the power factor of the condensors is so great that it must be taken into account. The power factor angle or the angle by which the current lags behind the theoretical ninety degree lead is known as the phase difference of the condenser.[1]

This paper is devoted to a description of a method by which the phase difference of paper condensers can be determined from the same data that are obtained in an experimental study of the phenomena of current resonance.

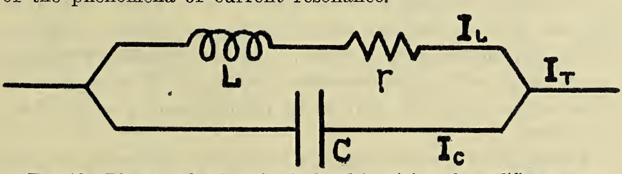


FIG. 16.—Diagram showing circuit for determining phase differences.

Figure 16 represents the circuit which consists of two parallel branches, one containing a coil with inductance L and resistance r, the other a variable condenser C. An alternating electromotive force is impressed upon this circuit and the value of the three currents I_T, I_L, I_C, read as the capacity of the condenser is increased by equal steps. The current in the inductive branch will remain constant. In the condensive branch the current

[1] F. W. Grover, Bureau of Standards, Bull., vol. 7, 495, 1911; vol. 3, 371, 1907. These papers contain a very complete discussion of condensers and their properties, with numerous references to other work upon this subject.

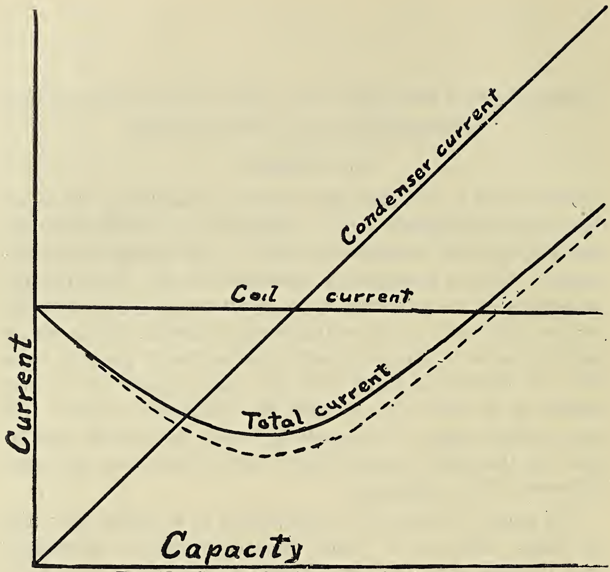


FIG. 17.—Curves showing strength of currents.

will increase uniformly as the capacity is increased. The total current will, however, decrease at first, pass through a minimum value and then steadily increase. This is a standard procedure in the study of current resonance and figure 17 represents the results that would be obtained by plotting such a series of observations.

Figure 18 is a vector diagram of the currents assuming zero phase difference in the condensers. If the impressed electromotive force be taken as the axis of reference the vector OL represents the current in the coil which lags by the angle ϕ given by the relation $Cos\ \phi = \frac{r}{z}$ in which expression r is the resistance of the coil and z its impedance. The vectors OC_1, OC_2, etc., represent different values of the current in the condensers, and the vectors OR_1, OR_2, etc., are the corresponding resultant or total currents as found by the parallelogram method. The values of the total current obtained by this graphic method are represented in figure 17 by the dotted line. It should, of course, fall exactly upon the line of observed values and the discrepancy is to be attributed to the fact that the phase difference of the condensers has not been taken into account.

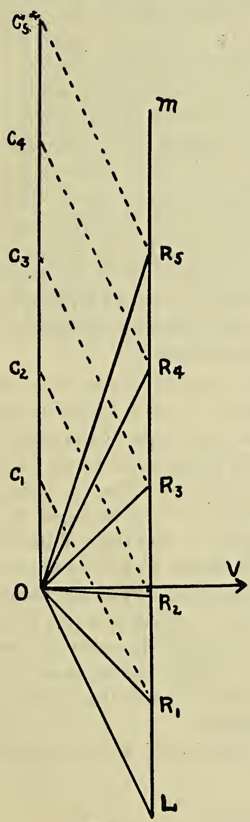


FIG. 18.

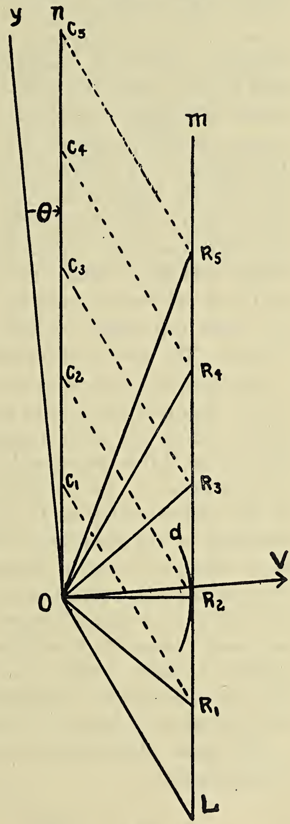


FIG. 19.

FIG. 18.—Vector diagram of currents assuming zero phase difference.
FIG. 19.—Vector diagram assuming known phase difference.

If we assume that the phase difference θ is known and construct the vector diagram, figure 19 will be the result. The angle θ determines the slope of the line *On* along which fall the vectors representing the different values of the condenser current. The line *Lm* upon which end the vectors representing the various values of the total current is, of course, parallel to *On*. If the angle θ has been taken correctly all of these total current vectors as found by the parallelogram method will check exactly with the observed values. If θ is taken too small the resultants will all be too short, if θ is too long the resultants will be larger than the observed values. A cut and try method could be employed but there is one of the total current vectors which has such properties as to make it possible for it to be used to determine the position of the line *L m*. This vector is the one shown in figure 19 as $O\ R_2$. It represents the minimum value of the total current and as the figure shows must be perpendicular to the line *L m*. *O L*, $O\ R_2$, and $L\ R_2$ must then form a right angled triangle of which two sides are known. Thus the slope of *L m* is determined and with it the slope of *O n* and ultimately the value of the angle θ which is the phase difference of the condensers. The method of procedure is as follows:

The required data are secured for a parallel circuit such as that of figure 16 and plotted as in figure 17, smooth curves being drawn which are more accurate than the single observations. The vector *O L* is drawn with its length proportional to the current in the coil. As the impressed electromotive force is taken as the axis of reference, *O L* lags behind *O Y* by an angle determined by the resistance and impedance of the coil. With *O* as a center and with a radius corresponding to the minimum value of the total current the arc *d* is described. From the point *L* a line *L m* is drawn tangent to this arc. From *O* a line *O n* is drawn parallel to *L m*, this line giving the direction of the capacity current vectors. *O y* is drawn ninety degrees ahead of the axis of reference. The angle θ between *O y* and *O n* is therefore the phase difference of the condensers.

The phase difference may also be determined from the following formula

$$\theta = Cos^{-1} \frac{r}{z} - Cos^{-1} \frac{I_L}{I_T}$$

in which *r* is the resistance of the coil, *z* its impedance, I_L the coil currents, and I_T the minimum value of the total current.

In the development of the above theory a sine wave electromotive force has been assumed. If there are higher harmonics the effect will be to increase the apparent value of the phase difference. In this case there will be no value of the capacity for which perfect resonance will be secured. All values of the total current will be larger than for sine wave conditions and for a given value of the coil current $O\ L$, the radius of the arc d will be increased resulting in a greater value of the phase angle θ.

In the ordinary laboratory experiment this is not a serious matter unless the harmonics are very prominent. In our own laboratory this difficulty is avoided by the introduction of considerable inductance in series with the parallel circuit.

The above method of measuring the phase difference of condensers is not proposed as a standard or accurate method. It is, however, of some theoretical interest and has proven to be of great practical value in a laboratory where students are studying the alternating current circuit with the use of the commercial paper condenser.

PHYSICAL LABORATORY,
STATE UNIVERSITY OF IOWA.

THE CRYSTAL PHONOPTICON IN ITS ADAPTATION TO ENABLE THE BLIND TO READ THE PRINTED PAGE.

F. C. BROWN.

The crystal phonopticon is an arrangement of apparatus whereby illumination characteristics (e.g. such as come from a small portion of any printed page) of variable arrangement, intensity and sequence may be transformed into sound progressions of corresponding variable intensity, arrangement, duration and sequence. It is called the Crystal Phonopticon because by the use of recently discovered crystals of selenium[1] light impressions are transformed into sound impressions. The key to the successful production of such an apparatus lay in the high sensi-

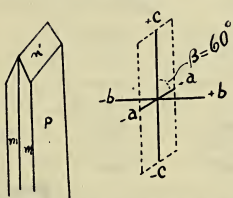


FIG. 20.—Diagrams showing characters of selenium crystals.

bility of these isolated crystals to light. The sensibility is increased by the transmission of the light action along the crystal[2] much in the same way perhaps that a nervous impulse is transmitted along a nerve, and yet further increased by mounting the crystal under pressure.[3] The increased sensibility of a single crystal or a small group of crystals has made possible the construction of a far more sensitive apparatus than was possible with the old selenium cells as suggested by Fournier D'Albe.[4] It is not possible to use a selenium cell in the same way that I have used individual crystals of selenium.

The Selenium Eye.—The essential part of the crystal phonopticon is the selenium eye, which consists essentially of a row of

[1]Phys. Rev. N. S. 4, p. 85, 1914.
[2]Brown and Sieg, Phil. Mag. S. 6, 28, p. 497.
[3]Loc. cit.
[4]Proc. Roy. Soc. A, Vol. 90, p. 373, 1914.

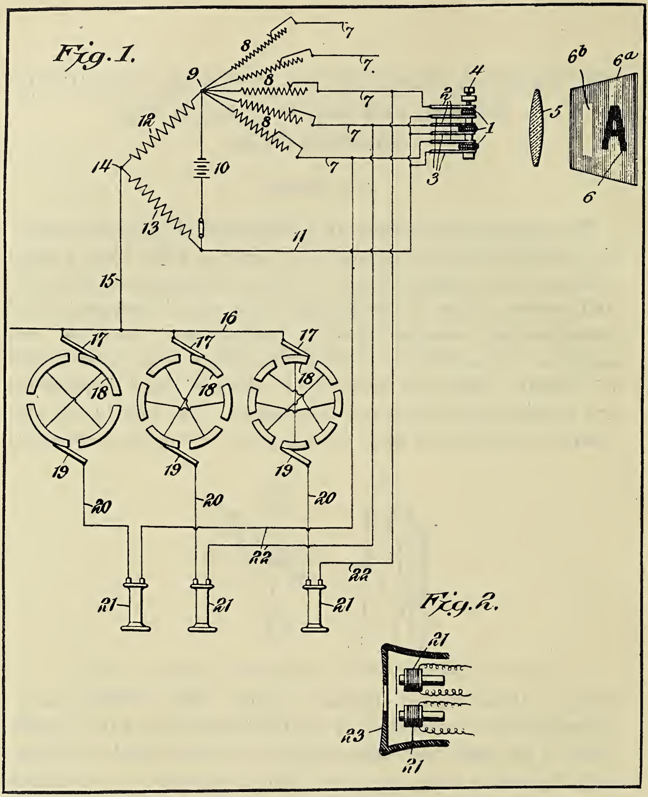


Fig. 21.—Diagram of the crystal phonopticon.

selenium crystals, at 1, figure 21, a slit, at 6^b, to expose only a narrow strip of an illuminated page and a lens (at 5) for focussing this illuminated portion on the series of crystals. The background at 6^b corresponds to any limited background that the human eye might observe, the lens corresponds to the crystalline lens of the human eye and the crystals conventionally shown correspond to the rods and cones of the eye.

Continuing the analogy to the eye, the electric current through the crystals bears certain resemblance to the nervous impulse going out from the rods and cones. The resistances in fig. 21 are so chosen that when the white page is illuminated, there may be a zero or small electric current through the telephone receivers. Then when a dark letter or part of such letter moves in front of the lens at focus 6^b there is less light focussed on all or part of the row of crystals. The crystals that receive less light instantly increase in resistance and so cause a current to flow through the receivers as long as the dark portion of the letter remains at the focus of the lens.

The Discernment of Characters.—As various characters move in front of the lens there is a combination of electric currents set up in the various telephone receivers. There is also a various combination of sequence in which these currents may appear depending on the form of the character that passes before the lens. Also these electric currents vary in intensity depending upon the width of line or part of letter that is in focus.

The various electric currents may be discerned by the ear by having in each circuit individual to each crystal both a telephone receiver and an interrupter. Each circuit has a frequency of interruptions distinct and different from all the other circuits. Therefore each circuit produces a different pitch in the ear from every other circuit. Then the ear will detect the form of a letter on a black page by the order and sequence of the different pitched notes that the ear hears. Also a trained ear will

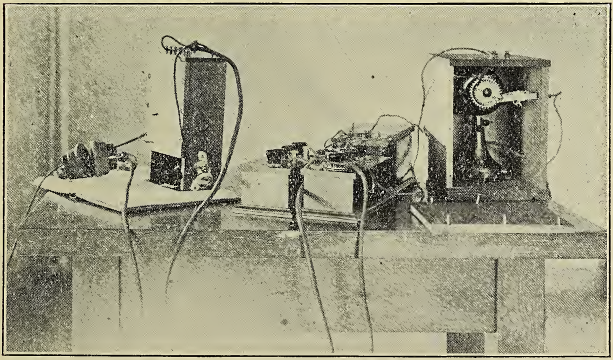


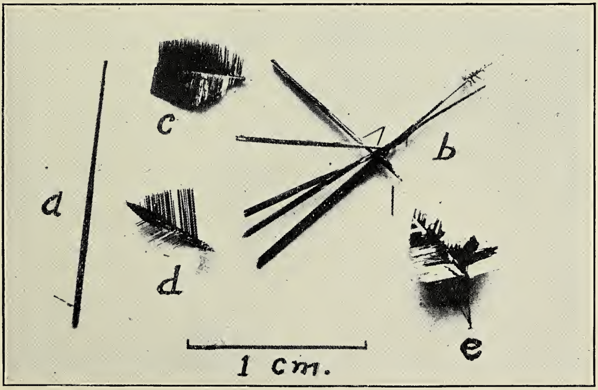
FIG. 22.—The Crystal Phonopticon in present state of development. (a) Selenium eye with head receivers on the book to the left in the picture. (b) Motor with interrupters to the right. (c) Remaining parts are auxiliary resistances, wires and battery.

be able to make certain discernments based on the intensity and duration of each pitch.

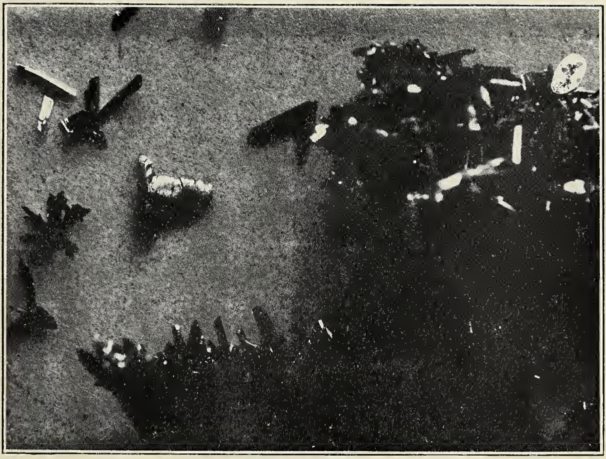
Construction.—The standardization of the details of construction is a matter that will have to be determined after much study. The smaller the number of crystals and corresponding pitched notes the easier it will be for the student to detect some of the most characteristic letters, also the simpler and less expensive will be the apparatus. On the other hand there must be enough variation in sound combinations to enable the reader to distinguish every character. Two crystals and two receivers may be sufficient. On the other hand as many as five or six may be advisable. Only experience can tell.

If more than two notes are necessary these may all be heard in one receiver, which would be the usual practice. However, it may be that a greater distinctness and clearness may be obtained using two or more resonating plates in one receiver as shown in figure 21 (Fig. 2). One or both ears may be used as experience will dictate.

The Physical Laboratory,
State University of Iowa.



Crystals of selenium. First produced at the State University of Iowa.



Figures showing crystals of selenium, all of which are light sensitive. These crystals were first produced at the University of Iowa.

NOTES ON CERTAIN ELASTIC PECULIARITIES OF PHOSPHOR BRONZE WIRES.

L. P. SIEG AND A. J. OEHLER.

Introduction.—Some previous work by one of the authors with wires of an alloy of platinum-iridium, portions of which work were published in these Proceedings,[1] indicated that when the wires were used as suspensions for torsion pendulums, the relations between the period of vibration and the amplitude were exceedingly complicated. The effect of drawing these wires was dealt with in another paper.[2] In all these papers referred to, the statement was made that similar tests should be applied to some of the more common wires in the hope of finding similar, even though smaller effects. Through press of work these experiments have been deferred until the present year. This particular paper will deal with but one feature of the work, namely, the effect of drawing on the elastic nature of phosphor bronze wires. The writers are indebted to the American Electrical Works, of Phillipsdale, Rhode Island, for kindly furnishing them with specimens of the wires.

Significance of the work.—Physicists, and no doubt many others, will realize that it is highly important to know intimately the elastic nature of phosphor bronze wires on account of the fact that these wires are in such common use in the manufacture of delicate suspensions of all kinds, particularly for galvanometers. Often, especially in absolute measurements, we depend on the general law for vibrating wires that the coefficient of simple rigidity determined statically be in agreement with the same coefficient determined kinetically. This agreement is possible only where the wires follow the law that the period of vibration, in angular harmonic motion, is practically independent of the amplitude. In fact the only thing, aside from internal friction of various sorts, that can affect the period should be external air friction, and for reasonably slow periods this should not be a serious source of error.

[1]Ia. Acad. of Sci., Proc. XVII, p. 185, XVIII, p. 115, XIX, p. 189.
[2]Phys. Rev. 35, 347, 1912.

Apparatus, and Experimental Methods.—We were supplied with a series of wires of phosphor bronze, all drawn from the same original alloy. There were thirteen of these wires, representing successive drawings, and ranging in diameter from .100 mm. to .508 mm. Previous work by one of us, already referred to, indicated that platinum iridium wires showed a marked deviation from constancy of period with varying amplitude, the larger periods being associated with the larger amplitudes, and particularly it was pointed out that the variation became more

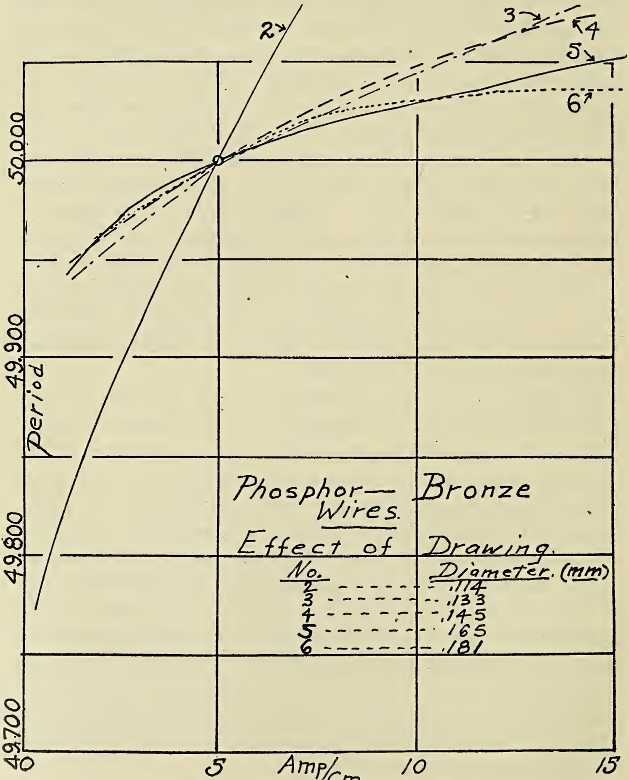


FIG. 23.—Effect of drawing on wires.

marked as the wires were successively drawn down to smaller lengths. In these present experiments similar, though smaller effects were found, and for a sample set of experiments are shown in figure 23. The curve is practically self-explanatory. The coördinates are amplitude per cm. of length of the wire experimented on, and period of one semi-vibration. The numbers on the curves from *2* to *6* indicate that we are dealing with a series of successive drawings, the succession of the drawings running inversely as the numbers. That is, number six is the largest wire experimented on, and number two the smallest. The

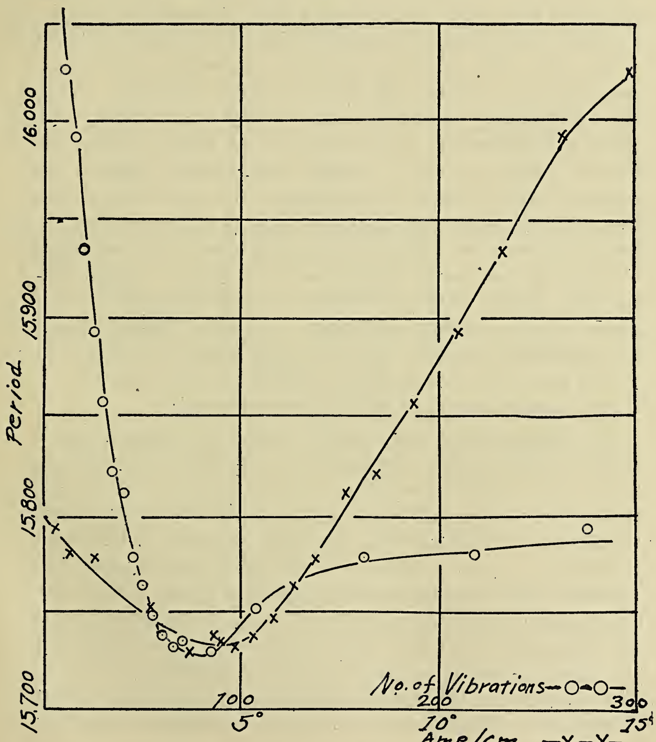


FIG. 24.—Curves showing effect on wires of heating and long continued vibrations.

effect of the drawing is clearly brought out. It is of especial interest to note that the wire that showed the greatest deviation from the assumed law of elasticity, No. 2, is of the size .114 mm., most usually employed in the manufacture of galvanometer suspensions. The apparatus employed will not be described, as both it and the method have been fully detailed in the former volumes of these Proceedings, already referred to.

A New Effect.—The curves in figure 23 represent the results that were obtained from these wires by using them just as they came from the draw plates of the makers. After numerous experiments were made on the points above discussed, it was determined to see what effects would arise from various treatment of the wires. The two treatments that were employed were heating almost to redness, and long continued vibrations. After these preliminary treatments were employed, an entirely new effect was discovered. This effect is to be noted in figure 24. Here as before the curve (marked with crosses) indicates the relation betwen period and amplitude. It will be noted that the period decreases with amplitude just as in the previous experiments, with the important exception that at an amplitude of about 4° per cm. of length, the curve takes a sudden rise, and from this amplitude downward it continues to rise. This seems to be an entirely new effect. The other curve in figure 24, represented by the circles, is for the same wire except that in this case the period is platted against vibration number. It is only another way of illustrating the same point.

To make sure that this new effect did not come about as a result of differences in the original amplitude of the displacement of the supported weight, it was determined to let the wire rest for some days, and then to start it in vibration with a small amplitude, carrying out the experiment as usual, and then increasing the initial amplitude in successive experiments. The results of these experiments are graphically shown in figure 25. The curves would be so near alike that only the observed points are represented, the curves not being drawn. It is evident that the form of curve is practically the same, regardless of the initial amplitude of the vibration, at least within the limits of our experiments. The curve is perhaps clear enough to entail no additional explanation.

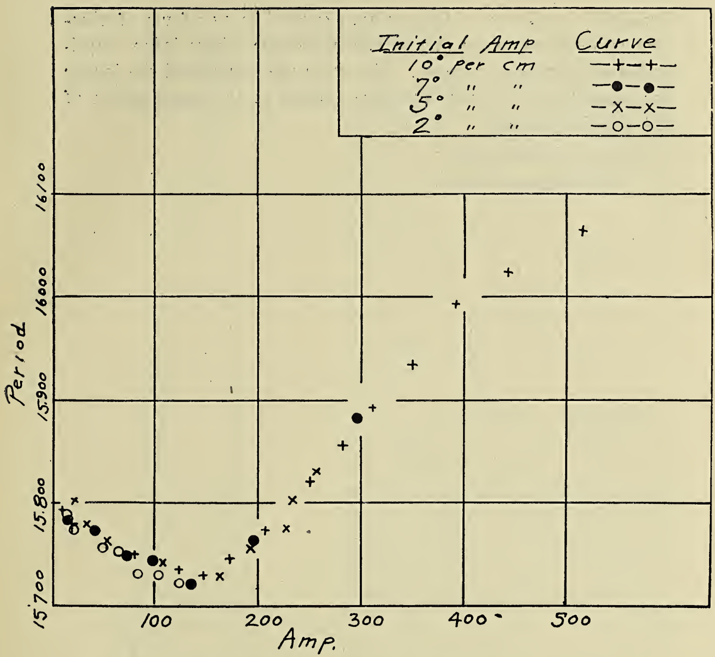


FIG. 25.—Diagram showing effect on wires of varying amplitudes.

Conclusions.—The specific results of the experiments on phosphor bronze wires that are for record in this paper are the following:

1. The effect of drawing these wires is to make the departure from ideal elastic solids increase steadily with the increased fineness of the drawn wires.

2. A new effect, which might be classed as a second order effect, superimposed on the one noted above, has been discovered. This effect is the increase in period with decreasing amplitude after a certain limiting amplitude has been reached. From the results of the above experiments it is quite evident that great care should be used by all experimenters who use such wires, and

especially is this true if the wires are used in any form of absolute measurements, or in any measurements where large amplitudes of vibration are used. The finer the wires, and the larger the amplitude, the more the care needed in the examination of the elastic constants.

PHYSICS LABORATORY,
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A SIMPLE DEVICE FOR DEMONSTRATING THE TEMPERED SCALE.

L. B. SPINNEY.

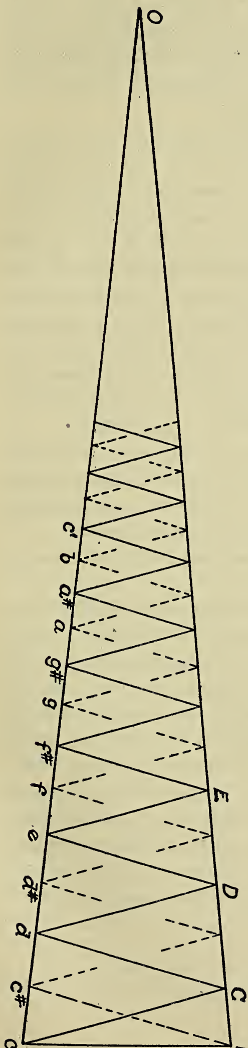


FIG. 26.—Diagram for demonstrating the tempered scale.

The diatomic scale consisting of a succession of eight tones and containing three intervals known as "major second intervals," two known as "minor second intervals" and two "half-tones," is not adapted to musical instruments of "fixed pitch" (e.g. the piano, harp, etc.) for the reason that it does not without a multiplicity of keys (strings) allow of transposition or change of keys.

For fixed-pitch instruments, therefore, the scale is modified in the following manner. First, an additional tone is inserted in each of the larger intervals (major and minor seconds) of the scale—thus breaking the octave into twelve instead of seven intervals, and second, the pitches of the various tones are so altered as to make the interval between any two successive tones the same. This scale is known as the scale of "equal temperament" or briefly, the tempered scale.

The "interval" between two tones, as the term is here used, is the ratio of the pitch of the higher tone to that of the lower. It follows that on the tempered scale this ratio is the same for any two adjacent tones. The numerical value of this interval is 1.05946, since the sum of twelve such intervals is 2, the numerical value of the octave interval.

These considerations coupled with the fundamental law of string vibrations, to the effect that, for a string of given weight and tension, the frequency of a vibrating segment is inversely proportional to its length, suggest a simple method of finding those string lengths which will give the successive tones of the tempered scale.

Draw two intersecting straight lines including any convenient angle (see accompanying diagram, figure 26). From the point of intersection lay off on one line any convenient length Oc=L, on the other a length OC=L÷1.05946. Join the points Cc by a straight line. Locate the corresponding points B and c# and join by a dotted straight line. Now draw the series Cd, dD, De, etc., and the dotted series, parallel to Bc# and cC. By this means the points c#, d, d#, e, etc., are detemined at which a string of length L (=Oc) must be stopped to give the successive tones of the tempered (chromatic) scale. This will be evident from the construction of the figure in which Oc/OC=OC/Od=Od/OD= etc., the value of this ratio being 1.05946 by construction.

If this diagram is drawn on the top of a sonometer, or a table-top across which a string is stretched, and bridges are placed under the string opposite O and c, it forms a complete finger board for running the major, minor and chromatic scales.

The device lends itself to the demonstration of the following relations:

(1) Comparison of the major and minor scales. (2) Comparison of the major and minor chords. (3) To show that on the tempered scale any note may be taken as key note, and all scales are equally good. For this purpose choose any point as starting point, calling it point 1. Number the points from point 1 upward. Sound in succession the tones given by the string when stopped at points 1, 3, 5, 6, 8, 10, 12 and 13. (4) Comparison of just and tempered scales. Lay off from O on Oc lengths equal to 8/9, 4/5, 3/4, 2/3, 3/5 and 8/15 of L. The points so determined are those at which the string should be stopped to give the tones of the just scale. A glance at the board will now show to what extent each interval of the tempered scale is falsified.

Physics Laboratory,
Iowa State College.

AN ATTEMPT TO DETECT A CHANGE IN THE HEAT CONDUCTIVITY OF A SELENIUM CRYSTAL WITH A CHANGE IN THE ILLUMINATION.

L. P. SIEG.

Introduction.—Modern electron theories indicate that the electrical and thermal conductivities of good conductors should stand in very close agreement with each other. One of the first theoretical developments was that of Drude.[1] While, perhaps, it will not be necessary to rewrite his formula here, we can at least state that he determined on purely theoretical grounds that the ratio of the thermal to the electrical conductivities for good conductors should be a function only of the absolute temperature. This theoretical formula has had excellent verification in the work of Jaeger and Disselhorst,[2] who worked with most of the common metals. It occurred to the writer that an interesting experiment could be performed with an isolated crystal of selenium in order to determine whether or not the action of light lowers its resistance to heat conduction in the same or any other measure, that it does in the case of the electrical resistance. Little hope was entertained of obtaining as great a change in the thermal as in the electrical conductivity on account of the high resistance of the selenium, but it was hoped that there might be some small effect in this direction. In looking up the literature of the subject it was found that there was but one published paper, that by Bellati and Lussana,[3] who worked, not with a crystal, but with thin sheets of crystallized selenium. Their method was somewhat crude, but they reported that there was an increase in the thermal conductivity when the thin plate was exposed to sunlight of the same order of magnitude as the increase in the electrical conductivity. (See reference to the Beiblaetter).

Apparatus and Method of Observation.—The apparatus used is illustrated in diagram in figure 27. Heat is generated in the

[1]Ann. d. Phys. 1, 566, 1900; 3, 369, 1900.
[2]Preuss. Akad. Wiss. Ber. Sitzungsber. 38, 719, 1899, also Phys. Tech. Reich., Wiss. Abh. 3, 269, 1900.
[3]Atti del R. Inst. Ven. (6) 5, 19, 1877. Also Abs. Beib. d. Ann. 11, 818, 1887.

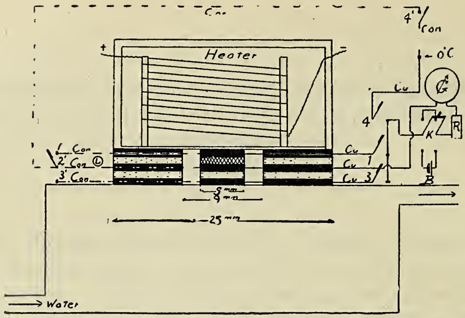


FIG. 27.—Apparatus for detecting change in heat conductivity of selenium crystals.

upper part, marked "heater". This heat flows through five layers of material to be described immediately, and thence to the lower vessel through which tap water flows. There is thus maintained a temperature gradient from the top to the bottom. The five layers are in two parts; the outer, in the form of thin washers, and serving as guard rings; and the inner, consisting of thin discs. The apparatus is drawn to scale, and there are sufficient dimensions shown to make the relative sizes clear. The order of the washers, from top to bottom is: copper, glass, copper, glass, and copper. The order of the discs from the top down is: copper, selenium crystal (fern-like growth, made up of hexagonal crystals), copper disc, glass disc, and copper disc. Thermo couples of copper and constantan which pass through, and are insulated from the outer copper washers, are fastened into the three copper discs in the center. As mentioned, the purpose of the outer washers was to serve as guard rings, so that with a given temperature gradient throughout from top to the bottom there would be very little or no lateral heat transfer. If there is no lateral heat transfer, then we can develop a simple equation for the relation of the thermal conductivity of the selenium to that of the glass. Assuming that the heat transferred passes on from the top to the bottom, we have the formula for the relation of the heat conductivity of the selenium to that of the glass[4]

$$\frac{K_1}{K_2} = C\frac{T_2 - T_3}{T_1 - T_2}$$

[4]See Christiansen, W. Ann. 14, 23, 1881, for derivation of formula.

where T_1, T_2 and T_3, are respectively the temperatures of the top, middle, and bottom copper discs. C is a constant. So this apparatus will not give the absolute thermal conductivity of the selenium, but will give the ratio of that conductivity to that of glass. If we assume, as we are surely justified, that light does not affect the thermal conductivity of glass, then we are in a position with this apparatus to discover if there is any change in the thermal conductivity of the selenium with illumination. The illumination was obtained by means of a 25 watt tungsten lamp, having a full frosted globe, placed at *L* in figure 27.

The connections at the right hand side of the diagram are perhaps clearly enough indicated. By the proper manipulation of the keys it is possible to get the temperature differences (when galvanometer readings are reduced to temperatures) between the various copper discs. Also it is possible, by throwing the key *K* downward, to place a cell in circuit, and thus get the measure of the electrical conductivity by means of the resulting galvanometer deflection.

Without going more into details in regard to the experiment, the table below is referred to for a brief indication of the results. In this table the first six columns represent respectively the temperature difference between the top and middle discs, between the bottom and middle discs, between the room temperature and that of the middle disc, the temperature of the top, of the middle, and of the bottom discs. The seventh column represents the average temperature of the selenium crystal; eighth column the relative electrical conductivity of the crystal; the ninth column represents the ratio of the thermal conductivity of the selenium to that of the glass; the tenth column represents the ratio of the electrical conductivity in the light to that in the dark; and the last column represents the state of the selenium. It will be noticed that the effect sought for is missing, or at least is so small that it becomes inappreciable. There seems a general tendency for the thermal conductivity to increase with increased temperature of the selenium, but there does not seem to be any tendency for any change with the illumination. This is to be noted in connection with the fact that the same illumination increases the electrical conductivity nearly three times.

T_1-T_2	T_3-T_2	T_4-T_2	T_1	T_2	T_3	$T_1+T_2/2$	C	k/k_2 × Const	R	State of Selenium
1	2	3	4	5	6	7	8	9	10	11
10.9	—3.3	6.7	27.2	16.3	13.0	21.8	27	.34	2.48	dark
10.9	—3.4	6.3	27.6	16.7	13.3	22.1	67	.35		light
12.5	—4.1	3.7	31.8	19.3	15.2	25.6	33	.37	2.12	dark
12.8	—4.2	3.7	32.1	19.3	15.1	25.7	70	.37		light
19.4	—7.1	—2.3	44.7	25.3	18.2	35.0	41	.39	1.75	dark
19.5	—7.2	—2.6	45.1	25.6	18.4	35.4	72	.39		light
27.9	—9.8	—7.7	58.6	30.7	20.9	44.7	45	.36	1.67	dark
28.2	—10.4	—7.7	58.9	30.7	20.3	44.8	75	.38		light
46.1	—17.5	—19.8	88.9	42.8	25.3	65.9	53	.39	1.55	dark
46.4	—17.5	—19.2	88.6	42.2	24.7	65.4	82	.38		light
61.7	—23.8	—28.8	113.5	51.8	28.0	82.7	92	.39	1.28	light
61.7	—24.4	—29.4	114.1	52.4	28.0	82.3	72	.40		dark
73.8	—29.1	—37.4	134.2	60.4	31.3	97.3	72	.40	----	dark

Conclusion.—Contrary to the experiments described above, by Bellati and Lussana, I have failed to detect any increase in the thermal conductivity of selenium as a result of exposure to light. At any rate while the electrical conductivity increased nearly *300* per cent., the thermal conductivity increased, if at all, less than *4* per cent. This does not seriously disturb the accepted electron theories, but makes us modify them in connection with the element selenium. It may be that the number of free electrons in the selenium is much smaller than the number in ordinary good conductors, and so that even if a large number of them are made free, there are still too few of them to have much effect on the thermal conductivity. In other words the thermal conduction is by means of the atoms and molecules. On the other hand it may be quite possible that there are no free electrons in the selenium in the sense of being completely free, but that they are unstable in the atom, and that the action of light makes them more unstable. The electrical conduction takes place then because the electric field can draw the electrons out of the atom. There being no field in the case of the thermal conduction, the electrons would stay in the atom, and hence there would be no change in the thermal conductivity with the increased illumination.

PHYSICS LABORATORY,
UNIVERSITY OF IOWA.

THE EFFECT OF CHANGE OF LAMP VOLTAGE ON VISION.

WM. KUNERTH.

It must be apparent to any one who has tried to read or study by the light of an incandescent lamp that there is occasionally such a great change in the impressed voltage as to be decidedly objectionable. These changes may be due to a turning on or off of a great number of lamps at the same instant, or to the closing or opening of a circuit containing a relatively big power consuming agent.

This report is to give an answer to the question as to how great a change in lamp voltage is permissible without being objectionable to the eye, and how small a change in lamp voltage can be detected by a person reading. It is based upon experimental results obtained from actual conditions in the laboratory.

The persons experimented on (10 in number) were seated in such a way as to have the light fall over their shoulders. They were college students with normal eyesight. The room was illuminated by a 100-watt, 110 volt tungsten provided with a shade. The normal intensity of illumination at the various places where these subjects used light varied from 0.84 ft. candles to 1.44 ft. candles, but the variation in sensibility of the eye between these limits is very small as shown by the curve in Plate XXXVII taken from Wickenden's ''Illumination and Photometry''. This variation was not sufficient to cause any serious error, for no appreciable difference was noticed between the data of the person who had high illumination as compared with the person who had lower illumination. It was therefore assumed that all the data thus taken could be compared on practically the same basis.

A mercury rheostat and a voltmeter were in the lamp circuit, and changes in the rheostat could be made without having anybody in the room become aware of it except as he noticed a change in the illumination. Also the change in voltage was sudden, just as on a line when energy is turned on or off, for it was accomplished by merely putting in or picking up a link. The watches of all people in the room were adjusted to agree with each other, and so placed before each person that he could easily see the exact time without attracting anybody's attention. No one then would notice another put down an observation as to change in illumination. These results were therefore independent of each other and were compared and summarized only after the test was complete.

The subjects were asked to read each his own text book while the test was going on. Each person was supplied with paper and pencil and requested to make note of changes in the illumination and the exact time at which the change took place; also whether it was an increase or decrease; whether it was much or little, and whether it was objectionable. The lamp was fed by a 120 volt storage battery, and hence was constant excepting for the changes purposely introduced.

The voltage was varied all the way from 115.6 to 68 volts by steps of 1-6 volt to 33 volts. The test was run in three installments of about twelve minutes each. The eyes had to be kept constantly on the book so as not to miss a change, and hence a much longer period was deemed undesirable. The changes were made at intervals varying from 30 seconds upward.

It may be noticed from the curve Plate XXXVIII, that a change of less than one volt is noticed by practically nobody and that a change of five and one-half volts is noticed by practically everyone. Account was also taken of whether the voltage change was an increase or a decrease. As there was practically no difference between the two in the effect upon vision the results were all plotted together in Plate XXXVIII, but it seems worthy of note that the eye is no more nor less sensitive to an increase in illumination than it is to a decrease. The subjects experimented on noticed every decrease as a decrease and vice versa. Such careful distinctions are perhaps not always made under ordinary conditions, for a person reading in his own home is not expecting changes in voltage as these subjects did.

The curve in Plate XXXIX shows how great a change in voltage is permissible without being objectionable. A change of 25 volts was objectionable to practically everyone, and a change of 11 volts was objectionable to half of the subjects. This test continued for only a comparatively short time. It is reasonable to suppose that the eye would show greater sensitiveness to changes and be more inclined to object if the voltage should show variations over a long period of time, say weeks or months. For that reason the minimum change here considered objectionable is perhaps a little higher than one meets in reality.

If carbon lamps had been used the permissible change would be much less. When calculated from the formula[1] $\frac{I}{I_{st}} = \left(\frac{V_o}{V_{st}}\right)^k$ where Io is the C. P. at a voltage expressed by Vo and Ist is the C. P. at a rated voltage Vst, the exponent k is about 3.6 for all tungsten lamps requiring 1.25 watts per M. H. C. P. and 4.8 for gem lamps requiring 2.5 watts per M. H. C. P. each at the rated voltage. From this it is noted that a change of 3.67 volts on the gem lamp produces as much change in the illumination as a change of 5.5 volts on the tungsten, which was the change noticed by practically every one. From the same formula it can be shown that only 7 1-3 volts change is required on the gem lamp to correspond to an objectionable change of 11 volts on the tungsten.

We have a right to use 3.6 for k when we deal with tungsten lamps whose efficiency is 1.25 $\frac{\text{watts}}{\text{M. H. C. P.}}$ and 4.8 when dealing with carbon lamps whose efficiency is 2.5 $\frac{\text{watts}}{\text{M. H. C. P.}}$ This was tried out by an auxiliary experiment in which tungstens were used ranging from 100 watts to 25 watts and carbons ranging from 100 watts (40 C. P.) to 20 watts (4 C. P.). For the carbons the efficiency is much less and hence the value of k greater; but for tungsten lamps the value of k is very nearly a constant.

For the older forms of carbon lamps the value of k is much higher, and hence the permissible change in voltage would be much less. For that reason much better regulation is required for the older types of lamps than for those most commonly used at present.

A 100-watt tungsten, also a 200-watt, and a 300-watt tungsten, all gas filled, having an efficiency of about 0.8 $\frac{\text{watts}}{\text{M. H. C. P.}}$ were also tried, with the result that the change in C. P. for a given change in voltage was a little more marked than for the vacuum tungstens. For the gas filled lamps the value of k in the formula was very close to 4. The above statements are borne out by the accompanying table showing experimental results.

[1]Trans. I. E. S. 3., p. 459.

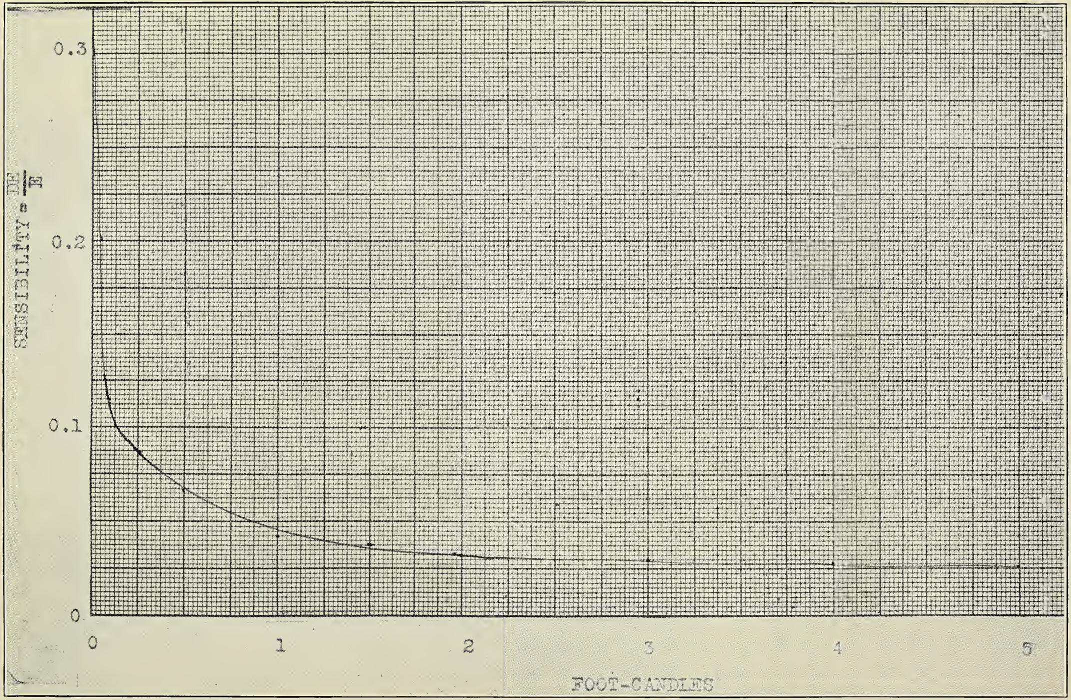
The decimals are the C. P.'s at the specified voltages as compared with the C. P.'s at 110 volts which are taken as unity.

Volts	100 watt Carbon 40 C. P.	50 watt Carbon 16 C. P.	30 watt Carbon 8 C. P.	20 watt Carbon 4 C. P.	100 watt Tungsten, 80 C. P.	60 watt Tungsten, 48 C. P.	40 watt Tungsten, 32 C. P.
110	1.0	1.0	1.0	1.0	1.0	1.0	1.0
105	0.765	0.766	0.757	0.716	0.840	0.853	0.860
100	0.583	0.566	0.559	0.490	0.712	0.706	0.698
95	0.437	0.422	0.413	0.338	0.583	0.600	0.587
90	0.321	0.301	0.282	0.218	0.475	0.480	0.474
80	0.156	0.138	0.133	0.096	0.302	0.305	0.317

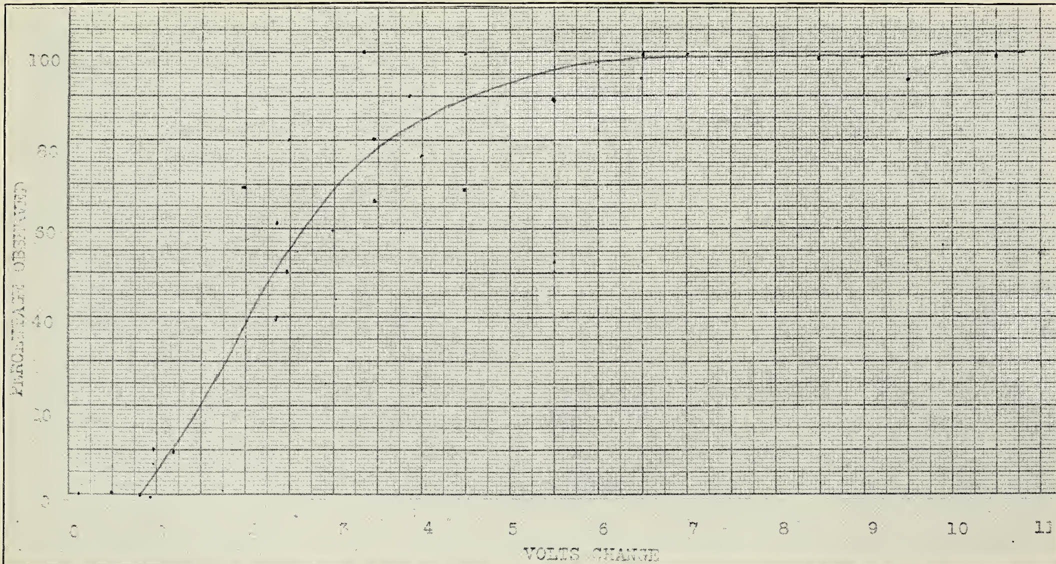
Volts	25 watt Tungsten, 20 C. P.	100 watt nitrogen filled	200 watt nitrogen filled	300 watt nitrogen filled
110	1.0	1.0	1.0	1.0
105	0.842	0.820	0.834	0.825
100	0.701	0.673	0.686	0.670
95	0.592	0.522	0.570	0.561
90	0.475	0.41	0.464	0.456
80	0.302	0.246	0.279	0.291

If the voltage changes came in very quick succession, (say at half second intervals) the changes in illumination would make themselves felt much more for the small sized lamps than for the big ones, because the filaments are thinner and hence cool off much more quickly. This, however, has no detrimental effects upon the results herein given.

Physics Laboratory,
Iowa State College.

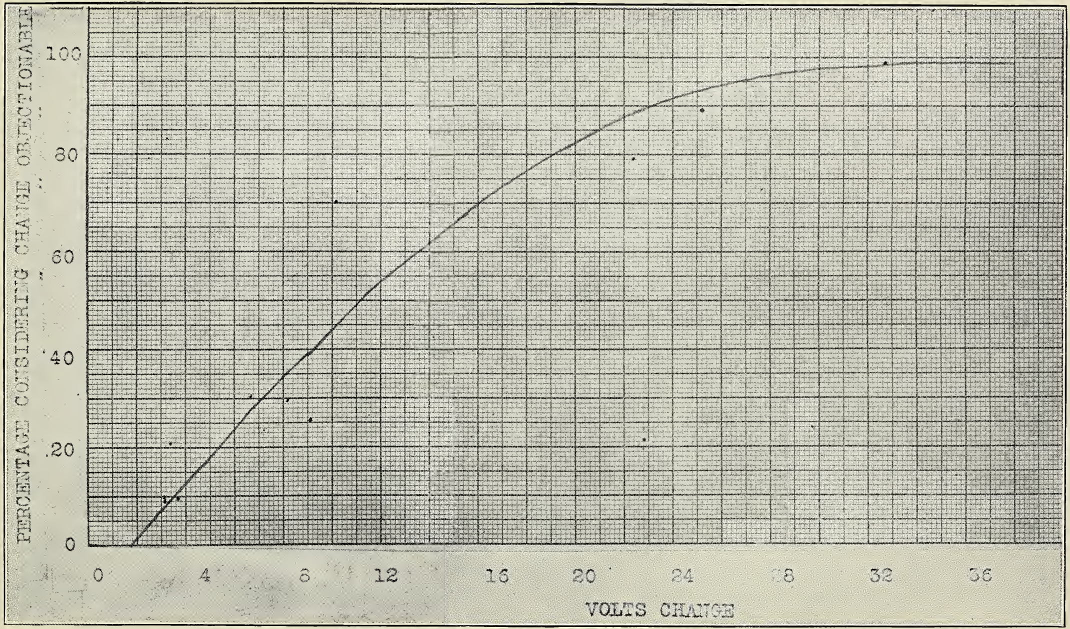


Variation in sensibility of the human eye.



Changes in voltage of lamps observed.

PLATE XXXIX.



Permissible changes in voltage.

PSYCHOLOGY APPLIED TO THE IMPROVEMENT OF CONTROL OF THE PITCH OF THE VOICE IN SINGING.

CARL J. KNOCK.

The object of this research is to ascertain some of the elements in the acquisition of accuracy of pitch in singing. The study was divided into three divisions: (1) a preliminary series of five tests, in which no information was given the observer in regard to the accuracy of his singing; (2) a practice series of ten tests, during which the observer was informed of the error in pitch after each trial; and (3) a final series of five tests conducted in the same manner as the first. The object of the first test was to ascertain the accuracy of their singing without training; the second was the training series, the object of which was to correct the errors and to form new tonal concepts and voluntary control; and the object of the third series was to find out whether or not the observers had profited by the training in the second series and to what extent they carried it over into actual practice.

The tonoscope, a 256 v. d. tuning fork, and a resonator were used in this experiment. The observers, four men and eight women, were all interested in music, but none of them had had any special training in singing. The tones sung were the fundamental, third, fifth, and octave. The fundamental tone was obtained from the fork. As soon as the observer had the given tone clearly in mind, he sang that tone and immediately followed it by singing one of the intervals.

The tables below give the average errors in terms of vibrations and the per cent of gain in the second and third series over the first.

MEN.

	First series. Error.	Second series. Error.	Second series. Gain. Per cent.	Third series. Error.	Third series. Gain. Per cent.
Fundamental	1.9	.5	77	1.1	42
Third	2.4	.9	62	1.8	25
Fifth	3.1	1.1	64	2.4	23
Octave	2.3	1.2	47	1.9	22

WOMEN.

Fundamental 4.2	1.8	57	2.3	45
Third 5.2	1.9	63	3.8	27
Fifth 5.9	2.3	61	4.2	30
Octave 6.0	3.4	43	3.5	44

The records show that the natural tendency of the women was to sing sharp throughout. The men sang the intervals sharp but the fundamental flat. Very few persons sing in true pitch. The reason for this is that the ear is not keen enough to detect small errors in pitch and to act as a check in accuracy of singing. This was very evident in the first series where no information was given the observer in regard to his errors. In this series the observers sang in their usual manner. Although they all sang sharp or flat, they were apparently satisfied with their singing, for they made no attempt to correct themselves. Hence we find that no improvement was made in this series and the variation in the average error was small.

In the second series the errors were proportionally much smaller than those in the first. This clearly indicates that accurate checking of errors in pitch enhances the ability to strike a tone and to sing an interval. The decrease in error was so pronounced in the first test that there was very little improvement made during the rest of the series.

The errors in the third series were somewhat larger than those of the second but smaller than those of the first. This is significant, for it indicates that there was a transfer of gain from the training series to the final unaided series; or, in other words, voluntary control had been developed through accurate checking of errors.

This proves quite conclusively that training with accurate checking of errors develops accuracy of pitch in singing. What the exact nature of the development is, may be difficult to explain, but it is probably in the form of new tonal concepts, better muscle control, keener discriminative power, increased confidence, and ability to eliminate disturbing factors.

Psychology Laboratory,
State University of Iowa.

PSYCHOLOGY APPLIED TO THE MEASUREMENT OF MERIT OF ADVERTISEMENTS.

HARRY H. GOULD.

The problem to be presented in this paper is that of measuring the relative merits of a series of advertisements. The advertisements are arranged in their order of merit with the best at one extreme, the poorest at the other, and the intervening ones in their ranking order as determined by the method of procedure used in the experiment.

The distinctive feature of this attempt is that it rests upon a fundamental analysis of scoring factors which serve as a basis upon which the judgments are made. The advertisements are compared and ranked upon the basis of each of these specific factors separately. To make the final results show the relative values of the advertisements as a whole, it is essential that this list of scoring factors shall be all-inclusive of those factors which go to make up a perfect advertisement.

The analysis of scoring factors was made in the following manner. First an analysis was made of the mental processes which must be induced in the reader by an advertisement in order to be effective. Thus it is necessary that the advertisement attract the attention of the reader; it must have attention value. Its meaning must be readily intelligible to the reader; it must have meaning value. It must create a favorable feeling tone in the reader; it must have feeling value of the right sort. It must be remembered; it must have memory value. And finally it must convince the reader and impel him to act; it must have persuasive value.

The next step was to carry this analysis still further and determine the specific factors which contribute towards each of these ends. The results of this analysis are as follows:

1. Attention value
    1. Intensity
    2. Strikingness
    3. Clearness
    4. Feeling tone
2. Meaning value
    1. Distinctness
    2. Relevance
    3. Familiarity
    4. Aptness
    5. Simplicity
    6. Specificness
    7. Vividness
    8. Emotional congruity
3. Feeling value
    1. Æsthetic appeal
    2. Familiarity
    3. Emotional congruity
    4. Sincerity
    5. Appeal to instincts
    6. Appeal to interests
    7. Appeal to emotions

4. Memory value
    1. Intensity
    2. Vividness
    3. Feeling tone
    4. Familiarity
5. Persuasion value
    1. Vigor
    2. Suggestion
    3. Appeal to instincts
    4. Appeal to interests
    5. Appeal to emotions
    6. Specific direction
    7. Personal appeal
    8. Authoritativeness

These scoring factors having been determined upon, the method of procedure is that technically known as the "order of merit method", the reliability of which has been demonstrated beyond question many times in psychological laboratories. According to this method, the advertisements are taken and arranged in a regular ascending order for one of these concrete factors at a time.

This arrangement is made for each of the scoring factors included in the complete analysis, and the place held in the series by each advertisement for each of these factors is recorded. Then the sum of the numbers indicating the ranking held by each advertisement in all of the twenty-four arrangements is found, and these numbers taken as a measure of the relative merits of the different advertisements as a whole; the smaller the number representing such sum, the greater the merit of the advertisement.

This method of measurement has been applied in our experimental work to series of mail order copy, and its reliability tested by checking up the laboratory results with the actual keyed results, so that we feel we can claim a reasonable degree of accuracy, both for the analysis of scoring factors and for the method.

If this method proves as workable in the hands of the average business man as in the case of the skilled observers used in these tests, the immense practical significance to the business world is apparent, when we consider that nearly a billion dollars are expended annually in advertising, and a large percentage of this amount is conceded by advertisers to be spent ineffectively.

Psychology Laboratory,
State University of Iowa.

THE PSYCHOGRAM IN VOCATIONAL GUIDANCE.

CARL E. SEASHORE.

The speaker reported a method, "percental rank", for reducing diverse psychophysic measurements to a common unit for the purpose of a simple and direct numerical statement and graphic representation of a series of measurements on talent. The illustrations were drawn from the measurements on musical talent. After a certain measurement has been standardized so that the various factors, subjective and objective, are under control, a large number, from 400 to 4,000, depending upon the needs, are made for the purpose of establishing a normal distribution of abilities. On the basis of this norm, all the cases are arranged in percental rank, the poorest one being 1 per cent, and the best 100 per cent, all the rest being arranged in the order of rank between these two extremes. Corresponding to this complete series of ranks the actual measurements, for instance, on tonal memory, are arranged in a parallel column so that one can at once convert a given measure on tonal memory into a percental rank or vice versa. The same is done for each and every kind of measurement but these are all reduced to the same unit so that a record may run something like this:

	Per cent.		Per cent.
Tonal hearing	19	Sensitiveness to sound	90
Tonal memory	46	Discrimination for sound	78
Tonal imagery	20	Reproduction of a tone	48
Consonance	70	Reproduction of an interval	52
Time sense	51	Vocal training	89
Free rhythm	31	Instrumental training	98
Regulated rhythm	39	Musical appreciation	40

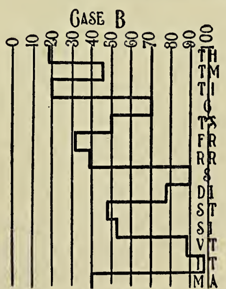


FIG. 28.—Psychogram showing musical talent.

These percentages may then be expressed in a single curve as here shown, which may be called a *psychogram.* Anyone acquainted with the meaning of these measurements can then tell at a single glance the specific character of individual talents in quantitative terms. The same principle may be applied to any kind of talent, regardless of how diversified the units of measurements may be.

Psychological Laboratory,
State University of Iowa.

SNAKES "SWALLOWING" THEIR YOUNG.

E. D. BALL.

Doctor Herrick in his review of the "Infancy of Animals" in a recent number of Science raises the question of the accuracy of observations on snakes swallowing their young. As the writer once had what was probably a particularly favorable opportunity to witness this phenomenon, it occurs to him that the following facts may be worth recording.

The country school in Iowa which the writer attended was held in the ordinary frame schoolhouse supported by a "cobblestone" foundation of water-worn rocks more or less embedded in mortar. The school house faced the south and a set of narrow steps led up to the single central door. Through the foundation wall about half way between these steps and the southeast corner of the building, and about eight to ten inches above the surface of the ground, was an irregular opening about two inches in diameter. This opening was used as a refuge one spring and summer by a large and "motherly" looking specimen of the common garter snake of the region. The snake kept close to the hole at first and disappeared at the slightest sound. Later as we became interested in it, it was not disturbed and became accustomed to the ordinary noises of the children and would, if not too closely approached, often lie in the sun along side the wall during recess time. One day as we came trooping out at noon the snake raised its head several inches from the ground, uttered a hissing sound and then lowered its head to within an inch or two of the ground and opened its mouth quite widely. This rather frightened us and all eyes were on the snake, when from around the corner of the house and from further away in the yard came a number of small snakes which rushed pell-mell into the open mouth of the mother. When the last one was in, the mother snake raised her head quite high, wriggled over to the hole and disappeared. She was back there again at the next recess and the performance was repeated for a number of days. After this the same thing occurred at each recess, and two of us, who had even then budding naturalistic instincts would occasionally ask to "go out" in order to get a performance for our special benefit.

When the troops of children were pushing and elbowing "to see" they would crowd up within a few feet of the snake, and the performance was very hasty and the snakes' disappearance rapid—the whole occupying only a few seconds. When, however, we went out alone and were careful not to get too near at the start, the mother snake would often not go into the hole at first but simply raise her head and remain in that position for several minutes, or until our curiosity prompted us to approach too close, when she would go in rather liesurely.

At these times the first little snakes to enter the mouth would almost instantly turn around and stick their little heads out and thrust out their forked tongues as defiantly as you please. Often there would be three or four of these heads sticking out at one time, and considerable signs of a rumpus going on inside her body a few inches back from the head. These signs we interpreted as the other little snakes fighting for a chance to get their heads out.

The little ones never seemed to be far away and often would be lying alongside the mother. The hiss seemed to be the sign for them to scurry for the mouth, and often two or three would be entering at the same time, while frequently before the last one was in there would be one or more heads sticking out. We never saw a little snake come entirely out, for as soon as the last one started in the mother snake would raise her head quite high, higher than that species ordinarily carries its head. The bulge in the mother snake was always in that part above ground, and there was always considerable movement in the bulge.

There could be no possibility of an optical illusion through the small snakes' going under the mother, because as soon as they were in, the head was always raised higher than the length of the little snakes and their heads and often an inch of their bodies would be showing out of the mouth at this time. Moreover the hole the mother's body went through was a tight fit around the bulge so that no little snakes could have gone in outside the mother, even if they could have reached up to the hole, which they could not. And if they were going into the hole at all, why go past it as they often did to reach the mother's mouth? This same performance has been witnessed several times since under less satisfactory conditions, but at the time no question had been raised in the writer's mind and no particular attention was paid the details.

UTAH AGRICULTURAL COLLEGE,
LOGAN, UTAH.

THE CROW.

FRED BERNINGHAUSEN.

The crow is the most harmful bird. He feeds on carrion and also carries hog cholera by feeding on the dead hogs. He commences feeding at the ear and there takes his fill, then flies from one farm to another and so carries the disease. Loss from hog cholera three years ago was ninety-nine thousand and nine hundred and ninety hogs; two years ago it amounted to one hundred forty-seven thousand six hundred and seventy. The crow will carry the foot and mouth disease in the same way and also destroys the newborn sheep in the pasture by picking out their eyes.

Three years ago the loss to the United States on account of weeds was one hundred forty million dollars, now the report is two hundred million dollars a year. Iowa is an agricultural state and we lose a large part of this money. We have three kinds of ground sparrows and they destroy in Iowa one hundred seventy-five tons of weed seed every year. These birds begin nesting in the month of March and raise young ones until August. The crow flies over the ground where the farmer puts in his oats and destroys the nests of the ground sparrows which are between the corn stalks on the ground. When the ground was new the crow fed on grub worms but now as there are but few grub worms he feeds on the young ground sparrows.

He is also a destroyer of the wild canary bird which nests about ten to twenty rods from a farm building in the tassel of the corn. This leads people to think the crow goes after the corn, but if he was going to eat corn he would feed at the far edge of the field, as the farmer is no friend of the crow.

He is also a destroyer of the prairie chicken which eats eighty per cent of butter print or ragweed in this state. The farmer will leave a rod or so in the hay field where there is a prairie chicken's nest; but the crow will soon spy the nest and destroy the eggs of the young ones.

The crow destroys the quail's nest too. He will fly up and down till he finds the nest, runs the parents from the nest and destroys the eggs of the young ones. The quail feeds on morning glory seeds, potato bugs and foxtail.

It has been stated that the crow eats grasshoppers but this is not always true as the grasshoppers are to be found at about the time the corn is in the milk stage and the crow feeds on the corn rather than on the grasshopper. If you dissect the crow you will find his stomach contains corn instead of grasshoppers. Further than this how many eggs and chickens does he destroy in Iowa? He is also a destroyer of many helpful birds in the forest-growing country. The birds that are seed destroyers are as follows: first, the ground sparrow; second, the mourning dove; third, the wild canary; fourth, the quail. These birds are of great value to the farmers of the state. But the crow is a destroyer of these birds. Therefore there should be a bounty on the crow in every county.

ELDORA.

NOTES ON IOWA PENTATOMOIDEA.

DAYTON STONER.

The average person usually refers to almost any kind of insect as a "bug" but, employing the latter term in its proper sense, it represents the common name of an insect which belongs to one of the largest and best represented groups in North America. All bugs belong to the order Hemiptera which name is derived from the character of the fore wings though wings are not present in all members of the order. The group may be briefly diagnosed as follows:

Metamorphosis incomplete, i. e., there is no resting stage or period during which the insect does not take food in the course of its development after hatching. Mouth suctorial and of the same general form throughout all the stages; owing to the structure of the mouth parts these insects are able to take only liquid food. Wings developed outside the body except in a few apterous forms. Malpighian tubes few in number. Head set into pronotum.

This large order, comprising about 6,000 species in North America, is of great variety and of considerable economic importance. The noted entomologist David Sharp says that "If anything were to exterminate the enemies of Hemiptera, we ourselves should probably be starved in the course of a few months."

The Hemiptera are apparently not closely related to any other existing order of insects and Kirkaldy suggests that, without doubt, they have sprung from a Paleozoic or Archeozoic neuropteroid source. As a matter of fact the Hemiptera have sprung from neuropteroid forms but no true Hemiptera existed in the Archeozoic and it is not until Lower Permian that the first hemipteroid type is found; it is in that period that we find the first instances of typical hemipterous mouth parts.

The Hemiptera of Linneaus' time were practically the Hemiptera of the present day except that the family Thripidæ is now excluded. Some authors have employed the term Rhynchota or Rhyngota to designate the order but this seems to have sprung from Fabricius' use of the name in his "Systema Entomologiæ" which was published in 1775. The name "Hemiptera" was used by Linnaeus in the 10th edition of his "Systema Naturæ" and in order to be consistent with the laws of priority we must adhere to this nomenclature.

The scope of the superfamily Pentatomoidea may be briefly summarized with the statement that the members are Gymnocerate Heteroptera having a short, broad, lozenge-shaped body and a very large scutellum. Antennæ usually of five segments. Labium with four segments.

WORK THAT HAS BEEN DONE ON IOWA PENTATOMOIDEA IN IOWA.

Practically nothing has been done on this group in Iowa outside the lists and a few notes by Professor Herbert Osborn now of Ohio State University. At the time of his work on Iowa Hemiptera (1888-1898), Osborn was associated with the Iowa State Agricultural College at Ames and his specimens are now in the collection of that institution. All of Osborn's notes on Iowa Pentatomids were published in the Proceedings of this Academy and the dates together with brief summaries of his papers now follow in chronological order so that the historical setting of this work may be brought to mind.

Proc. Ia. Acad. Sci., 1888, page 40, Herbert Osborn—"The Hemipterous Fauna of Iowa" (abstract). In this paper the number of families of Homoptera and Heteroptera occurring in the state is mentioned as well as the number of genera and species in each family. Twenty-one families are listed for the Heteroptera. Of the Pentatomoidea, the number of genera and species in each family is indicated as follows:

Scutelleridæ	2 genera	2 species
Thyreocoridæ	1 genus	3 species
Cydnidæ	2 genera	2 species
Pentatomidæ	17 genera	26 species
Total	22 genera	33 species

Proc. Ia. Acad. Sci., Vol. I, Part II, 1890-1891, pages 120-131, Herbert Osborn—"Catalogue of the Hemiptera of Iowa". In this paper the number of species recorded from the state is raised to thirty-seven. They are distributed among the families as follows:

Scutelleridæ	2 species
Thyreocoridæ	3 species
Cydnidæ	3 species
Pentatomidæ	29 species

Localities and abundance only are given.

Proc. Ia. Acad. Sci., Vol. I, Part IV, 1893, pages 120-123, Herbert Osborn—''Notes on the Distribution of Hemiptera''. At this time an additional species (*Eurygaster alternatus* Say) was recorded for Iowa, thus raising the number of recorded Iowa species of Pentatomids to thirty-eight. Little more than locality records for this species and for other species before recorded are given. Twenty-nine species of Pentatomids are mentioned in the paper but most are listed from other states.

Proc. Ia. Acad. Sci., Vol. IV, 1896, pages 172-234, Herbert Osborn and E. D. Ball—''Contributions to the Hemipterous Fauna of Iowa''. Here, locality records for a few species of Pentatomids are given.

Proc. Ia. Acad. Sci., Vol. V, 1897, pages 232-247, Herbert Osborn—''Additions to the List of Hemiptera of Iowa with Descriptions of New Species''. In this paper eight additional species are listed along with one genus, *Geotomus* sp. of the family Cydnidæ.

Proc. Ia. Acad. Sci., Vol. VI, 1898, pages 36-39, Herbert Osborn—''Notes on the Hemiptera of Northwestern Iowa''. Four additional species are listed at this time so that the total number of recorded species to this date was fifty-one. Brief notes on the abundance, occurrence, etc., of the four newly recorded species are given along with some similar data on other species of Hemiptera.

Proc. Ia. Acad. Sci., Vol. VI, 1898, pages 40-46, H. E. Summers—''A Generic Synopsis of the Nearctic Pentatomidæ''. This work is largely a translation and rearrangement of the Nearctic genera and subfamilies as found in Stal's ''Enumeratio Hemipterorum'' and affords a convenient table for determining the Iowa genera.

Summing up, then, all the species of Pentatomoidea recorded by Osborn we find a total of fifty-one. His first list, which was also the first list for the state, gave a total of thirty-three species so that during the decade from 1888, the year of the appearance of the first list, to 1898, the year in which the last additions were made to this list, an increase of eighteen species is noted.

SCOPE OF THE PENTATOMOIDEA IN NORTH AMERICA AND IN IOWA.

Nathan Banks in his "Catalogue of the Nearctic Hemiptera-Heteroptera", (Am. Ent. Soc., 1910) lists 218 species in the group Pentatomoidea. The four families are represented by the following number of species:

Pentatomidæ	149 species
Scutelleridæ	25 species
Cydnidæ	28 species
Thyreocoridæ	16 species

As the writer's collection now stands all but thirteen species of the fifty-one recorded from Iowa by Osborn are represented by Iowa specimens; of these thirteen recorded species, five are represented in the collection but these specimens are from nearby states and so can not be included in the list of Iowa species so far as this collection is concerned. Of the 218 species of Pentatomoidea recorded from North America, 113 species are now represented in the collection.

In addition to Osborn's list of fifty-one species, six species have been added to the state faunal list during the past two summers. One of these is the Harlequin Cabbage Bug (*Murgantia histrionica* Hahn) which is of great economic importance in the south but which seems to have reached its northern limits of distribution, at least in this longitude. But two specimens of the species have been found and, although the search has been continued in various supposedly favorable localities in the state, other specimens have not come to light.

Since most of the species still unrepresented in the collection have been recorded from the western part of the state it is likely that a summer's collecting in that region will yield the greater number of these as well as, perhaps, some new records. Geological and floral conditions in western Iowa begin to take on the characteristics of the Great Plains farther west so that this region in Iowa should show a hemipterous fauna at least approaching that of the plains across the Missouri river.

TIME AT WHICH THE WRITER'S WORK WAS BEGUN.

During the spring of 1913 the writer began assembling specimens of the group Pentatomoidea as a working basis for future investigations on the subject. About fifteen species donated by Professor Wickham and a few other species which the writer already possessed served as a nucleus for the collection. Since that time, through the media of collecting, donations, exchanges and purchases, the collection has been considerably augmented as has been indicated above. Many locality records from the United States and a few from Canada and Mexico are included in the list.

OBJECT AND PLAN OF THE PROPOSED WORK.

Since, as before mentioned, little has been done on the Iowa species of the group Pentatomoidea, and that some time since, it was thought that some contribution might be made if data were collected on the following points—synonymy, descriptions, tables for determining species and genera, locality records, distribution and abundance of various species in detail, ecological notes, food habits and as complete a bibliography as possible.

During the progress of the work thus far it has been found that literature bearing on only Iowa species is widely scattered, must be obtained from many sources and some is quite inaccessible to many students on account of its cost or rarity. No single book or paper which the writer has seen has dealt with all these subjects for the group as a whole although some work of a similar nature has been done on a few of the genera. For this reason it was thought advisable to bring as much as possible of this matter together in one place and also to add any new material and information that might seem worth while. To accomplish this end much field observation and collecting will be necessary and this part of the work is only now fairly under way.

COLLECTING OF MATERIAL.

In work of this sort much material for comparison is needed; specimens of any given species from widely separated localities are desirable in order to determine the limits of distribution and the ecological status of the species; specimens of plant-feeding species from as many different plants as possible are desirable for a knowledge of food habits as to whether they are of limited or wide latitude; specimens of predaceous forms taken in the act of feeding are interesting and valuable from the economic standpoint; and specimens taken under other and varying conditions all help to complete one's working collection of a group. In order that the fauna of the state may be typical and representative in a collection, specimens must be secured in many localities presenting different geological, ecological, botanical and other conditions.

The studies of the writer have been greatly facilitated through another line of work that is being undertaken for the Iowa Geological Survey and, in conjunction with this investigation, practically every county in the state will be visited before the work is completed. It is largely through this kind of collecting that some additions to the locality records of Osborn will be made and the limits of distribution for the state be worked out more definitely.

Most of the Pentatomids are taken by beating vegetation with a sweep net. The Cydnids are found in or on the ground and something may be learned of the hibernating species in the other families by searching under sticks, leaves, rocks, etc., in winter, fall and early spring. A few species have been found in almost every month of the year.

ECONOMIC STATUS OF THE GROUP.

Many of the species of the Pentatomoid group are of considerable economic importance from an agricultural standpoint. Some are beneficial and some are harmful but it is not often that any great damage is done by any of the Pentatomids except in the case of the Harlequin Cabbage Bug. This insect feeds on cabbage and other cultivated and wild Cruciferae and the loss each year in the southern states amounts to thousands of dollars. Great numbers of the bugs attacking a plant will cause it to wither and die due to the many punctures made by the insects' beaks and to their taking up of the plant juices. Often entire fields are devastated by this hardy and prolific insect.

At Ames, in the summer of 1913, we found that potatoes were attacked by the Negro Bug, *Thyreocoris pulicaria* Germar, and some of the plants, particularly young ones, were stunted in growth. Nothing of a serious nature was observed, however. Tobacco is often injured by these bugs but, of course, not to any appreciable extent in this state.

The genus *Euschistus,* which includes one of our most abundant and widely distributed species, E. *variolarius* Beauv., contains other species which are mainly plant feeders, though a few are predaceous to some extent and are beneficial for the most part since they destroy noxious insects. *Euschistus variolarius* is known to feed on Asparagus, Carduus, Thermopsis, Zea mays, broom corn, oats, rye, red clover, tomatoes, raspberries, mullein, peaches, tobacco and grasses. It is also said to feed on some lepidopterous larvae as well as on plant juices. In Iowa we have found this insect most commonly in fields of clover and timothy.

Perhaps we are most familiar with the members of this family as a whole from the fact that when one of the bugs is disturbed a very ill-smelling odor is given off. And often when eating raspberries, blackberries or strawberries from the vines we have tasted something equally as bad. It is due to this propensity for crawling on berry vines coupled with the evil odor that many of the Pentatomids are known as ''Stink Bugs'' or ''Berry Bugs''. The odor emanates from an internal secretion which may be liberated at the will of the insect. In the adult, the fluid issues from a small opening on the episternum at either side of the mid-coxae. The shape and disposition of this opening is of considerable taxonomic importance.

The members of the old genus *Podisus* may, on the whole, be classed among our beneficial bugs since they destroy annually great numbers of noxious insects. This genus is represented in Iowa by five species. In the nymphal stages many of the bugs are plant feeders and in the adult stage some are predaceous and others are both predaceous and plant feeding, sometimes to an injurious extent. Among the insects attacked by the species of *Podisus* found in Iowa may be mentioned several species of leaf-feeding beetles (Chrysomelidae). In the eastern states the larvae of the Gypsy Moth and other noxious lepidopterous insects have been recorded as being preyed upon by various species of the genus.

COMPARISON OF THE WORK ALREADY DONE WITH THAT NOW IN PROGRESS.

As previously mentioned, in practically the only work done on Iowa Pentatomoidea, that of Osborn, little more than lists of the various species are given. In only a few instances are food plants included and his collecting was rather circumscribed in its scope, most of his locality records being from Ames and a few points in northwestern Iowa. This is not in criticism of Osborn's work for his studies in Iowa Homoptera were much more extensive and thorough. But the fact still remains that no other investigation of this group has been conducted since in the state.

Of the species *Neottiglossa undata* Say, Osborn says, ''not common'', and this is the only reference that has been made in any of the literature as to its status in Iowa. The writer has specimens of this species from the following localities: Ames, Iowa City, Monticello, Centerville, Homestead, Dubuque, Waukon, Chariton, Des Moines, Indianola, Decorah, Robinson and West Union. It has been taken on mullein and grape. The following field note will give some idea of its abundance: "7 July, 1914, This species (*N. undata*) very common along roadsides and on grape just south of the West Side at Ames, Iowa. Collected thirty specimens and as many more could easily have been secured * * *."

Osborn says of the species *Hymenarcys aequalis* Say, "not common". More than fifty specimens are in our collection from the following localities: Iowa City, Bayfield, Monticello, Hampton, Indianola and Corydon. We have found the species in practically every month of the year.

The pretty green species *Thyanta custator* Fabr., is indicated as "not common" in Iowa and Osborn suggests that it has about reached its eastern limit for this latitude. However, we have found it in practically every one of the thirty-four counties visited in the state during the past summer. A considerable number of host plants are mentioned in our field notes.

Still other records might be cited but it will be been from the above instances that conditions within the state have changed during the past fifteen years and it is not surprising that the work of more than a decade ago has become somewhat antiquated. It is due largely to this state of affairs that the field offers good opportunity for investigation.

The difficulties encountered in a problem of this kind, as may be expected, are numerous and oftentimes perplexing and complicated. Such matters as what system of nomenclature to employ, questions of synonymy, thorough collecting in certain localities, the ever-present question of what constitutes a species and many other and sometimes unforeseen hindrances confront one continually. It seems to the writer that if one can contribute one's small portion by assisting another who may, at some time, be working on a similar problem something will have been accomplished. If at least some of the way shall have been made a little easier for other workers in the field the effort will not have been in vain.

State University of Iowa.

NOTES ON THE DISTRIBUTION OF THE PRAIRIE SPOTTED SKUNK IN IOWA.

B. H. BAILEY.

In 1906 the U. S. Department of Agriculture published faunal bulletin No. 26 by Arthur H. Howell, Assistant Biologist of the U. S. Biological Survey on the "Revision of the Skunks of the Genus Spilogale". According to this report the only species referred to Iowa is *Spilogale interrupta* Raf., three specimens of which were examined from this state, one of which came from Gladbrook, and two from Marshalltown. His distributional map shows the range of this species as extending to southeastern Minnesota on the following statement by Mr. E. T. Seton "He (E. T. Seton) states that two were killed by a trapper in March, 1904, on the Mississippi river 40 miles southeast of Minneapolis. The animal was previously unknown to trappers in that region, so that this is doubtless an instance of recent extension of range."

In a more recent work, "Mammals of Illinois and Wisconsin," by Dr. C. B. Cory of the Field Museum, Chicago, is the following: "This species may occur in western Wisconsin, as its range is known to extend to northeastern Iowa and the southeastern border of Minnesota but so far as known it has not as yet been taken within our limits." Whether Dr. Cory or others have actually examined specimens from northeastern Iowa I do not know, but a head of *Spilogale interrupta* which was killed at Chester, Howard county, Iowa, April 20, 1915, makes certain the fact that they are found there.

As to the region in Iowa south and east of Marshalltown no published account of the distribution in this territory of animals of this genus could be discovered. I knew that spotted skunks or civet cats, as they are commonly called, are found about Cedar Rapids, and, hearing rumors that they extend farther south and east, a trip to Burlington and Keokuk, April 1 and 2, afforded the opportunity to make inquiry about this species in that part of the state.

At Burlington I purchased from Mr. H. Ranke, a local furrier, a raw skin of *Spilogale interrupta* which was taken about four miles north of the city, and he also permitted me to examine a number of tanned skins which unfortunately had the tails removed in the process of tanning. Though they varied in the amount of white in the body markings they were apparently all skins of *Spilogale interrupta*.

Mr. Ranke stated that he has never seen one of the civets with white at the end of the tail. The skin purchased shows as much white in body markings as any of the others, but the tail is entirely black at the tip. Mr. Ranke also said that they are caught sparingly on the Illinois side of the Mississippi.

Mr. Weil of Weil & Hirsch, fur buyers at Burlington, said that fifteen years ago Illinois trappers who came to Burlington from the Illinois side used to ask him what those little spotted skins were which they saw among his furs. Now, however, a few are caught on the Illinois side. Mr. Hirsch also said that about 10 per cent of all skunks trapped at Burlington are civets.

In Keokuk I found in the public school collection, a mounted *Spilogale interrupta*, which was probably, though not certainly, a local specimen. It bore the date of March 6, 1873, and was labeled *"Memphitis chinga"*.

Mr. Louis Sterne, a fur buyer in Keokuk, says that to his knowledge the civets always have black tails, and that about three out of ten of all skunks he buys are civets.

On April 24 at Davenport three mounted specimens of *Spilogale interrupta* were examined at the Davenport Academy of Sciences. Two bore labels and the third was without data. Number 6077 and number 6078, *Spilogale interrupta*, were both taken within the city limits of Davenport, December, 1905, by Mr. E. S. Ballord. Each specimen showed a very little white pencil of hairs at the tip of the tail. The skulls could not be examined.

Upward of sixty tanned skins of *Spilogale interrupta*, many from southeastern Iowa, were examined at the store of Richter and Sons, Davenport. The tails were still on these skins and only seventeen showed even a pencil of white hairs at the extreme tip.

Inquiry at Mt. Pleasant, Fairfield and What Cheer, indicates that the spotted skunk is a not uncommon animal in those parts.

In the Mammal Hall of the State University of Iowa Museum are two mounted specimens and one skeleton of *Spilogale interrupta*, Nos. 11670, 10624 and 11671. All were taken at Solon, Iowa, in the fall of 1894 and collected by J. M. Adams. These are typical. A skull of *Spilogale interrupta*, No. 24221, in the

State University Museum also was examined. It is from Wall Lake, Iowa, December 2, 1908, collected by John A. Spurrell.

Dr. C. B. Cory of the Field Museum, Chicago, kindly sent for examination and comparison three skins and skulls of mammals of this genus; two are of *Spilogale interrupta* and one of *S. putorius* which is reported to come into southern Illinois. The latter specimen, *S. putorius,* is a topotype and differs markedly from all our Iowa specimens examined, especially in the amount of white at the end of the tail, and to a lesser degree in cranial characters.

I find at present no evidence of intergradation between *Spilogale interrupta* and *S. putorius* in Iowa. That this may occur in western or southern Illinois is not unlikely.

The present paper endeavors simply to extend the known distribution of *S. interrupta* over eastern and southeastern Iowa, in fact making the known distribution of this species state wide.

THE BUILDING AND FUNCTION OF THE COLLEGE MUSEUM.

B. H. BAILEY.

It is with a keen sense of how far short of the real mark he shall come that the writer aims at the center of this target. It is also with an appreciation of the situation in the average college with regard to meager funds, limited space, lack of appreciation by the authorities as well as the public, and the frequent unpreparedness along museum lines and the overworked condition of the professor of natural sciences.

Few of our Iowa colleges are without some sort of a museum. The catalogs either list the museum under that name in the index or mention is made of it in connection with the courses in Biology. That there has been at some time or other a person, or persons, in all these places who have spent time and money in the collecting of objects of various sorts which appealed to them, or to others who have donated them, our college museums attest. That this spirit of collecting and preserving objects of natural history is worthy I think no one will deny, but the present condition of the average college museum leaves open to serious question whether the time and effort required are worth the candle, and the question may well be asked what real purposes do they serve.

May I say, too ,that the acquaintance of the writer with college museums has not been gained by a mere perusal of the catalogs of these institutions, else I might be of the opinion that there was left little to be desired in them but that the alumni and friends should add to their volume.

The actual inspection is made with difficulty in some cases after the janitor has been located, after the proper apologies for dust and evident lack of care have been made, and the statement that really very few visitors are admitted and the department makes little use of the material for teaching. Sometimes, however, one's pilot points with evident pride and volubility to the sorry row of "stuffed" objects hanging from perch or stand, the remains of what might be mistaken for a "shredded wheat biscuit" meal in evidence through some crack or seam, and a label scarcely more definite than the conception of a lifelike pose in the mind of the taxidermist whose work they are. Now it is not my purpose to ridicule such exhibits for I have been guilty of all the above and our institution still contains specimens of the above type, but I have tried to see what better things may come to us all in the effort to get away from these travesties on the most beautiful of created things, these "museums of unnatural history," as they have been called.

The primary function of a college museum, as I understand it, is its utility as an agency for illustrating what is taught in the curriculum. This at once limits the field of the college museum. In general, articles of virtu and mere curios are not desirable, and other limitations may suggest themselves according to the range of the subjects taught in the institution. A knowledge of what to keep out of the museum is quite as necessary as what to admit and feature, and the common practice of turning over to the college museum the curios of the "what not" or the accumulations of the garret, while it yields an occasional good and useful specimen, generally should be discouraged unless one is allowed a free hand in augmenting the dump with much of this rare (?) junk. Another bugbear is the collection which widow so and so wishes to leave to the colllege as a memorial to her husband on condition that it be kept intact in its own case as presented. Unless such collection can be distributed, of course, with the donor's name on each specimen, the collection is a nuisance, and only if large enough to be separately housed or, in case it is a special collection along some one line is it worth admittance. Imagine a library made up of Smith's or Jones' or Brown's private book collection each ranging all the way from the works of the immortal William S. to the Tip Top Weekly and each housed in its own peculiar case with a label indicating why its owner had no further use for it! I am convinced that the college museum may well keep within the bounds of the subjects of the departmental curriculum and that all the material admitted be available and free for such disposition as in the curator's judgment seems best.

With a view then to its usefulness in teaching, I strongly favor the placing of emphasis on local collections. The local flora and fauna, geology and mineralogy, should receive first consideration. To a large degree this material can be secured with comparatively little expense, and in the course of years the collections for that locality made by carefully directed students, as well as by people of more scientific attainment, may become fairly complete.

After the local collections I would place the purchase of typical specimens from foreign parts, which will supplement the local material and be useful as illustrating more completely the subjects taught. The matter of exhibiting in a college museum striking or extraordinary objects of any kind merely because they attract attention is to be discouraged.

Unless funds are available to purchase occasional supplementary specimens there will be a lack of balance. This can be helped by exchange with other museums, but one is sadly handicapped without funds for this purpose.

After the question of what to exhibit comes the question how to exhibit. This is difficult to answer or even discuss because of the varying conditions in colleges, but I do not refer now so much to the room or space available, as to the method of display.

The conception of a museum as a "series of carefully written labels each illustrated by a good specimen" is to my mind close to the mark. A carefully labeled specimen though not so perfect may be and often is far more valuable than a more perfect specimen poorly labeled or with no label at all. The thousands of unlabeled or poorly labeled specimens in our Iowa collections is enough to make one's heart ache (and one's head ache if he is searching for information). Too often also is it true that "out of sight is out of mind" and unlisted material that is stored in drawers is forgotten just when most needed for the class room. A card index and catalog of accessions will prevent this. The usefulness of a museum is directly in proportion to its accessibility.

Another function of the college museum should be to save in as nearly perfect condition as possible and permanently, such specimens of our vanishing life as may come to hand. This brings up the question of modern taxidermy. Even the best museums of the east are finding the methods of a few years ago utterly failing in their durability and permanency. Skins cured with alum and stretched over clay manikins, like Hornaday's Giant Ray, apparently "get mad and tear themselves to tatters." The methods now followed however seem to promise better things and I believe are permanent if skillfully done. Specimens will always require care but once thoroughly prepared the necessary attention is reduced to a minimum.

Faithfulness in mounting and permanency should be our aim. There is no more reason why we should put up with the painful and grotesque stuffed birds and mammals that stock our college museums than that we should be satisfied to draw our ideas of art from a few cheap chromos, or that our notion of music be obtained from instruments out of tune. The best in taxidermic art today stops in birds just short of the song, and in mammals just short of graceful motion. A few well mounted and carefully labeled birds and mammals would be far more attractive than and fully as useful as the scores of poorly stuffed specimens now to be seen everywhere. The cabinet or closet might better hold the rest in the shape of skins, where they are just as useful and look far better.

May I lay especial emphasis on the saving of species that are destined to speedy extinction. In the Coe museum a Whooping Crane has occupied a conspicuous position for years though poorly mounted and with feathers stained with grease. Dr. Hornaday most emphatically advised its preservation and it was recently remounted by an expert at the Carnegie Museum. Today it is a thing of beauty and promises, with reasonable care, to be a joy forever. There are many specimens in all our museums that are worthy of similar treatment. If not given attention, a few years at most and the grease, if not the insects, will put these specimens forever beyond recall. It is truly startling to find how little of Iowa material is in the largest and best museums of this country and it is distressing to note the shabby condition of that within the museums of our own state. I read with peculiar pleasure the words of Prof. Henry Osborn, the first President of this Academy, in his address to the newly organized society, (P. 35, Iowa Academy Proc., 87-88-89; Pub. 1890) in which he says, ''The principal means at present existing for the illustration of the fauna, flora, geology and mineralogy of the state are connected with educational institutions. The State University, Agricultural College, Iowa College at Grinnell, Cornell College at Mt. Vernon and possibly some others possess collections of some extent. In all of these, however, and necessarily from the educational standpoint, it will be found that much space is given to foreign animals, and that our local fauna is meagerly represented. In none of them is there anything like a comprehensive exhibit of the state fauna. The State University is rich in mammals from the Hornaday collection, and will doubtless have a good representation of the mammalian fauna of the State. The Agricultural College has a fairly complete series of the birds of the State, either mounted or in skins, also considerable collections of reptiles and insects. The museum of the Davenport Academy has a more local object and its museum is espcially rich in anthropology. It will be seen that in no place in the State is there a collection especially devoted to exhibiting the resources of the State,'' etc.

While some institutions have made strides in the direction suggested twenty-five years ago by Professor Osborn, the colleges of Iowa have lagged sadly behind and some college museums have deteriorated rather than improved. May not the coming twenty-five years mark a distinct advance in the development of the museum as an educational factor in our colleges, and an attractive as well as valuable center for the dissemination of the truths of nature.

BIOLOGICAL LABORATORY,
COE COLLEGE.

MACROSCOPIC FAUNA OF A SMALL BROOK.

D. M. BRUMFIEL.

INTRODUCTION.

The brief paper here presented is but the first of a series of studies which the writer proposes to work out concerning the ecological relations of the animal life of Johnson county. Johnson county has been chosen as the field for observations for several reasons, among which are its availability from Iowa City and the University buildings as a center, its wealth of diversified habitats, and the most excellent work already done by Professor Bohumil Shimek in the field of plant ecology, upon which all studies of animal ecology depend, as all animals ultimately depend upon plants for food.

Any piece of work must have a beginning. The animal life of the small brook was chosen as an opening wedge to the larger subject because the brook represents the earliest stages of the development of a permanent stream in the reduction of the purely terrestrial habitats to the ultimate sea level water habitat by the process of erosion. Such streams afford the most favorable opportunities for study during the spring months. A further reason for the choice lay in the fact that the particular stream which receives the attention of this study lies within a few minutes walk of the State University.

The writer does not hope to introduce any new or startling facts. The fauna of the typical small stream has been surveyed and recorded many times and the various habitats with their respective associations of species which it affords have received treatment in Shelford's Animal Communities of Temperate America. However, no extensive consideration of the animal life of the county could be considered complete without such a study and its present application to an Iowa stream may prove interesting to workers other than the writer.

THE STREAM.

The brook which is made the basis for this study lies within the city limits of Iowa City, although its valley lies outside the residence district. There are one farmhouse and three suburban homes which might indirectly contribute sewage contamination to its waters. It forms the north fork of what was formerly known as Butcher's Run, due to the location of a slaughter house in its valley years ago, and it is virtually a tributary of that slightly larger stream. It joins Butcher's Run a few rods from the juncture of that stream with the Iowa river. The smaller north fork was chosen rather than Butcher's Run for the greater part of these observations because the latter has ceased to be normal owing to the encroachments of dwelling houses along the upper part of its course.

North Fork has a sinuous course for about one-third of a mile through partly wooded bluegrass pasture. Its valley forms the characteristic V of young streams. This valley secures its supply of ground water near its head in the form of seeping springs. For some distance below this point the stream is scattered through a semi-boggy, grassy area with a definite channel only at intervals. The upper part of its course runs through soil and has less well defined alternating rapids and pools than would be the case if the material were more heterogenous. The lower portion of its course shows in sharp definition the alternation of pools and rapids. Some of these pools were perhaps a rod in extent and showed a depth of over a foot (Plate XI, figure 1). The rapids show little of the loose stone, gravelly character so often encountered in small streams but are formed by the outcropping of solid shelves of stratified rock over which the water passes from one pool to the next (Plate XL, figure 2). Such rapids provide scant shelter and places of attachment for many of the common forms of rapid water life.

The bed of the stream was filled throughout with quantities of the decaying leaves which had fallen from the trees in forested portions of the basin and had been concentrated by the rains in the main stream beds. These, with the algae covering the rocks and generously distributed throughout the streams, afforded an unlimited food supply to all plant feeding forms.

On April 10 the stream was dry for a few rods at its mouth but showed running water elsewhere in its course. It is said to go completely dry for weeks at a time during the summer months.

ANIMAL ASSOCIATIONS OF THE BROOK.

The animal life of such a brook as that described lends itself to ready classification into special associations depending upon the nature of the physical and vegetational features of the environment. For example the rich fauna of many of the larger pools consists of a surface film association, a bottom association, a free-swimming association and a marginal or transition zone association, etc. For convenience it has been deemed advisable to consider the life of this brook under two main heads, (1) the upper brook, and (2) the lower brook, with various subdivisions into associations where the data permit.

(1) The upper brook.

The upper part of the stream, as has been mentioned already, consists of a slowly moving shallow stream of water, with occasional clear cut channels, but for the most part creeping through semiboggy, grassy areas. The bottom was muddy throughout, covered with algae, and containing much decaying vegetable matter from last year's foliage.

The animal life here consisted of various Entomostracha, Planaria on the bottom, with Tipulid larvae as the prevalent larger form. Other undetermined dipterous larvae were taken. A few crayfish burrows were observed in the wet ground.

(2) The lower brook.

Here the cutting of the stream through heretogenous material has developed well defined rapids and pools, each deserving of separate consideration.

THE RAPIDS.

The rapids of this stream are peculiar in that they consist almost wholly of stratified rocks over which the water drops, thus affording scant shelter and places of attachment for the more common forms inhabiting rapid water (Plate XL, figure 2). These stones were covered with algae and upon each shelf lay masses of decaying leaves.

No animal form was strictly peculiar to these rapids. The artificial burrows of Chironomous larvae occurred here in numbers, many with the larvae inside. Other forms such as Tipulid larvae, Stratiomys larvae and Hydrophilid beetles were taken from among the decaying leaves and from the crevices in the rocks. These were also found in the pools.

THE POOL ASSOCIATIONS.

The pools, with their large expanse of quiet water, of a depth not so great as to prevent the thorough influence of the sun's rays, permit the growth of an abundance of algae and other aquatic plants on the bottom and of semiaquatic plants at the margin. This richness of plant life and the variety of physical conditions make possible a division of the fauna into separate associations, such as already have been pointed out.

Surface film association.—Here the physical features of importance are the atmosphere as a direct supply of oxygen, and the surface tension of the water. The most characteristic form is the Water strider, which breathes the air directly, is enabled to support itself upon the surface film, and takes its food by preying upon other insects that have fallen into the water.

Many forms from the free-swimming association depend on the surface for breathing, coming up at intervals to renew their supply of oxygen. Tipulid larvae which live in the mud on the bottoms must take their oxygen from the air, thus establishing a connection between these two associations.

The bottom association.—Upon the bottoms of the pools has become concentrated the silt together with vegetable debris, composed in a large part in this instance of the decaying leaves. Living plants are attached here.

Dredgings from the muddy bottoms of such pools have brought to light such forms as flat worms (Planaria), pond snails, the larvae of Chironomous and Corethra, dragonfly larvae and water scavenger beetles (Hydrophilidae). Cranefly larvae (Tipulidae) also are found in numbers on the muddy bottom but their distribution is limited to the margins where the water is sufficiently shallow to allow them to reach the surface with the breathing apparatus located on their posterior extremities. Many of the free-swimming forms spend a part of their time on the bottom or upon the vegetation growing there. Examples of these forms are May fly larvae, mosquito larvae, larvae of Dytiscid beetles and adults of the same.

The free-swimming association.—The free-swimming association consists of these forms which spend much of their time moving about throughout the water and which have access to all parts of the pool although they may be taken in temporary connection with those forms of the other associations proper. The larvae of the May flies and of the Dytiscid beetles form excellent examples of animals of this class which do not have to come to the surface for breathing. The immature stages of the Mosquitoes and the adult Dytiscid beetles both play an important part in this association but each of these is so constituted anatomically that it must rise to the surface at intervals to renew its supply of oxygen.

The transition zone association.—The transition zone association is characterized by those forms the distribution of which is limited to that area included in the margin of the brook—the edge of the water itself and the immediate banks of the stream. The vegetation of this region consists for the most part of semi-aquatic and mesophytic plants. A great abundance of vegetable debris is usually to be found. The mudflats occasionally found at the edge of the stream contain the burrows of Heterocerid beetles. Spiders crawl about on the vegetation and make excursions out over the water. Staphylinid beetles were taken from partly submerged decaying leaves. Frogs, while they may be found temporarily in any of the associations, must receive distributional classification with the transitional zone forms. Examinations of the stomach contents of *Rana pipiens* Sch., taken from Butcher's Run show that their food supply comes partly from forms that have aquatic habits during at least a part of their lifetime. The air above the brook at times fairly swarms with the adults of the May fly and Simulium or Buffalo gnats. Craneflies were taken from the vegetation near the edge of the water.

CATALOGUE OF THE FORMS TAKEN.

In the foregoing discussion of the various associations of animals afforded by the brook only such forms were mentioned as were considered particularly characteristic of each of those associations. The following is a catalogue of those forms of animal life taken in this rather superficial survey, with merely enough reference to their habits and life history to account for their presence in such a brook as that under observation. The table on page 373 presents much of the same data in condensed form.

Platyhelminthes.—The flat worms were represented by the fresh-water Tricads in the form of *Planaria* sp. These were observed crawling about on the muddy bottom of the shallow stream near its source. They were also taken frequently in dredging the larger pools. At the time of the first observations, April 10, they were found in great numbers, almost to the exclusion of other forms, in a pool near the mouth of the brook which had become isolated by the drouth. These worms receive their nourishment from the ooze, etc., on the bottom. Their food is necessarily microscopic.

Mollusca.—Pond snails, of two species,[1] *Physa gyrina* Say, and *Limnaea* sp ?, constituted a great part of the individuals of the larger forms in the bottom associations. They were present in numbers, crawling about over the bottom and upon the growing vegetation as well. It is supposed that vegetable matter composes at least the principal part of the food of these snails. The eggs, in their masses of jelly, attached to the under surface of the decaying leaves, were found at almost every dredging.

Entomostracha.—These minute Crustaceans abound in varying numbers throughout the whole of the brook, although they belong primarily to the free-swimming association. Of these the Ostracoda were by far the most prevalent, the masses of green algae being fairly alive with them. A horde of the little animals was observed feeding on the soft parts of a dead snail, *Physa gyrina* Say.

Of the Copepoda, *Cyclops* sp ?, was observed, though not in such great numbers as the individuals of the Ostracoda.

Arachnida.—Spiders of the Drassidae, the ground spiders, comprising several undetermined species, form a very important part of the transition zone association. They haunt the vegetation at the water's edge and sally forth upon the surface film of the water itself to prey upon drowning insects.

Insecta.—By far the greater number and variety of forms of animal life in the brook are those of insects. They dominate to a large measure the life in each of the associations. Five orders are represented, Ephemerida, Odonata, Hemiptera, Coleoptera, and Diptera.

Ephemerida—May flies.—The nymphs of the May flies abound in all of the quiet pools during the weeks of early spring. The nymphs of *Callibaetis* sp ? and *Blasturus* sp ? were taken in numbers by use of the dredge net on April 10 and April 17. These numbers had been very much reduced by April 24, due to the emergence of the imagos. On April 17 the subimagos were observed leaving the nymphal skins at the water and taking flight immediately. One of these when captured was recognized

[1]Determined by Prof. B. Shimek.

as belonging to the genus Callibaetis but the species was not determined. On April 24 these hovered above the water in great numbers, their long anal cerci acting as rudders to keep them facing the breeze in flight. The nymphs of these genera form prevailing factors in the free-swimming association. Their leaflike abdominal gills provide them with oxygen as they swim about or rest upon the vegetation. They are plant feeders.

Odonata—Dragonflies.—Nymphs of the dragonfly, *Gomphrus* sp? were taken occasionally in dredging the muddy bottom with its leafy debris. These are practically confined to the bottom association. They are predaceous, feeding upon other insect forms and have been known to attack and devour tadpoles and other forms of similar size.

Hemiptera.—Two families of the Hemiptera were recognized, the Hydrobatidae and the Corisidae. Of the former, commonly known as the water striders, two species, probably *Gerris marginatus* Say, and *Gerris remegis*, were taken. These belong wholly to the surface film association. They move about over the water, supported by surface tension, with great freedom and agility. They are predaceous and prey chiefly upon other insects which have fallen into the water. Upon one instance the writer observed a strider seize a Simulium fly but a few seconds after it had touched the surface and proceed to transfix it with its beak to devour the body juices. Another specimen made a meal from a drowning May fly adult.

The Corisidae, or water boatmen, are free-swimming insects and form a part of the free-swimming association, although they come frequently to the surface and occasionally may be found floating. They are predaceous and for the most part feed upon other insects. Specimens of *Corisa* sp? were taken from the larger pools.

Coleoptera—Beetles.—The observations made in this study involve beetles of four families: Dytiscidae, Hydrophilidae, Staphylinidae, and Heteroceridae.

1. Dytiscidae. The Dytiscids, or predaceous diving beetles, were represented by two species, *Acilius mediatus* Say and *Laccophilus fasciatus* Aube. These beetles move about with great rapidity through the water and form an important factor in the free-swimming association due to their predaceous food habits. They are obliged to rise to the surface occasionally to renew their supply of oxygen, taking a bubble of air down with them under

their wing covers. Dytiscid larvae of at least two species were taken. These also are predaceous and the writer observed one larva of a large species which had seized a larva of a Tipulid fly larger than itself and into which it had sunk its long mandibles. Another of the same species gave chase to a May fly nymph and persisted for several minutes until the greater fleetness of the pursued enabled it to escape its enemy.

2. Hydrophilidae. Four species of the Hydrophilidae, water scavenger beetles, were taken, of four genera: [2]*Hydrobius fuscipes* Linn., *Helophorus lineatus* Say, *Philydrus cinctus* Say and *Cymbiodyta fimbriata* Say. While these beetles swim about freely their food habits as scavengers confine their activities to the debris-covered bottom and on this account they must be placed in the bottom association.

3. Staphylinidae. Two species of Staphylinidae, the short winged scavenger beetles, namely *Tachyporus jocosus* Say and *Stenus* sp? were taken from partly submerged masses of decaying leaves. These beetles are wholly terrestrial in their adaptations and must be included in the transition zone association.

4. Heteroceridae. The burrows of Heteroceridae, the variegated mud-loving beetles, were observed on some of the small mudflats formed by silt deposition along the course of the stream. These beetles are one of the most characteristic forms of life on the mudflat and hence become important members of the transition zone association. No specimen was taken.

Diptera.—By far the greatest number of species prevailed among the forms of Diptera in their aquatic immature stages. Representatives of five families were taken as follows: Culicidæ, Chironomidæ, Tipulidæ, Stratiomyiidæ and Simulidæ.

1. Culicidae—Mosquitoes. By far the most abundant forms of the Culicidae were the larvae of Culex which had made their first appearance in the pools in great numbers by April 17. Upon April 24 these had increased greatly in numbers and a very few had pupated. Microscopic materials are swept into the mouth and contain both plant and animal matter. These larvae belong to the free-swimming association although they are obliged to rise to the surface at intervals for breathing purposes.

Coretha sp? larvae were taken in small numbers on April 10, 17, and 24, and pupae were added on the latter date. These

[2]The species of beetles listed in this paper were determined by Prof. H. F. Wickham, of the State University.

forms are predaceous upon the smaller animals, such as Entomostracha, and have been known to feed upon May fly nymphs. Their transparency enables them to feed to great advantage without being exposed to the attacks of other forms. Their other habits are similar to those of Culex and they also are members of the free-swimming association.

A specimen of *Corethrella* sp? in the larval stage was taken from one of the pools. The habits of this genus as far as known are very similar to those of the two preceding genera.

2. Chironomidae—Midges. Larvae of the genus Chironomus were taken by dredging the pools on the various dates mentioned above. They were taken also on April 24 in their artificial burrows on the rock shelves which had been a part of the rapids during greater flow of water. These feed upon decaying vegetable matter and are confined to the bottom association although they occasionally swim about free from the bottom.

A few specimens of the genus Ceratopogon were taken in the larval stage April 17. These are free-swimming forms wriggling about for the most part among the aquatic plants near the surface. It is presumed that this genus is carnivorous in its food habits.

3. Tipulidae—Craneflies . Tipulid larvae were taken in numbers from the shallow, muddy bottomed upper part of the stream on April 24. They also occur abundantly near the edge of the pools partly buried in the mud. Their distribution in the pools is limited to those depths that will enable them to reach the surface to obtain air with the specially adapted posterior end. In some cases the little depressions, caused by surface tension, which mark the location of the breathing apparatus of the Tipulid larvae fairly dot the marginal waters of the pools. They feed on the decaying plant matter in the muddy bottom, and belong to the bottom association. A single adult was taken April 24 from the grass beside the brook, but the species has not been determined.

A single pupa, similar in most characters to the pupae of certain Tipulidae was taken from the rock shelf of the rapids April 24.

4. Stratiomyiidae—Soldier flies. Larvae of *Stratiomys* were taken from all of those places recorded for Tipulid larvae but in decidedly fewer numbers. These larvae crawl about over the bottom in shallow places with the posterior segments turned up-

wards to bring the breathing spiracle on the extremity of the body to the surface, or they swim about, coming to the surface at intervals where the water is deeper. They feed by sweeping microscopic organisms into the mouth. As a large portion of their time is spent on the bottom, and most of their feeding is done there, it seems best to include them in the bottom association.

5. Simulidae—Black flies. Adults swarmed about in such great numbers on April 17 as to make it uncomfortable near the stream. They resembled *Prosimulium pecuarum* Riley, but did not bite.

Vertebrata.—The vertebrates were represented by two species of common frogs, the Leopard frog, *Rana pipiens* Sch., and the common tree frog, *Hyla versicolor* LeConte. The Leopard frog makes the marshes and brooks its normal habitat while the little tree frog takes to the water only during the breeding season. The eggs of *Hyla* were taken from one of the pools on April 17. These hatched in three days when taken into the laboratory.

The stomach contents of two specimens of *Rana pipiens* Sch., taken April 24, tell the story of their food habits.

Specimen No. 1.	One May fly adult
	remains of six sowbugs
	one small terrestrial beetle
	one dipterous larva, probably Tipulid
	other unrecognizable material.
Specimen No. 2.	Larvæ of Carabid beetle
	one spider and remains of two others
	two sowbugs
	one snail, *Limnaea?*
	remains of one Myriopod
	three small beetles, remains of one other

The variety of these contents shows that the supply has come from both terrestrial and aquatic forms. The frog is therefore a most important member of the transition zone association.

TABLE OF FORMS TAKEN FROM THE WATER AND FROM THE TRANSITION ZONE OF THE BROOK, WITH INFORMATION AS TO THE PARTICULAR ASSOCIATION OF WHICH THEY FORM A PART, THEIR FOOD AND NUMBERS.

Animal	Association				Food				Numbers	
	Surface film	Bottom	Free swimming	Transition zone	Herbiverous	Predaceous	Scavenger	Microscopic organisms	Numerous	Few
Flatworms, *Planaria* sp?		+					+	+	+	
Ostracoda			+				+	+	+	
Copepoda, *Cyclops* sp?			+					+		
Mollusca, snails,										
Physa gyrina Say		+			+				+	
Limnaea sp?		+			+					+
Spiders, *Drassidae*				+		+			+	
May flies, *Blasturus* sp? nymph			+		+				+	
Callibaetis sp? nymph			+		+				+	
Dragon fly, *Gomphrus* sp? nymph		+				+				+
Water strider, *Gerris marginatus* Say?	+					+			+	
Gerris remegis?	+					+			+	
Water boatman, *Corisa* sp?			+			+			+	
Dytiscid beetles,										
Acilius mediatus Say			+			+			+	
Laccophilus fasciatus Aube			+			+			+	
Hydrophilid beetles,										
Hydrobius fuscipes L.		+					+			+
Helophorus lineatus Say		+					+			+
Philydrus cinctus Say		+					+			+
Cymbiodyta fimbriata Say		+					+			+
Staphylinid Beetles,										
Tachyporus jocosus Say				+			+			+
Stenus sp?				+			+			+
Heterocerid Beetle				+					+	
Mosquitoes, gnats,										
Culex sp? larvæ			+					+	++	
Corethra sp? larvæ			+			+			+	
Corethrella sp? larvæ			+					+		+
Midges, *Chironomous* sp? larvæ		+			+		+		+	
Ceratopogon sp? larvæ			+			+			+	
Crane-flies,										
Tipulidae, larvæ		+					+	+	+	
Soldier-flies										
Stratiomyiidae, larvæ		+						+	+	
Frogs, *Rana pipiens* Sch. adult				+		+				+
Hyla versicolor le Conte, larvæ			+			+				+

CONCLUSIONS.

In the opinion of the writer the most significant facts brought to light by this study of the animal life of the brook are these: (1) the wonderful variety and complexity of the fauna in a habitat that does not remain constant throughout the year; and (2) the dovetailing interdependence of each species upon others in the environment, the number of individuals in each case depending primarily upon the food supply, which ultimately reverts to the amount of plant life.

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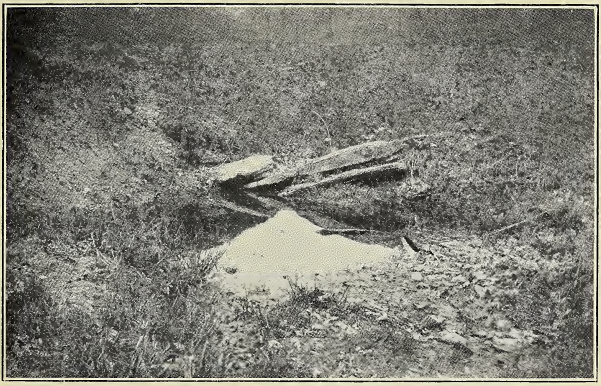

FIG. 1.—A large pool in the North Fork of Butcher's Run, Iowa City, Iowa. From this pool were taken specimens representing every form recorded from pools. Photograph taken April 17, 1915, by the author.

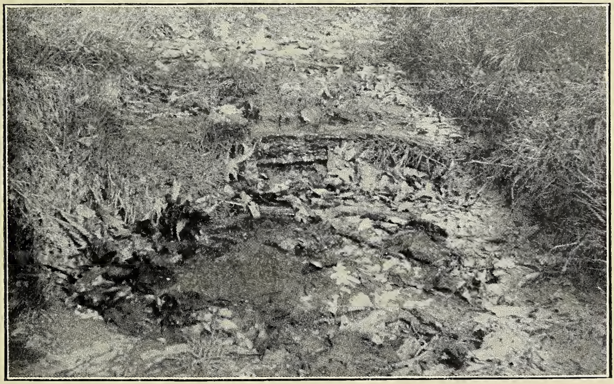

FIG. 2.—One of the characteristic rock shelf rapids of the North Fork of Butcher's Run, almost dry. Photograph taken April 24, 1915, by the author.

IS THE APPETITE OF SWINE A RELIABLE INDICATION OF PHYSIOLOGICAL NEEDS?

JOHN M. EVVARD.[1]

The pig is farrowed with a fairly definite set of specifications for development all wrapped up in their mystery in a two to three pound bundle of throbbing, active "stuff." And yet before the pig sought the outer life apart from the womb of his dam, these specifications were enclosed in the minutest bit of protoplasm, the impregnate ovum resulting from the union of two germ cells, one from the male and the other from the female.

These specifications may be likened unto the specifications for a house—the fulfillment is altered only upon provocation, and not then if avoidable. Certain materials are needed for this developing piglet: water; proteins, really amino-acids, perhaps such as tryptophan, lysin, cystin, tyrosin, and many others; carbohydrates, probably of different sorts; fats of the effective kind; minerals such as calcium, iron, magnesium, sodium, potassium, perhaps manganese, arsenic, and others; acid elements such as chlorine, sulphur, phosphorus; vital substances, perhaps vitamines[2] or "accessory diet factors"[3] or "akzessorische nahrstoffe"[4]; and in reasonable probability other essential unknowns.

There must not only be enough of these various nutrients at the right time in the alimentary tract, but likewise not an overdose if optimum development is to be attained. Then too, the happy combination of these various factors in diet is a problem for the *wisest of sages of all ages.*

Who will take the contract to figure out the bill of materials from the mostly unknown specifications? This has been attempted as will be shown shortly.

That appetite is not to be depended upon in the formulation of rations is insisted upon by Jordan[5] who, in speaking of cattle, puts the proposition thus: "Once in a while some one talks

[1]Acknowledgment is made for the collaboration and encouragement of William H. Pew and Russell Dunn.

[2]Funk, C.: Studien über das Wachstum, Ztschr. f., Physiol. Chem., 1913, LXXXVIII, 352. Also see Ergebn. d. Physiol., 1913, XIII, 124.

[3]Hopkins, F. G.: Feeding Experiments Illustrating The Importance of Accessory Factors in Normal Dietaries., Jour. Physiol., 1912, XLIV, 425.

[4]A term suggested by Hofmeister. See also Oseki, S.: Biochem. Ztschr., 1914, LXV, 160.

[5]Jordan, Whitman Howard: The Feeding of Animals, 1906, p. 279.

wildly about leaving food valuations to the 'old cow.' It is considered sometimes a telling argument against the chemist's wisdom to declare that he and the old cow do not agree. Certainly the cow knows better than the chemist what she likes to eat, and it is little use to offer her foods she does not relish. Even a chemist knows that. If, however, a dozen commercial feeding stuffs were spread around on a barn floor it would be much safer to trust an agricultural chemist, especially one experienced in stock feeding, to select a ration than any cow ever grown—Holstein, Ayrshire, Jersey, long-horned, dishorned, or what not. The cow would probably get at the corn meal and stay with it until well on the way to a fatal case of indigestibility. Her judgment is just about as good as that of a child with a highly cultivated 'sweet tooth' ''.

Sherman[6] on the other hand, has well said, in speaking of man: ''A well-ordered appetite may not only serve as an indication of the amounts of food needed over long periods and under different conditions of activity, but also when the conditions of life are fairly uniform may be highly efficient in determining a regular intake of calories from day to day.''

Faith in the ability of man to balance his own diet is very emphatically expressed by Sir James Crichton-Browne,[7]—''The nutrition of man involves an intelligent appreciation of the needs of the body, under different conditions of existence, and constant modification and adaptation to changing environment, and states of activity, and health. There is no finality about it''. To which might be added an appreciative, Amen!

After all when we come to consider the matter we are forced to admit that in spite of the quite impressive teachings of Chittenden[8] and his school, mankind keeps on eating just about in the ''same old way,'' namely, according to appetite and not according to the chemical scales. This is not evidence, of course, that what the vast majority does is the best, but it does signify that the new scheme of ''Limitation'' does not appeal sufficiently to affect a change in established habits of the people.

Many well-meaning and enthusiastic individuals, among whom the author is included, who have tried the low protein standards of Chittenden soon lose their interest and revert to what appears to them, the ''good old appetite way.''

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[6]Sherman, Henry C.: Chemistry of Food and Nutrition, p. 219.
[7]Crichton-Browne, Sir James: Delusions in Diet or Parsimony in Nutrition, pp. 21, 22, 23.
[8]Chittenden, Russell H.: Physiological Economy in Nutrition, also the Nutrition of Man.

But let us not get too far afield, but return to Crichton-Browne: "It is not on a priori physiological data, nor yet on laboratory experiments—elucidative and educational though these may be—that the science of dietetics is based, but on common observations and on the hereditary customs of mankind".

And now the emphasis is placed on the ability of animals other than man to choose their rations quite in keeping with their development: "The lower animals select with unerring precision, as long as they are in a natural environment, from the materials around them those best fitted for their wants, and they do this by distinctive discernment inherited from a long line of naturally selected ancestors, while they are checked in their consumption by a sense of repletion of coeval origin. We unhesitatingly infer that the articles they choose are, of all nutrient material accessible to them, those best adapted to the special needs of their economy, and that their consumption of them is proportioned to their needs for the time being. But man is, as regards his bodily functions, subject to the same laws as those which govern the lower animals, and we cannot doubt that in the formation of his dietetic habits he has been guided by the same kind of influences which have been operative throughout the animal creation in the choice and consumption of food".

And those of us who have had experience with the feeding of domestic animals find much of solace and of truth in the well-expressed convictions of Crichton-Browne. The temptation to quote one more passage of Crichton-Browne in order to emphasize the "appetite factor" is yielded to: "Natural instinct or primitive experience has guided the different varieties of our species in their selection of viands suitable to their geographical situation and modes of life, has restrained them within proper bounds in their consumption of these, and has even taught them to combine and balance the different constituents of these in a way on which chemical science can scarcely improve".

While hardly agreeing entirely with all the quotations made, yet it is quite important that the somewhat unusual viewpoint of Crichton-Browne be kept clearly in mind.

Pavlov[9] has very entertainingly and instructively called our attention to the appetite and its manifestations in the normal

[9]Pavlov, I. P.: "The Work of the Digestive Glands," 1910.

body physiologic. The "psychic" or "appetite" juice from the Pavlov angle has a new and broadening influence. After all the forces potent and the reactions and actions evident within the living organism have more significance than most of us have dreamed.

The feeding of children according to their appetite has a champion in a popular lecturer and writer, Hutchinson,[10] who presents the proposition in this vein: "We recognized, years ago, that instinct, craving, an untaught preference for a particular thing or action always means something; indeed, we might almost say in Browning's phrase, that it 'means intensely and means good,' in nine cases out of ten. It is the crystallized result of the experience of thousands of generations, and while, like all other impulses, it must take its place in the parliament of instincts and submit to the rules of order of reason, in the main it is a safe and invaluable guide". This statement is stimulated largely in discussing the child's instinct or cravings which lead sugar-ward.

Very interestingly, he pursues the subject further, telling of the appetite of the normal child, speaking of it in this wise: "The appetite of a healthy child of the kindergarten age is something appalling. He is a walking famine, a hunger incarnate. All is grist that comes to his mill, and all hours of the day or night are alike to him. But he needs every ounce that he will devour, and not one penny's worth of it will be wasted. Don't bother about the child. Just be sure that his food is right, pure, sound, and of the best quality, then let him go ahead! His wisdom is of the ages; yours where it clashes with his, is of the almanacs, of the catechisms and copybooks, of the silly chatter of the street and the kitchen".

Certainly this argument of Hutchinson's is quite sensible and well worth our while to consider seriously. Those of us who have children realize that there is, to all intents and purposes, more truth than fiction in these things talked about. The idea of allowing children to eat when they will, which we have found to work admirably with pigs, is expressed by Hutchinson thusly: "The notion that the stomach requires a certain definite interval or rest between tasks in order to get up its supply of gastric juice has been completely exploded".

[10]Hutchinson, Woods: We And Our Children, pp. 65, 79, 81, 84, 98.

Then a little later, we find the remedy for curbing the cravings of children for sweet stuffs, and this remedy is to feed them properly in all ways. In other words, give them a chance to manifest their appetite and an equal opportunity to satisfy it. As Hutchinson says: "When children are properly and adequately fed, they can be trusted with the candy box, the open fruit-basket and the nut bag, to say nothing of the key to the jam closet, or the pantry."

Somewhat farther on we find this facetious "seasoned with judgment" philosophy concerning the child: "He ought not to eat like a pig, of course, but he should want to". To know pigs is to appreciate this rich bit of sentiment.

Fletcher[11] in his system which is widely known as "Fletcherism" bases his entire system upon a proper and intelligent interpretation of a normal appetite. All his schemes appear as means to this end. Now listen to what is said: "Appetite is the most important factor in nutrition." * * * "In its normal state, Appetite is a perfect indicator of the bodily need of nutriment and moisture, both as to quantity and as to the chemical elements required at the moment." * * * "Appetite can be easily comprehended and read and the degrees of its satisfaction understood by simple attention and study for a brief period (Vide Someren) * * * [12]That we all eat more than we can assimilate is unquestionable. How can we determine the right quantity? Instinct should guide us but an abnormal appetite often leads us astray. Nature's plans are perfect if her laws are obeyed".

Mendel[13] and Osborne have noted indications "that the animals (rats) tend to make choices which are advantageous to their growth". These rats were "allowed * * * a choice (a) between foods comparable in every respect except the proteins, and (b) between foods containing the natural and artificial protein-free milk respectively".

The question of variety (which the average appetite takes advantage of) in the diet upon which we shall dwell but little, finds a champion in Sir Henry Thompson:[14] "The great practical rule of life in regard to human diet will not be found in enforcing limitation of the sources of food which nature has

[11]Fletcher, Horace: "The A B Z of Our Own Nutrition", 1910, 13th edition, pp. 6-7.
[12]*Ibid*, p. 29.
[13]Unpublished data, personal communication from Mendel, Lafayette B., 1915.
[14]Thompson, Sir Henry: "Diet in Relation to Age and Activity," 1908, p. 28.

abundantly provided. On the contrary, that rule is fulfilled in the perfect development of the art of adapting food of any and every kind to the needs of the body according to the very varied circumstances of the individual, at different ages, with different forms of activity, with different inherent personal peculiarities and with different environments''. Certainly Sir Henry would exhaust the possibilities in so far as source of food is concerned to gain or secure all of those simple and medium simple, and complex things that go to make up the body physiologic and to enable this living bundle of sinew, fibre, bone, nerve, and what not to work (live) to the fullest advantage. Most assuredly, the wider the variety the greater is the possibility of including in the diet or ration all of the essential nutrients; when the appetite is completely followed there is ordinarily a wide range of choices made, and thus the liklihood of physiologic satisfaction is the greater.

Mendel[15] has recently emphasized the great importance of the correct selection of efficient nutritive units, calling attention particularly to the fact that ''we must know what nutrient units of any nature are indispensable, and further, whether a complete lack or deficit of them in the intake can be made good by direct synthesis''. The stupendous task of balancing the diet, or the ration is clearly evident to students who scrutinize the evidence critically.

In formulating dietaries for the feeding of humans as well as standards for animals in general there must be considered the great complexity of the ordinary food or feed constituents—proteins, carbohydrates, fats, and ash, of which, in addition to water, diets and rations are composed. Discussion concerning recent developments and newer viewpoints in nutrition, based upon a study of these food constituents is quite in place. That there are manifest differences and differences in the proteins, in the fats, in the carbohydrates, and in the ash of different foods is made clear in recent researches.

Protein metabolism may be rightly studied and interpreted nowadays on the basis of the amino-acids present. Or as Mendel[15] puts it: ''the protein requirement, we shall not err in identifying it today with the specific amino-acid needs of the grow-

[15]Mendel, Lafayette B.: Nutrition and Growth, Jour. Am. Med. Ass'n., 1915, LXIV, pp. 1539-1547.

ing. organism''. Osborne[16] and Mendel have done classic research along these lines, as have Abderhalden[17] and others. Proteins, being built up of some eighteen or more amino-acids or building stones, offer a very complicated subject for specific study.

When it is realized fully that these eighteen amino-acids in their various possible combinations can form millions upon millions of proteins, no two of which are alike, we stand astounded. The great possibilities of combination and recombination that are evident make one rather pause before the stupendous problems involved in the assimilation and functioning of proteins of the many sorts. The appetite of the pig possibly may fairly quickly tell us more about which of these amino-acids should be present in his ration and in what amount much more effectively than long, laborious, standard, ordinary chemical and physiological research. At any rate, the indications are that the pig can come nearer selecting his protein diet naturally, than can technically trained men.

Peculiarly enough, the pig shows great preference for milk, and for meat, the amino-acids of which are quite efficient. Is this a reason why growing pigs take to the milk and the meat so readily, and why after they are quite well-grown they may almost cease eating the meat in the presence of the Indian corn or maize?

The carbohydrates, which in general chemical work are designated as the Nitrogen-Free Extract plus Crude Fibre, are in reality a very intricate mixture of various compounds, in many and diverse proportions. There are lactose, the milk sugar, the starches, dextrins, sucrose, maltose, glucose, cellulose, the pentosans, and a multitude of others. The mono- and poly-saccharides appear in various quantities and proportions. In view of the very great development in protein physiological research the

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[16]Osborne, Thomas B., and Mendel, Lafayette B.: Feeding Experiments With Isolated Food Substances, Carnegie Institution of Washington, 1911, Pub. 156; Feeding Experiments Relative to the Nutritive Value of Maize, Jour. Biol. Chem., 1913, XIV; Am. Jour. Physiol, 1913, (a) XXXII, 16: Nutritive Properties of Proteins of the Maize Kernel, Jour. Biol. Chem., 1914, (b) XVII, I: The Comparative Nutritive Value of Certain Proteins in Growth, and the Problem of the Protein Minimum, Jour. Biol. Chem., 1915, XX. Osborne, Thomas B.: The Nutritive Value of the Proteins of Maize, Science, 1913, XXXVII. 185. (These papers give further references to the literature of the subject.)

[17]Abderhalden, E.: Fütterungsversuche mit vollständig abgebauten Nahrungsstoffen, Ztschr. f. physiol. Chem., 1912, LXXVII, 22. Abderhalden, E., and Hirsch, P.: Fütterungsversuche mit Gelatine, Ammonsalzen, vollständig abgebauten Fleisch und einen aus allen bekannten Aminosäuren bestehenden Gemisch ausgeführt an jungen Hunden, Ztschr. f. physiol. Chem., 1912, LXXXI, 323.

field for study among the carbohydrates appears very fruitful, and it may be that large differences in the nutritive effects of these various sugars, starches, and other carbohydrates will develop when thorough exploration is made. That physiological research already indicates these differences is manifest in a paper by Mendel and Mitchell.[18] That the unmistakable appetite of pigs for "milk" whey, skim-milk, and buttermilk may be in part accounted for by the superior value of lactose, the sugar of milk, is not beyond the pale of reasonable expectation.

Why is cane-sugar, in its absence, but in the presence of an abundance of starches in general, so much craved by small growing children, and by men fatigued?

The problem of "balancing the diet or ration", respectively of men and other animals on the basis of known physiological and chemical knowledge deepens as the intricate and involved elements of nutrition are carefully scrutinized.

The fats, heretofore thought to be interchangeable, are now commanding considerable attention because of their specific effects. It is demonstrated that there is a marked difference in the ordinary fats such as butter-fat, cod-liver oil, beef fat and oils, cottonseed oil, olive oil, corn oil, and so on.

McCollum and Davis[19] have shown with rats that nutritive failure "sooner or later supervenes" when they have been brought through a period of successful growth on diets of purified food constituents, but containing no flats.

Now Osborne and Mendel[20], practically simultaneously, were carrying on similar rational research with these "high carbon and hydrogen with low oxygen" (compared to proteins and starches) compounds, demonstrating likewise that the fats, or some unknowns associated with them, possess peculiar but absolutely essential nutritive properties.

Strikingly enough, McCollum and Davis secured positive favorable nutritive results with "butter-fat, egg yolk fats, kidney fat (ether soluble portion of kidney free from visible fat), and the

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[18]Mendel, Lafayette B., and Mitchell, P. H.: Chemical Studies on Growth. Am. Jour. Physiol., 1907, XX, 81. See also Mendel, Lafayette B.: Nutrition and Growth (Note 15), pp. 1539-1547 for discussion of carbohydrate nutrition.

[19]McCollum, E. V. and Davis, Marguerite: Jour. Biol. Chem., 1913, XV, p. 167; 1914, XIX, p. 245; 1915, XX, 641; and 1915, XXI, 179.

[20]Osborne, Thomas B., and Mendel, Lafayette B.: Jour. Biol. Chem., 1912, XII, 81; The Relation of Growth to the Chemical Constituents of the Diet, Jour. Biol. Chem., 1913, XV, 311; The Influence of Butter-Fat on Growth, Jour. Biol. Chem., 1913, XVI, 423; The Influence of Cod-Liver Oil and some Other Fats on Growth, Jour. Biol. Chem., 1914, XVII, 401; see also Proc. Soc. Exper. Biol. and Med., 1915, XII, 92.

ether extract of the ripe testicle of the cod fish'',—negative findings being evident with commercial lard, olive oil, cottonseed oil, and tallow. Osborne and Mendel found cod-liver oil and the lighter oils of beef fat to have the special effective virtues, but not so almond oil.

Recently McCollum and Davis[21] have demonstrated that the favorable substance—or rather similar effects as produced from the effective fat feeding—is noted in the feeding of corn grain (fed in toto). Seemingly, the other grains such as wheat, rye, and oats are not nearly so effective although the separated wheat embryos give quite marked results.

To make this ''Fat'' matter a bit more elucidative a representative concrete example may be in order: Certain rats are fed on a definite mixture of food constituents of which lard comprises a portion of the ration, it being the lone source of fat. For a few months, these rats appear to prosper, but lo! and behold! after these preliminary days of apparent success they cease to gain in weight,—in truth shortly begin to decline—the ultimate disaster being death if the lard or a portion of it is not replaced with an effective fat or oil. Substitute the lard with olive, or cottonseed oil and the results are absolutely negative, but use butter-fat or cod-liver oil, and the rats take on new life, cease traveling the ''downward road that leads to earthly oblivion'' and begin to mend, their weight increases, and sooner or later, if the decline is not carried to the point of bodily collapse, grow again into good, healthy, active, nimble, sleek-looking rats.

Stepp[22] has likewise pioneered in these fat investigations and his studies are interesting in that tripalmitin, tristearin, and triolein were not effective in bringing his ''experimentally declined'' mice back to health. Stepp affirms that the particular effective substances, soluble in alcohol-ether are not fats. Cooper[23] has recently shown that this decline is not due to the absence of lipoids from Stepp's alcohol-ether extractions, as he (Stepp) suggested, but to the transfer of the vitamines of the

[21]McCollum, E. V., and Davis, Marguerite: The Influence of Certain Vegetable Fats on Growth, Jour. Biol. Chem., 1915, XXI, 179.

[22]Stepp, W.: Versuche über Fütterung mit lipoidfreier Nahrung, Biochem. Ztschr., 1909, XXII, 452; Fütterungsversuche mit lipoidfreier Nahrung, Verhandl. d. Kong. f. inn. Med., 1911, XXVIII, 324; Experimentelle Untersuchungen über die Bedeutung der Lipoide Für die Ernährung, Ztschr. f. Biol., 1911, LVII, 135; Experiment über die Einwirkung langdauernden Kochens auf lebenswichtige Nahrungslipoide, Verhandl. d. Kong. f. inn. Med., 1912, XXIX, 607; Weitere Untersuchungen über die Unentbehrlichkeit der Lipoide für das Leben, Ueber die Hitzezerstörbarkeit lebenswichtiger Lipoide der Nahrung, Ztschr. f. Biol., 1912, LIX, 366: See Mendel, Lafayette B.: Note 15, also.

[23]Cooper, Evelyn A.: The Relations of Vitamines to Lipoids, Biochem. Jour. 1914, VIII, 347.

material to the extract of alcohol-ether which is not fed. At any rate, our point is made—namely, that there is a marked dissimilarity in fats (or what they specifically carry) as regards their nutritive value.

It appears reasonable that inasmuch as there is such a marked and peculiar difference in the nutritive effects of different fats difficulty would be experienced in attempting to ideally balance an animal's ration in these respects. Now, it is not altogether certain, but it seems entirely reasonable if we base judgment on our general physiological knowledge of nutritional problems, that not only should there be a difference in the actual amounts of total general fat given but that the quantities of the specific effective unknown or unknowns necessary may vary considerably as animals of different species go through the cycle from egg to egg.

When one must take into consideration the quantity as well as the quality of the food constituent in question and likewise balance this resultant with various altering demands of the animals used, and the general environment during the investigation it is readily perceived that the difficulties involved are stupendous. The "fat" unknowns are of sufficient magnitude to rather discourage those with even iron hearts.

To attack this problem from the standpoint of appetite, in other words, from the standpoint of giving the pigs or other animals worked with, an opportunity to express their choice, would certainly be a logical method of attack. Let it be granted that the appetite may sometimes "go wrong", yet is it not excellent policy to give the appetite an opportunity to show wherein it is right or wherein it is wrong?

The great role played by the ash, as determined in the regular chemical routine of feeding-stuff analyses, is almost untouched. The effects of the phosphorus compounds alone, so well reviewed by Forbes[24], are certainly extensive.

Then there is the calcium, which comprises more of the minerals of the ordinary body than any other, and about which we know comparatively little. Evvard, Dox, and Guernsey[25] have

[24]Forbes, E. B., and Keith, M. Helen: A Review of the Literature of Phosphorus Compounds in Animal Metabolism, 1915, Tech. Bul. 5, Ohio Agr. Exp. Sta.

[25]Evvard, John M., Dox, A. W., and Guernsey, S. C.: The Effect of Calcium and Protein Fed Pregnant Swine on the Size, Vigor, Bone, Coat, and Condition of the Offspring, Am. Jour. Physiol., 1914, XXXIV, 312.

found that calcium added to a corn ration fed to young pregnant swine affected the dams as well as the farrowed pigs favorably, making them larger and stronger.

Recent results of Evvard and Dox[26] indicate that young swine choose most optimum amounts of calcium carbonate when same is allowed at free-choice, this being compared to theoretical allowances mixed with the feed. The Free-Choice-Fed pigs having the carbonate continuously before them made better growth likewise, than where none was allowed; the basal grain ration of Indian corn (maize) and Linseed Oil meal (flax grain minus most of the oil) and Wheat Middlings being constant in all respects.

Hart and McCollum[27] in some observations with swine find that: "When swine are restricted to corn meal and gluten feed little or no growth can be secured, but with an addition of salts, making the entire ash content of the ration very similar in quality to that of milk, growth approximating that of a normal curve was secured to at least 275 pounds. These results are not in harmony with the theory that the failure of swine to grow on corn alone is due entirely to the incomplete nature of its protein content."

These salts consisted of a mixture of secondary potassium acid phosphate and calcium lactate. The effect of these mineral additions was pronounced. It is quite suggestive to quote further from this paper concerning the ability of swine to select from their normal environment some of the materials which they are not given when fed by man: "Restriction to mixed grains and distilled water did not allow normal growth with swine. This emphasizes again the very great importance of either the mineral side of a ration, or as yet unknown factors operative in the normal environment of this species, namely, soil rooting, natural water, etc."

These investigators clearly recognize that the pig, when allowed access to the great out-of-doors, evidently secures something that is quite indispensable for his normal physiologic wellbeing. Just what these substances are, of course, are largely for the present unknown, but it is sufficient to say that the appetite of the pig guides him rightly in finding that which enables him

[26]Unpublished data from Animal Husbandry and Chemical Sections, Iowa Experiment Station.

[27]Hart, E. B., and McCollum, E. V.: Influence on Growth of Rations Restricted to the Corn or Wheat Grain, Jour. Biol. Chem., 1914, XIX, 373.

to grow, and thrive, and live to good advantage, or as Hart and McCollum well put it: "These results are extremely important, indicating what a large factor in the growth curve must lie in those extraneous conditions usually surrounding the animal, but to which so little heed is given and concerning the details of which we understand so little. The salts carried by natural water or obtained by the animal from the soil are evidently very important factors in promoting growth when the ration is restricted to the grains."

It is hardly necessary or advisable to go into greater detail concerning the part played by the ash, especially the mineral nutrients in nutrition, and the wonderful maze of factors, with all their possible combinations involved. The fact that in practice progressive swine men have observed the "appetite" of the pig a better guide as what to supply, and how much to supply, and when to supply the mineral nutrients than their own "estimated mixtures" is quite to the point. In practice there is often allowed such mineral feeds as limestone, (calcium carbonate preferably), charcoal, wood ashes, phosphatic rock meal (used as a plant food), common salt (commercial sodium chloride), cinders, coal screenings, sulphur, sandstone, and others, giving the swine free access and free-choice to these in individual trough compartments; the futility of "guessing" as to the "optimum mixture" for swine of all classes and ages is quite evident.

The specific effects of various foodstuffs in changing the resistance of animals to certain poisons has been well brought out by Hunt[28]. The specificity of different foods as regards their action in the body is of great importance, and it is very essential indeed that the meagre information we now have concerning the action and reactions of the known constituents be greatly increased before we attempt to apportion out the daily food allowance over the chemical balance. There are too many unknowns to "play the game" of arbitrarily controlling the diet.

There are those who suggest that swine are not intelligent, hence would not be very successful in "balancing their rations". This is a bit beside the point but it is well to quote Robinson[29], who has written very thoughtfully about the dog, horse, donkey, ox, sheep, goat, cat and other domestic animals. He sounds his

[28]Hunt, Reid: The Effects of a Restricted Diet and of Various Diets upon the Resistance of Animals to Certain Poisons, Hygienic Laboratory, U. S. Public Health and Marine Hospital, Science Bulletin 69. See also "Experiments on the Relation of the Thyroid to Diet",—Jour. Am. Med. Ass'n., 1911, LVII, 1032.

[29]Robinson, Louis: "Wild Traits in Tame Animals," 1897, pp. 209-226.

praises of the domestic pig in these flattering lines: "* * * * the pig is by no means the gross and unintelligent beast he is supposed to be by many people who have to do with him, there are certain points in his character which it is difficult to describe or appraise without using terms which we generally consider appropriate to the highest human virtues". This naturalist goes on to tell about the "inexplicable faculty for discovering hidden stores of food" which certain mammals, such as the squirrels, have, when one is astounded to come upon this tribute to swine,—"Apparently, however, the hog, although, with the exception of ourselves, perhaps the most versatile and resourceful mammal in existence, does not possess any mental faculties of this mysterious order".

Robinson intimates that the pig naturally does not hide stores of feed like the squirrel, or bee, inasmuch as he puts the surplus of stores in the form of fat on his back; hence the need for the development of the faculty is not apparent. This is seemingly true: The pigs quite readily learn from experience to differentiate between pleasurable and displeasurable reactions.

That the newly farrowed piglet should know that "dinner" is awaiting him is, on deep thought, somewhat baffling and surprising. The very first action noticeable on the part of the piglet that comes into the world is the breathing. The first few respirations may be a bit labored but the natural rhythm is soon established. A subsequent move in which we are now interested, is made,—the piggie makes his way to the mammary glands, "mouths" the nipple, and begins to take milk nourishment. How did the pig know enough to do that? Some may say, "Instinct!" Others may say the pig does not "know" it—but at any rate the cold facts are that the pig finds the place of suckling and suckles without guidance, unless it sometimes be guided by the complacent but uncertain grunting of the sow. The piggie most often finds the "nectar of life" without the beckoning grunts of his dam, for many times the grunts are omitted in the partuition performance. We are reminded of Samuel Butler's[30]: "There is no sign of 'Fluke' about the circulation of a baby's blood. There may perhaps be some little hesitation about its earliest breathing, but this, as a general rule, soon passes over, both breathing and circulation, within an hour after birth, being as regular and easy as at any time during life. Is it reasonable

[30]Butler, Samuel: Life and Habit, 1878, pp. 55, 34, 8.

* * * to say that the baby does these things without knowing how to do them, and without ever having done them before, and continues to do them by a series of lifelong flukes?'' And again: ''It is * * *, those who do not know that they know so much who have the firmest grip of their knowledge''. Or this: ''Perfect ignorance and perfect knowledge are alike unselfconscious''.

The Butler argument is forceful, because it seems so logical and true.

"APPETITE" STUDIES WITH SODIUM CHLORIDE.

It has been demonstrated in a recent investigation, 1914, by Evvard[31] that well-grown young swine of approximately 150 pounds average weight make better use of common salt (sodium chloride) when it is fed ad libitum, it being accessible all of the time, than where it is mixed with the daily ration in varying proportions. The young swine in question received a basal ration of corn and oil meal (the flax grain from which a large portion of the oil had been extracted with heat and pressure). This basal mixture was constant, as regards quality, throughout the period; it being composed of 6.1 parts corn to 1 part linseed oil meal. There were 40 individuals in the experiment. These were divided, or rather distributed into five lots of eight each. These were fed as follows:

Lot I Basal Ration (as given).
Lot II Basal Ration plus 18[32] grams of salt daily, mixed.
Lot III Basal Ration plus 36[32] grams of salt daily, mixed.
Lot IV Basal Ration plus 72[32] grams of salt daily, mixed.
Lot V Basal Ration plus salt ad libitum. (The average consumption throughout the period on the average was 27.56[32] grams, which is midway between Lots II and III; the amount eaten varied, however, being as high as 42.6 grams early in the period and gradually reducing to less than 8 grams daily at the close.)

In brief, it may be said that there was a check period of 90 days preliminary run in order to determine just how the individual lots would gain. During this period the feed quantity and quality was kept constant in each lot, and no salt was allowed. Following this preliminary there came 71 days, however, in which salt was given to each lot of 8 hogs as stated.

[31]Evvard, John M.: unpublished data. To be published in full in Bulletin form later. Results Animal Husbandry Section, Iowa Experiment Station.

[32]On basis "Daily Consumption per Pig" we have respectively: Lot I,—none; Lot II,—2.25; III,—4.50; IV,—9.00; and Lot V,—3.45 grams.

In these 71 days, comparing each lot to what it did in the first preliminary 90 days, we find that:

Lot I gained 84.24 per cent as much.
Lot II gained 94.02 per cent as much.
Lot III gained 96.97 per cent as much.
Lot IV gained 94.13 per cent as much.
Lot V gained 97.23 per cent as much.

It is thus readily seen that the proportionate gain of the "salt ad libitum lot" was greater than any of the other lots. It is well to note that the "36 grams lot" seemed to do better than either "18" or "72 grams", in other words, an optimum was more closely approximated with an allowance of 36 grams or 4.5 grams per head daily; less salt than this was not so good, nor was more. The striking feature of this is that the *free-choice* group ate on the average just 3.45 grams daily, which would indicate that this was more nearly optimum than the 4.5 gram allowance of Lot III which is excelled.

Now, let us look to the feed requirement for a hundred pounds of gain in these 71 days as compared with the check preliminary period of 90 days as before:

Lot I required 101.88 per cent as much feed.
Lot II required 94.29 per cent as much feed.
Lot III required 91.56 per cent as much feed.
Lot IV required 89.92 per cent as much feed.
Lot V required 89.36 per cent as much feed.

The requirement for a hundred pounds of gain was comparatively less, therefore, in the "salt ad libitum" group (Lot V) than where the salt was omitted (Lot I) or mixed with the feeds (Lots II, III, and IV). It is quite evident that the addition of salt in varying amounts results, in every instance, in a cheapening of the gain; the feed required for a hundred pounds of gain was lessened. It is quite evident that the pigs which received salt according to their appetite made relatively the most economical gains of any group. The *free-choice* group compared to the "no salt group" in the 71 day salt feeding period required only 89.36 in contrast with 101.88 per cent as much feed as in the preliminary.

Evidently the salt requirement of these pigs was not constant throughout the experiment. This is manifested in the exhibition of their appetite, clearly shown in the data. The inconstant demand for salt makes it very difficult to apportion the same in the diet with any large degree of satisfaction. It would seem that it is well to allow common salt to pigs just as average humans like to take it, namely,—ad libitum according to appetite.

THE FREE-CHOICE SYSTEM OF SWINE FEEDING.

To determine whether or not pigs have the ability to balance their own rations preliminary investigations have been made in the laboratories of the Animal Husbandry Section, Iowa Experiment Station.

Three groups of five pigs each were fed in dry lot practically from weaning time, July 7, 1914, until they were more than eight months of age. One of these groups (II) was continued until almost a year old, or until April 14, 1915. Lot I was fed from separate self-feeders these specific feeds: whole corn grain, meat meal (containing 60 per cent of protein), whole oats, charcoal (made from maplewood), limestone (finely ground and running very high in calcium carbonate), salt (common rock) and water (from the ordinary College wells). Lot II was fed practically the same, the only difference being that linseed oil meal was added to the list of feeds. Lot III was fed differently from Lot I in that both oil meal and wheat middlings were added in separate compartments. All lots had free-choice, therefore, as to what they should eat and as to how much they should drink. Every pig was a "law unto itself" and progress was made in the experiment on the basis of "free and equal opportunity" for each individual in every lot concerned.

One lot only, namely, Lot II, which is entirely representative, is presented in so far as the feeding record is concerned (the charcoal, limestone, salt, and water figures are not included in this paper). Plate XLI shows the corn, meat meal, oats, and oil meal eaten daily, on the basis of ten day periods, throughout the experimental life of that group, or from the time they were 83 days of age until they were almost a year or exactly 350 days.

Evidently the palatability of the various feeds changed considerably (consult Plate XLI) as the feeding period progressed; in the beginning these pigs ate a ration composed practically of less than 80 per cent corn. The percentage of the different feeds eaten is given for the representative 3d, 10th, 18th, and 25th periods, or when the animals were respectively 108, 178, 258 and 328 days of age respectively.

PERCENTAGE COMPOSITION OF RATIONS BY PERIODS.

Ten Day Period	Age in Days	Feeds in a Hundred Pounds Eaten						
		Corn Grain	Whole Oats	Meat Meal	Oil Meal	Charcoal	Limestone	Salt
3rd -------	108	76.58	6.42	13.38	3.33	.10	.16	.02
10th -------	178	93.66	None	5.96	.35	None	None	.02
18th -------	258	99.47	None	.15	.05	.10	.07	.16
25th -------	328	94.42	None	3.27	.03	2.25	None	.03

The striking feature of these tabulated data is that they show the very marked changeableness of the pigs' appetites as manifested by what they eat throughout the period of growth and fattening. When the animal is young there is a great demand for high protein feeds, during which time we note that the proportion of meat meal (in comparison with corn, a "carbohydrate-fat" feed) is very high. After a time, however, when the growth impulse begins to slacken and the inherited specifications, in so far as growth is concerned, are quite largely taken care of, the amount of meat meal in the ration gradually decreases until it reaches a low point at about the age of 255 days (see Plate XLI), at which time it gradually begins to increase. It is to be noted in this connection that the corn, which has been furnishing most of the protein (practically all of it from the 223d to 303d day), is consumed after the 223d day in rapidly decreasing quantity, thus making it necessary for the pigs to increase the amount of high-protein meat meal eaten if the total protein intake is to be kept from diminishing markedly. Thus the increase in meat product is due primarily to the limitation of capacity on the part of the pig, which makes it necessary for him to eat more, as well as a larger per cent of meat meal, if he would keep up the protein per unit weight in his ration daily. In other words, with the capacity for feed lessened it is quite necessary to increase the richness of the mixture in protein in order to secure the requisite amount of this complex "amino-acid mixture" constituent. Reference to Plate XLII clearly shows that the actual amount of protein eaten to a thousand pounds live weight continually decreases in spite of the fact that the richness in protein of the mixture eaten has been increased. Note that the corn increases from 76 per cent of the entire ration on the 108th day to 99.47 per cent on the 258th day, and then gradually decreases to "make room" for the increasing meat meal and charcoal. As the pigs unfold in their development they vary their intake of food nutrients. In other words they vary the daily "Bill of Materials".

The charcoal consumption, although Plate XLI does not show it, it is well to note in passing, was at a minimum during the larger part of the feeding period, but when the pigs persisted in eating largely of corn, decreasing to a low point on the meat meal and oil meal, the pigs began to eat of the charcoal of maplewood. In practice we find that when fattening hogs are receiving a "corn alone" ration, charcoal is quite beneficial. Herein the appetite of the pig gives us a clue for further investigations: Is it true that pigs receiving corn alone require charcoal for optimum development; whereas those on corn and meat meal diet do not necessarily require it, at least not to such a marked extent?

The oats and oil meal eaten are seen gradually to decrease (see Plate XLI), the animals tending to visit the oats compartment but very, very seldom after the age of five months; whereas oil meal was scarcely touched after the seventh month. The great preference of the pig for corn grain and meat meal is demonstrated.

The pigs in Lot II weighed 316 pounds when they were eight months and four days of age, a very unusual record. Lot I, heretofore spoken of, weighed 304 pounds at the same age; whereas Lot III lifted the weigh beam at 303 pounds. It can thus be seen that, in so far as weights are concerned, all three lots did very creditably. As compared to ordinary systems[33] of feeding these weights are really exceptional. While this is not direct evidence that these "Free-Choice" fed pigs were fed to the maximum of advantage, yet the indications are favorable.

It is to be emphasized that the feed consumption of Lots I and III, not given, is in general in very close accord with that of Lot II. This is impressed by careful reference to Plates XLII, XLIII, and XLIV.

By the use of his Illinois standard (see Plates XLII, XLIII, and XLIV), worked out after a number of years of careful in-

[33]For further discussion of practice see Evvard, John M.: The Iowa System of Self-Feeding Swine, 1914, Corn Belt Meat Producers' Association. Report, 1914, pp. 56-69.

vestigation, Dietrich[34] was able to produce pigs that weighedwhen 251 days old, or really eight months and seven days, 308 pounds.[35] These were the heaviest for this age of any pigs he produced in all those years. Peculiarly enough, these "free-choice" fed pigs we are discussing, so chose their own ration that they weighed eight pounds more in three days less time with the best lot (II); the other two groups likewise were slightly heavier for their age than the Dietrich-fed pigs above mentioned. Then too, it is well to note that these pigs fed by Dietrich at the Illinois Experiment Station received milk during a considerable part of the feeding, which advantage was not enjoyed by the "appetite" fed pigs. These comparative figures are simply given to show that these pigs which were given a fair opportunity to eat a variety of feeds according to their own free-choice developed to exceptionally good weights in a very reasonable minimum of time.

Evidently the *free-choice* system whereby pigs have access to suitable feeds enables and encourages maximum development; in other words actually permits the inherited specifications to be fulfilled to all intents and purposes. Good breeding, and good feeding, and good environment are the three great requisites necessary in maintaining the maximum development possible. No one of all of these conditions should be omitted nor neglected; they should all receive the greatest consideration in order to encourage an animal to grow and thrive to the fullest advantage.

A *free-choice* fed pig (see Plate XLV), a female, made a wonderful record in so far as weights for age are concerned in one of the *free-choice* fed groups, namely, group II, which received these feeds ad libitum: shelled corn, meat meal, linseed oil meal, whole oats, limestone, charcoal, common salt and water. This female swine weighed 405 pounds when 247 days of age; an average pig this old usually weighs from 200 to 250, a very good one, 300, and the exceptional one, 350 pounds. A normal growth in weight is about 250 to 275 pounds in this time, this being very satisfactory indeed. What would have happened had this pig been hand-fed according to the ordinary "hit-and-miss" method? Observation would teach us that the chances would have been that we never would have known that "here is a record gaining pig." Of course, it is entirely possible that if

[34]Dietrich, William: Swine, 1910.

[35]Communication from W. J. Carmichael, Illinois Experiment Station, December 10, 1914; also verbal communication with H. S. Grindley, same Station, November, 1914.

milk had been added to this ration in addition to the feeds allowed, this pig would have made even a greater showing than it did. At any rate, there is the suggestion that this pig did remarkably well under this *free-choice* scheme of feeding and the indications are that the gains were greater than they would have been had ordinary methods been practiced. Inasmuch as this is the biggest pig for the age that has ever been fed in Experiment Station work, to our knowledge, this suggestion seems all the more real and true.

The palatability[36] of the specific feeds is not at all constant, but much depends upon the stage of development of the pig and on his environment; the pig seems to adjust himself automatically, perhaps unconsciously, to the conditions at hand. If he is growing he eats a larger proportion of protein, or better say, a mixture heavier in amino-acids, than after he attains his growth, when he is simply maintaining himself. That feed, therefore, which is palatable to swine when they are small, young, and immature may be relatively distasteful when they are large, old, and quite mature. It would seem that that feed is the most palatable which most nearly satisfies the appetite, this ultimately meaning the satisfaction of the specific cells in need.

The feeding standards which have been proposed for growing and fattening swine are still in a somewhat crude form. Attention is given primarily to the apparently digestible protein, carbohydrates, and fats; ratio of crude nutrients (that is, the number of pounds of carbohydrates or its equivalent present with every pound of protein); dry matter; and sometimes water. The Wolff-Lehmann standard, which has been the foremost one considered by animal husbandmen, was first proposed by Wolff,[37] a German scientist. This standard has been supplemented by the work of C. Lehmann of the Berlin Agricultural High School, Germany. This standard, based on the crude nutrients required per thousand pounds of live weight, is shown in Plates XLII, XLIII, and XLIV. The Illinois or Dietrich standard was proposed by Dietrich[38] of the Illinois Experiment Station. The Diet-

[36]For further discussion of this theme see,—Evvard, John M.: The Free-Choice System of Self-Feeding Swine, Nov. 1914. Am. Soc. An. Prod., Proc. 1914. (Not yet from Press in July, 1915.)

[37]Wolff, von, Dr. Emil, 1864, Mentzel and von Lengerke Agricultural Calendar; see also Henry: Feeds and Feeding, 1912, Twelfth edition, p. 590; Dietrich, William: Swine, 1910, p. 144; Woll, F. W.: Productive Feeding of Farm Animals, 1915, p. 294; and Jordan, Whitman Howard: 1901, Note 5, p. 435.

[38]Dietrich, William: Swine, 1910. The Revised Standard was given to the author by Dietrich in May, 1914, which standard is figured on the crude nutrient basis in Plates XLII and XLIII.

rich standard calls for a definite amount of digestible protein, carbohydrate, and fat daily for a hundred pounds of live weight; it pays little attention to the ratio of digestible or crude nutrients although these are figured and presented in Plate XLIV from the requirements which Dietrich suggests. Dietrich in addition gives the water requirement, but this is not considered at this time. These standards provide an interesting theme for discussion.

In converting the Wolff-Lehmann standard and the Illinois or Dietrich standard to the crude nutrient basis we have assumed[39] for the particular grain feeds used a digestibility of 80 per cent for the protein (which really means we added one-fourth or 25 per cent to the digestible figures given to get those presented on Plates XLI and XLII); 91 per cent for the carbohydrates (this calls for an addition of practically one-tenth or 10 per cent to the digestible figures given); and 70 per cent for the ether extract or fat (this calling for an addition of three-sevenths or approximately 42.86 per cent). We have likewise based the figures for the carbohydrate equivalent, assuming that one pound of crude fat is equal to 2.2 pounds of crude carbohydrate; therefore the fats are simply multiplied by 2.2 and this is added to the carbohydrate figure—this giving the crude carbohydrate equivalent. All figures are reduced to the Amounts Consumed Daily to a Thousand Pounds Live Weight.

Inasmuch as there is considerable variance in the digestibility of feeds, this depending upon the preparation of the feed, animals used, and also the ways in which the feeds are mixed together, it is deemed advisable to base the present paper upon crude nutrients rather than upon digestible ones; inasmuch as concentrated grains or their by-products were used entirely for the organic portion of the ration without any roughages whatsoever, the use of the crude nutrients is all the more justified.

The crude protein consumed daily to a thousand pounds live weight is given in curve form in Plate XLII. The striking features of this chart are:

1. The close similarity and coincidence of the feed consumption curves determined by the *free-choice* fed pigs fed upon three different combinations of feed.

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[39]Using as a basis figures from these sources: Forbes, E. B.: 1914, Ohio Exp. Sta. Bulls. 172 and 271; Dietrich, William, and Grindley, H. S.: 1914, Ill. Agr. Exp. Sta. Bull. 170; Grindley, H. S., Carmichael, W. J., and Newlin, C. I.: 1914, Ill. Exp. Sta. unpublished data; Jordan, Whitman Howard: Maine Agr. Exp. Sta. Rpt. 1886-87; Snyder, Harry: 1893, Minn. Agr. Exp. Sta., Bul. 26; and Evvard, John M., and Guernsey, S. C. 1910-11-12, Iowa Exp. Sta. Unpublished Data on Eighty Digestion Trials.

2. The somewhat natural tendency of the *free-choice* curves to gradually change without any general tendency towards abrupt differences. (This omits consideration of the ten day periodic variations.)

3. A "period of readjustment" is noticeable in the first 30 days, as it takes the pigs a few weeks to adjust themselves to the new conditions of eating,—new feeds, new quarters, new environment, and other not hitherto experienced factors.

4. The fairly close agreement between the Dietrich or Illinois standard and the "appetite" curves.

5. The contrasted character of the Wolff-Lehmann curves and the "appetite ones." The type of curve is different in these two instances.

Peculiarly enough, the pigs ate somewhat as the Dietrich Illinois standard would allow, but without the specific rises and falls.

While the breaks in the curves are noticeable, especially on the 135th day of age, the 145th and the 155th, yet these are probably due indirectly to technique, climatic and other immediate factors. After the pigs reached the age of 160 days, however, it is quite noticeable that the curves are more uniform. This is explained somewhat by an improvement in the method of "weighing back" the uneaten feed. At this time a constant hour was set aside for this procedure at the end of every ten day period; whereas formerly the feeds were "weighed back" sometime during the forenoon, considered as from 7 A. M. to 12 M. At any rate, the general natural tendency of the "free choice" "appetite" curves is well brought out; the data from a large number of trials would smooth out the appetite curves.

After the 245th day of age the Dietrich standard has not been formulated, hence it is incomplete from that point on.

The Wolff-Lehmann standard calls for a lesser amount of protein than does the "appetite" in most of the growing period, or until the pigs reach the age of practically 190 days, at which time the requirement is in excess of the appetite. Of course, it is entirely probable that if the protein allowance is based on the Wolff-Lehmann standard early in the period the pigs will tend to compensate for this deficiency later. We note this to a considerable extent in practice: pigs that have been starved for amino-acid mixtures during the early part of their life, do, when later given a free opportunity to eat of an abundance of amino-acids in the natural feeds increase their consumption over and above normal, that is over what these same pigs would have eaten had they been given an abundance from the beginning.

That there is a gradual and steady decline after the first 30 days in the ''appetite'' protein requirement is evident. This decline, however, after the pigs reach 240 days of age is not very marked, and from the 300th to the 355th day there is but a slight decrease, or about one-tenth the decline in actual amounts per unit weight that is noticeable between the 140th day and the 190th day. This probably indicates that the pigs have passed the period of maximum growth per unit of live weight,—which indication is borne out by the visual observations as regards increase in weight, height, length, and breadth of the animals under consideration.

The crude carbohydrate equivalent consumed daily to a thousand pounds live weight is given in Plate XLIII. The striking features of this chart are:

1. The marked similarity and coincidence of the curves of the three ''free-choice system'' or ''appetite'' fed lots.

2. The ''period of readjustment'' in the first thirty days of feeding.

3. Fairly close agreement of the Dietrich Illinois standard with the ''appetite'' curve when the pigs increase in age from 80 to 160 days; after which time, however, this standard calls for carbohydrate nutrients in excess of those actually eaten.

4. The gradual natural decline in carbohydrate equivalent consumption from the 160th day of age until the pigs are practically a year old. This decline is most marked after the pigs are a little more than five months of age, thus indicating that early in life the consumptive ability kept pace with the increase in weight. After the first five months of life, however, the capacity (as indicated by the amount eaten) did not enlarge proportionately as rapidly as the weight increased.

5. The relatively low requirement of the Wolff-Lehmann standard until the pig reaches seven months of age as contrasted with the ''appetite'' curve (or even the Dietrich standard requirement). The high comparative Wolff-Lehmann requirement after seven months is much greater than the ''appetite,'' fully satisfied from the beginning, demands. Judging these curves from the standpoint of reasonability it would seem that the lines

more naturally run are those of the "appetite" fed pigs, providing these lines are smoothed out on a "general average basis".

Dietrich found that his standard was more satisfactory than the Wolff-Lehmann one. If that is true then it would seem that the "appetite"-fed pigs are certainly nearly right, and there is a question whether or not they would not excel Illinois standard fed pigs.

Investigations are now in progress at the Iowa Agricultural Experiment Station in which the Illinois standard, the Wolff-Lehmann standard, and the *freedom of choice* or *appetite* system are being compared.

The ratio of crude nutrients (pounds of carbohydrate equivalent eaten with every pound of protein) has been worked out for the two discussed standards—the Dietrich and the Wolff-Lehmann, as well as for the *free-choice system* fed pigs. The close similarity of the ratios until the pig reaches about 190 days of age is quite strikingly evident. At this time, however, (187 days) the Dietrich ratio curve mounts to an almost inconceivable height, and then on reaching its maximum on the 210th day comes quickly down again to the apparently normal. This marked widening of the Dietrich ratio at this time is primarily due to the very rapid decrease in protein inaugurated on the 187th day. This decline continues until the 213th day when a level is reached. On the same day that this low level point of protein allowance is reached (213th day) the ratio begins to narrow, as is evident from Plate XLIV (compare Plates XLII and XLIV on this point).

Taking everything into consideration, the ratio of crude nutrients in the two standards and the "appetite" scheme more closely agree than the crude protein and the crude carbohydrate equivalent, consumption daily to a thousand pounds live weight. The disagreements, however, are clearly evident.

The Wolff-Lehmann standard approximates the "appetite" curve very closely up to the 175th day or thereabouts but from that time on it calls for a much narrower ration (which is more expensive, generally, though not always, from the animal husbandman's standpoint, than the ratio chosen according to the appetite). Practical men for the most part assuredly wish that the "appetite" curve as compared to the Wolff-Lehmann requirement be more nearly correct, because the former is more economical, ordinarily, likewise easier to accomplish.

The gradual tendency of animals to widen their ration as the period progresses is self evident. It has not been demonstrated heretofore to our knowledge that animals allowed free expression as regards satisfaction of appetite would widen their ration as these have done, only to narrow it again in the later stages of fattening. This is evidently what happens with growing pigs and the reason is probably not far to seek. From the 80th up to the 255th day of age the ''appetite'' fed pigs did gradually widen the ratio from about 1:4 to 1:7.7, after which time it was gradually narrowed until it reached a ratio of 1:6.4 on the 345th day. (This is disregarding the drop in Lot III on the 275th day, which is discussed in a footnote.[40]) One would think that with a narrower ration the pigs would, of course, want more protein per unit live weight, but reference to Plate XLII shows this not to be the case because the protein actually decreases gradually. Reference to the carbohydrate equivalent, Plate XLIII, likewise demonstrates that the carbohydrates per thousand pounds live weight eaten are gradually lessening at this time although comparatively at a more rapid rate than the protein.

Now, what is the reason for this narrowing of the ration, after the maximum ''wideness'' had been approached? Reference to Plate XLI shows that there is a gradual lessening in the amount of total grain feed eaten after the 193d day, at which time a maximum of a little over 9.7 pounds was reached until on the 350th day the amount of grain feed eaten had decreased to about 5.5 pounds, a decrease in consumption of more than 45 per cent. The total protein consumption likewise, has gradually declined after the 193d day although this decline has been somewhat slow from the 300th to the 355th day. The carbohydrate equivalent has lessened markedly after the 193d day, and this decrease continues to the finish of the experiment, the

[40]This is brought about by a somewhat marked increase in the amount of protein eaten in the meat meal at this time (275th day—see Plate XLII). But why this heavier meat meal consumption? This observation was simultaneously made: The pigs in Lots I and II began to eat charcoal at this time, and ate more in a day than during their whole previous lives. But not so with Lot III, as they seemingly did not realize that it was charcoal that was needed, and not meat product. However, at about the 275th day this group too tardily discovered that the "charcoal box was the place wherein to seek satisfaction of appetite," and shortly we note a decrease again in the meat consumption. Note, however, that Lots I and II, especially so the latter, started to eat large quantities of the charcoal on the 265th day, or just a few days after they had reached the maximum of almost 100 pounds (respectively 98.25 and 99.47 pounds) of corn out of every 100 pounds of all feeds (excluding water) eaten. Did the corn diet "set up" a peculiar combination of conditions that called for charcoal as a corrective, or antidote, or what was it?

decrease from the 300th to the 355th day being plain. To eat the certain minimum amount of protein, which may be assumed as absolutely necessary and to be as shown in Plate XLII, the pigs must narrow the ration toward the finish (after the 255th day) in order to get protein sufficient. The quality of the ration must be changed so as to have more protein in a hundred pounds of feed, inasmuch as less units of feed are being eaten because of an evident lack of consumptive ability.

Just what would lessen the capacity of the animals after the 193d day is not definitely known but this may be attributed to:

1. A lack of alimentary volume due to the greatly increased stores of internal fat.

2. An actual lessening in the demands for feed nutrients because the most rapid period of growth has been passed. The milch cow when giving a large quantity of milk daily will eat more feed than if not lactating; the same is true of the sow suckling pigs. The working man eats more heartily, naturally, than the sedentary one; the growing child eats to the limit ofttimes compared to the mature and aged. It is thus seen that the pig which is rapidly growing has great demands upon its digestive apparatus to eat and digest feed to furnish the necessary nutrients for assimilation. The greater the outlet for the assimilable nutrients the greater, ordinarily, the consumptive ability of the animal in question.

One dominant reason for the sometimes ineffective results secured in feeding according to ordinary standards is the difficulty of knowing the resultant of the many, specific units, as many as a hundred, which in all probability are comprised in an ordinary feeding-stuff such as maize grain, or meat meal, or oats, or oil-extracted flax grain residue. The suitability of different individual feeds for the animals in question has been determined largely from a careful observation of results secured in practical Animal Husbandry. This general knowledge of practical feeding-stuffs and their effects is of great advantage in supplementing the best feeding standards. At best the ''best'' standard available today is but a crude approximation of actual requirements. When the appetite is given full control of what shall be eaten it is surprising to note how the pigs naturally select the specific feeds which swine herdsmen have long since approved as of the best, and what is equally surprising the pigs show marked avoidance of those feeds usually considered as ill-adapted to swine.

Undoubtedly the kind of feeding stuff offered to growing and fattening swine determines to a considerable extent the relative quantity of the different feed constituents,—proteins, carbohydrates, fats, minerals, water, and so on,—which is consumed. On a milk diet for instance, in which buttermilk is allowed at free-will in conjunction with such feeds as Indian corn, 60 per cent protein meat meal, wheat middlings and rock salt, the amount of protein eaten tends to be quite high as compared to a similar ration without the milk,—but it is yet to be demonstrated that a lesser milk allowance (limited) under such circumstances would be an improvement judged from the physiologic viewpoint; it is entirely likely that economic considerations would preclude the possibility of allowing such large quantities of milk, yet that, too, depends upon the relative value of the different feeds in question. When buttermilk can be had for nothing and the other feeds are charged at normal corn belt (1915) rates, then the maximum consumption of the milk would likely be attended with greatest economic profit regardless of the physiologic aspects, unless they be unhappily and extraordinarily unfavorable to the milk addition, which development, however, is not probable. The point to this paragraph is this: The source of the different constituents,—proteins, carbohydrates, fats, and so on affects quite materially the best physiologic standards to be formulated. In other words, to be specific, it is quite probable that a different standard would need to be used in order to secure the greatest physiological returns if buttermilk and Indian corn are used as a general source of these constituents than if meat meal and Indian corn be depended upon. This theme, however, awaits much more investigation before it is possible to make positive statements, statements that can be backed up with the evidence.

In the formulation of human dietaries much effort has been expended in determining what different people actually eat under varying conditions of life. In the production of swine-feeding standards, however, this feature has been, to our knowledge, almost wholly neglected.[41] The pig has not been given an

[41]See Stabler, A. L.: Pig Feeding Experiments, 1911, Maryland Agr. Exp. Sta. Bul. 150. pp. 108-113. Stabler self-fed five young growing pigs for 77 days, giving them corn meal, wheat bran, linseed meal, and meat meal in separate troughs, but the results are presented without significant comment. In part he says,—"It is worth noting how regular these pigs were in their habits of feeding", and "the pigs ate much more of the corn meal than of all the other feeds combined", and, "these pigs made very satisfactory gains for feed consumed." The experiment was discontinued on the eve of "possible striking developments."

opportunity to "tell" what he would take in order to grow to advantage. If an investigator wished to improve the methods of swine feeding the usual and customary procedure has been to use the most approved standard as a basis and compare the new schemes with it. The method of deductive reasoning employed in the study of the human dietary stands in marked contrast to that used in the research done on swine standards. The pig has been kept in the background; whereas he might have occupied the foreground advantageously.

A few closing words concerning appetite, and the factors affecting nutritional needs may not be amiss. Appetite is the resultant of thousands upon thousands of generations of biological selection. Certain physiological specifications are inherited, and then unconsciously they are fulfilled in so far as the environment allows. The various demands, changing from day to day, affect the bill of materials necessary. Every slight act or movement plays a specific part in creating the nutritional demands. In addition certain external factors must be reckoned with, such as extremes of temperature, humidity, atmospheric pressure, and other conditions.

Factors which we control and factors over which we have no control are operative in this business of living our lives through the years of development; both must be reckoned with, and faced squarely from the nutritive standpoint.

SUMMARY.

1. There is much difference of opinion as to whether or not the appetite may indicate reliably the nutritional needs.

2. The futility of ideally balancing the diet or ration through arbitrary dietaries or standards, based on known physiological and chemical facts, is evident from a survey of the "field of possible unknowns." At best the attempt will result in what may be considered *Rough Estimates*.

3. The appetite of the pig appears to be a very good guide as to bodily needs; hitherto the apparent reliability of the appetite has not been duly appreciated.

4. Growing pigs fed sodium chloride (common salt) ad libitum made more rapid growth (increase in weight) with less requirement of feed per unit increase than when no salt was allowed, or when it was mixed in variable quantities with a basal ration of corn grain and linseed oil meal (whole flax grain minus most of the oil).

5. The ordinary feeding standards for swine—the Dietrich or Illinois, and the Wolff-Lehmann, in some respects closely approximate the appetite, but in many, they diverge widely. This divergence is quite naturally expected, inasmuch as there are so many "unknowns" involved as regards the animals to be fed, the feeds to be used, and the environment to be experienced.

6. The palatability of feeds is relative; the specific feeds which are relished early in growth may not be relished later when the animals are mature.

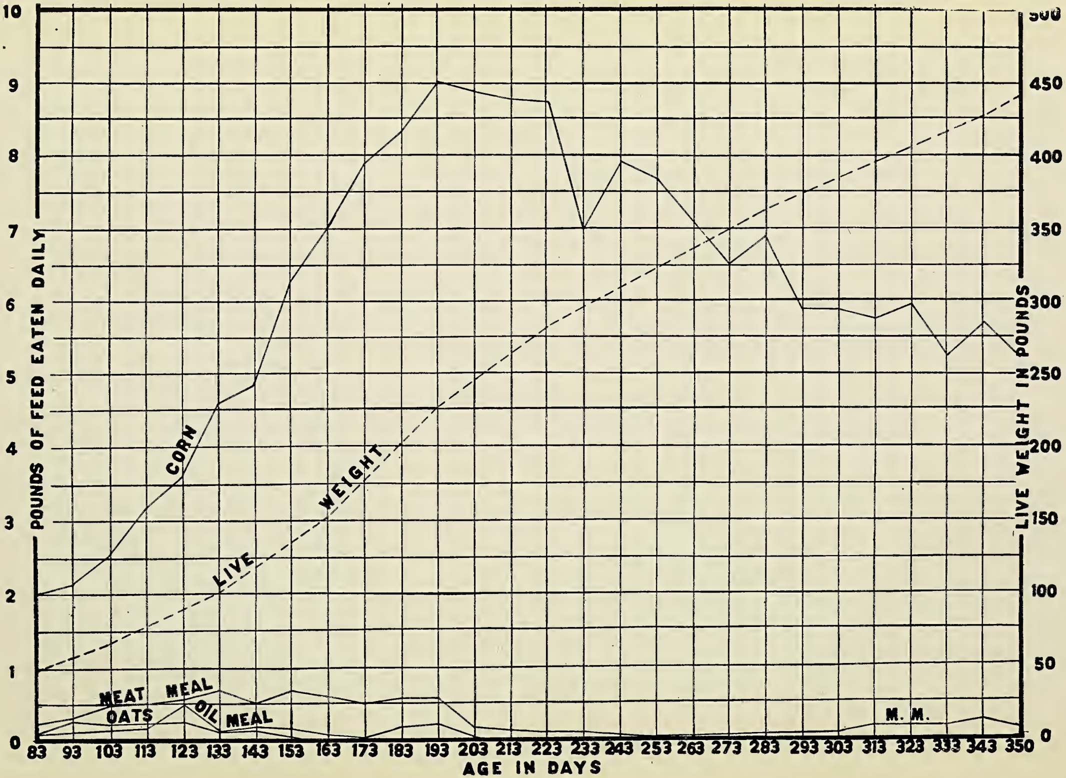
7. The appetite of pigs varies according to growth or development; many internal as well as external factors affect the desire for nutrients.

8. Pigs fed according to the "Free-Choice System of Swine Feeding," when given suitable feeds, grow very rapidly, ofttimes weighing 300 pounds at eight months of age; one pig so fed weighed 405 pounds in 247 days, a remarkably good record. Evidently this "growthy" pig was provided a most excellent opportunity, as regards the "bill of materials" supplied, to make the maximum development.

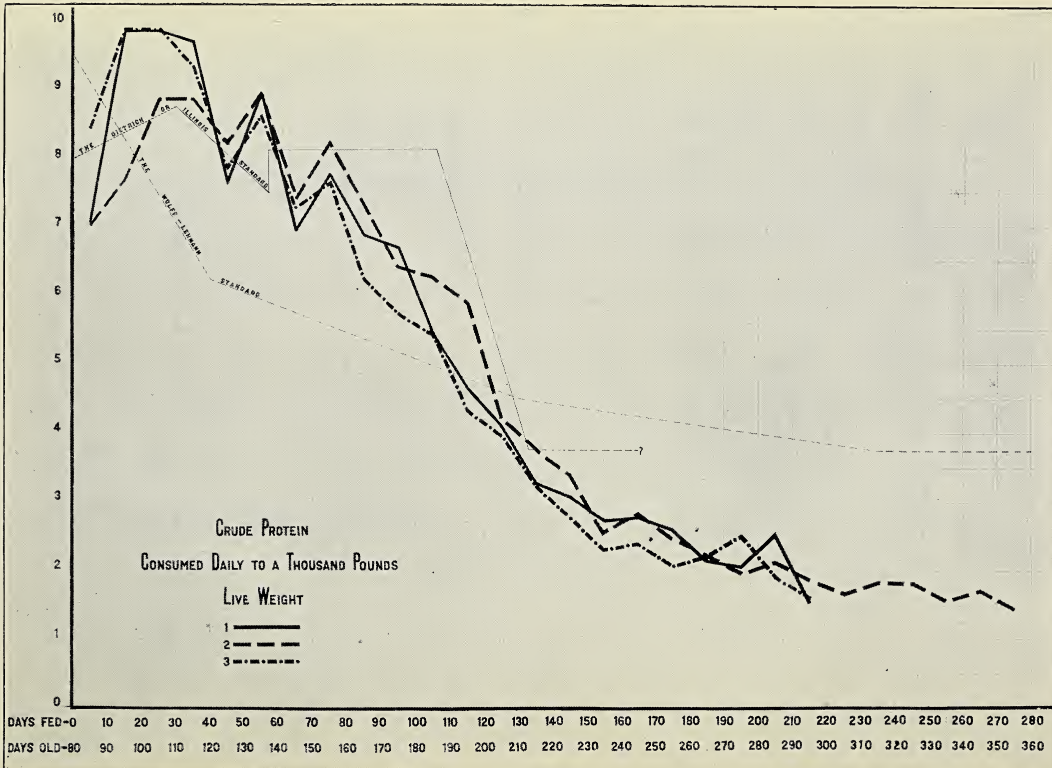
9. Heretofore in studying and formulating swine feeding standards the appetite of the pig has been largely ignored, dependence being placed on existing "man-made" standards. Each new comparison, therefore, was made with the various existing standards. Is it not time to face about and study normal "appetite" intake, using this as a rational basis for further investigation. In the study of human dietaries this has been diligently done, hence it is the more surprising that but little attention has been accorded the "pigs' appetite."

10. The "appetite" studies open a most promising field of research along nutritional lines.

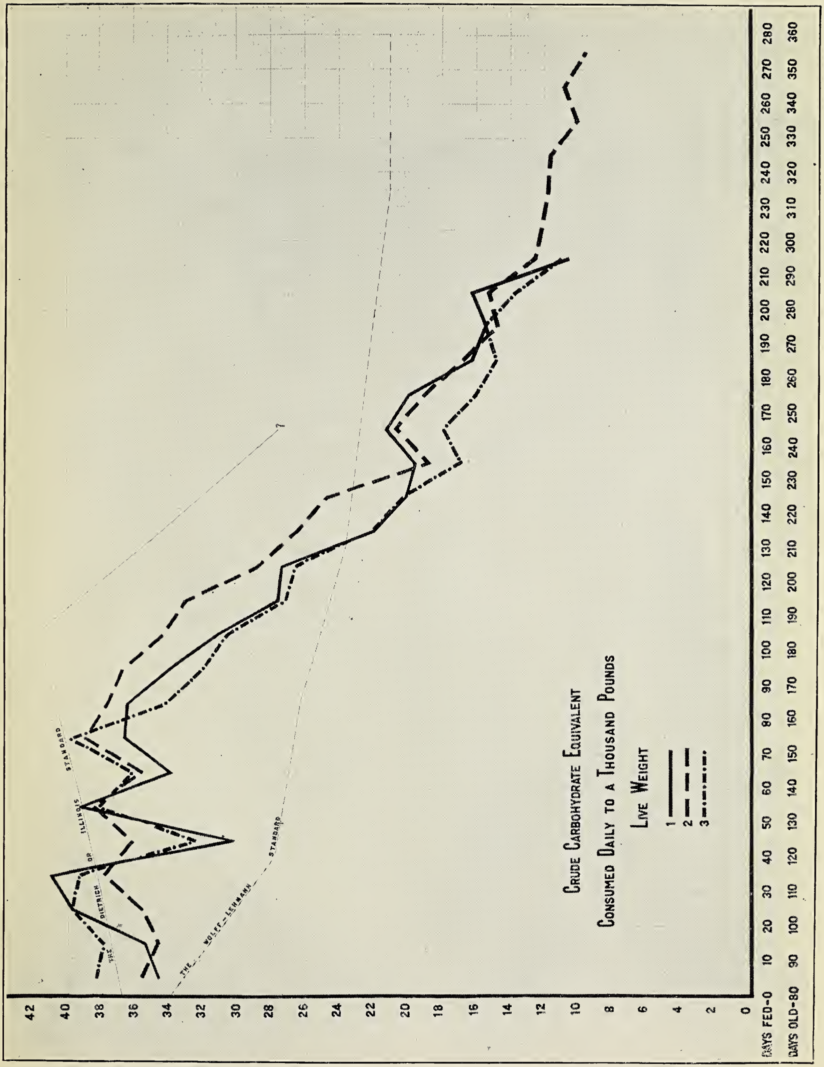
Animal Husbandry Section Laboratories
of the Iowa Experiment Station.



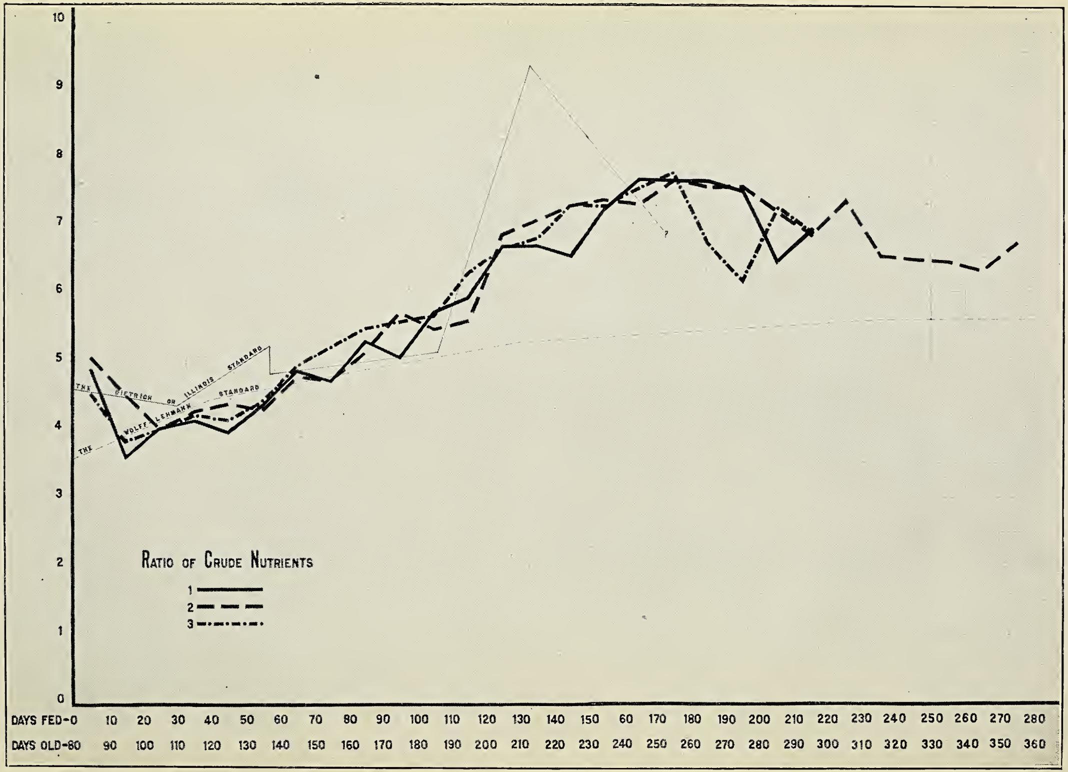
The food consumed daily in the "Free-Choice System of Swine Feeding," when pigs have free access to corn, meat meal, linseed meal, and oats; the progressive live weight is also plotted.



The crude protein consumed daily to a thousand pounds live weight in the "Free-Choice System of Swine Feeding," compared to the requirements of the Dietrich or Illinois, and the Wolff-Lehmann standards.



The crude carbohydrate equivalent consumed daily to a thousand pounds live weight in the "Free-Choice System of Swine Feeding," compared to the requirements of the Dietrich or Illinois, and Wolff-Lehmann standards.



The ratio of crude nutrients consumed in the "Free-Choice System of Swine Feeding," compared to the Dietrich or Illinois and Wolff-Lehmann standards.

A Free-Choice Fed Pig.
This female swine seemingly developed to somewhere near its inheritance, due indirectly to the system of feeding.

SUBJECT INDEX

AUTHORS' INDEX