PROCEEDINGS

OF THE

Iowa Academy of Science

FOR 1913

VOLUME XX

EDITED BY THE SECRETARY

PUBLISHED BY THE STATE

DES MOINES
ROBERT HENDERSON, STATE PRINTER
1913

June 12

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LETTER OF TRANSMITTAL.

DES MOINES, IOWA, July 1, 1913.

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

In accordance with the provisions of title 2, chapter 5, section 136, code, 1897, I have the honor to transmit herewith the proceedings of the twenty-seventh annual session of the Iowa Academy of Science and request that you order the same to be printed.

Respectfully submitted,

L. S. ROSS,
Secretary Iowa Academy of Science.

OFFICERS OF THE ACADEMY.

1912.

President—A. A. Bennett.
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Second Vice-President—C. N. Kinney.
Secretary—L. S. Ross.
Treasurer—George F. Kay.

EXECUTIVE COMMITTEE.

Ex-officio—A. A. Bennett, A. G. Smith, C. N. Kinney, L. S. Ross, George F. Kay.

Elective—B. H. Bailey, H. S. Conard, E. J. Cable.

1913.

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

EXECUTIVE COMMITTEE.

Ex-officio—C. N. Kinney, H. S. Conard, Henry Albert, L. S. Ross, George F. Kay.

Elective—E. N. Wentworth, E. J. Cable, A. G. Smith.

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Osborne, 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
Frankin, W. S 1897
Macbride, T. H 1897-98
Hendrixson, W. S 1899
Norton, W. H 1900
Veblen, A. A 1901
Summers, H. E 1902
Fink, Bruce 1903
Shimek, B. 1904
Arey, M. F 1905
Bates, C. O 1906
Tilton, John L 1907
Calvin, Samuel 1908
Almy, Frank F 1909
Houser, Gilbert L 1910
Begeman, L. 1911
Bennett, A. A 1912

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Baker, R. P...............Iowa City
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Begeman, Louis ....Cedar Falls
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Orr, Ellison .... Waukon
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Stiles, Harold .... Sioux City
Stoner, Dayton .... Iowa City
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Taylor, Miss Beryl..... Cedar Rapids
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Van Tuyl, Francis M..............
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Columbia University
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Wells, W. Stanley....... Sioux City
Wheat, G. G........ Cambridge, Mass.
Whitney, Thos. H........... Atlantic
Wright, John W........... Knoxville
York, Fred R.............. Iowa City
Yule, Mildred R.............. Clinton

CORRESPONDING MEMBERS.

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

TABLE OF CONTENTS

PROCEEDINGS OF THE

Twenty-Seventh Annual Session of the Iowa Academy of Science

REPORT OF THE SECRETARY.

Fellows and Members of the Iowa Academy of Science:

During the year since the last meeting of the Academy no vigorous campaign has been conducted to increase the membership. No attempt was made by the secretary to reach the high school science teachers other than by sending out programs of the 1913 meeting. This was done in order that the general character of the papers presented might be known. and the way be prepared to extend invitations during the coming year.

Three notices of the 1913 meeting were mailed to the members; in addition to the notices a program was sent to each member.

In February an invitation from the Minnesota Academy of Science was received by the president of the Academy, to send a delegate to represent the Iowa Academy at their 40th anniversary which occurred March 4th. It was hardly practicable to accept the invitation because funds were not available.

Almost every year a few authors append the names of the laboratories where their work was done, to the papers sent to the secretary for publication. It has not been the custom to indicate the schools or laboratories with which the authors may be connected. If it be desirable to make a change in this respect it will be well for the Academy to take action to that effect. The question is one upon which there may be difference of opinion. Also would it be well, or would it not, to give the academic degrees held by the members of the Academy, educational positions occupied, or positions of honor, and the schools with which they are connected, in the list of fellows and members as it appears in the Proceedings. No recommendation is made in this report.

It seems to be accepted as a fact that a law or rule that does not have the sympathetic support of the people passing the law or formulating the rule is not enforced nor indeed can it hardly be. Among our rules is one to the effect that an abstract shall be submitted with the title of the paper to be presented at the meetings of the Academy. Action to this effect was taken some years ago and the action has received endorsement during very recent years. Last year twelve abstracts accompanied the forty-six titles, and this year some twelve or thirteen abstracts accompany fifty-eight titles. A long list of titles, with a few abstracts scattered among them, does not appear well in the printed program. For the sake of uniformity, only the titles appear on the program this year.

The volume of Proceedings for 1912 is still on the press, but will soon be ready for distribution. Unfortunately, by error, the copy was set up in 8 point type. The secretary was not aware of the fact until the first galley proof was received. Upon correspondence with the members of the executive committee the decision was reached to print the volume in the type as set up, rather than prolong the delay in publication.

It is very evident that interest in the work of the Academy on the part of the members, is in a normal, healthy condition of growth. In 1910 thirty titles were presented; in 1911, thirty-four; in 1912, the anniversary year, forty-six, and in 1913 fifty-eight titles.

Respectfully submitted,

L. S. Ross, *Secretary.*

TREASURER'S REPORT.

RECEIPTS.

Cash on hand April 27, 1912	$161.84
Dues and initiation fees from fellows and members	214.00
Life member fees	14.00
Sale of proceedings	2.17
Interest on deposits	7.27
Total	$419.28

EXPENDITURES.

Expense of lecturer, 26th meeting	$ 37.89
Postage and stenographic work for treasurer	20.00
Stationery and postage for Past President Begeman	13.95
Programs, letterheads, envelopes, folders, etc	39 54
Binding reprints, etc.	78.75
Balance paid on banquet at Chamberlain Hotel	8.25
Postage and clerical work for secretary	23.20
Honorarium to secretary	25.00
Wrapping and sending out Volume XVIII	10.00
Cash on hand, April 26, 1913	162.70
Total	$419.28

Respectfully submitted,

George F. Kay, *Treasurer.*

REPORT OF COMMITTEE ON MEMBERSHIP.

The following names are recommended to the Academy.

TRANSFERRED FROM LIST OF MEMBERS TO LIST OF FELLOWS.

J. A. Baker, Indianola; Ira S. Condit, Cedar Falls; H. L. Dodge, Iowa City; G. B. McDonald, Ames; R. P. Getchell, Cedar Falls; E. A. Jenner, Indianola; T. C. Stevens, Sioux City; Harold Stiles, Sioux City; S. M. Woodward, Iowa City.

ELECTED TO LIST OF FELLOWS.

J. P. Anderson, Ames; Paul H. Dike, Mt. Vernon; J. M. Evvard, Ames; R. A. Pearson, Ames; G. N. Turpin, Ames.

ELECTED TO MEMBERSHIP.

F. W. Allen, Ames; E. K. Anderson, St. Charles; F. W. Beckman, Ames; Charles E. Blodgett, Atlantic; E. N. Boland, Ames; David H. Boot, Iowa City; John H. Buchanan, Ames; E. J. Butterfield, Dallas Center; E. P. Churchill, Iowa City; W. H. Davis, Cedar Falls; Clifford H. Farr, Iowa City; W. J. Ferguson, Des Moines; Miss Sebena S. Frasier, Oskaloosa; Miss Zoe R. Frasier, Oskaloosa; Raymond A. French, Iowa City; Ira N. Gabrielson, Marshalltown; C. E. Gethman, Eldora; Earl Grissel, Iowa City; B. H. Hammer, Ames; H. L. Hawkins, Little Rock; Miss Ruth Higley, Grinnell; F. B. Hills, Ames; L. G. Holbrook, Des Moines; Karl E. Kastberg, Boone; L. E. Kenoyer, Toledo; William L. Kuser, Eldora; F. L. Ovenly, Ames; W. W. Patrick, Iowa City; Herbert J. Plagge, Ames; J. C. Pomeroy, Ames; T. H. Quigley, Dallas Center; O. B. Read, Pella; L. K. Riggs, Toledo; Fred S. Risser, Des Moines; A. H. Shatz, Merrill; C. J. Schmitt, Eldora; W. B. Slattery, Spirit Lake; Wilbert A. Stevens, Tabor; Miss Katherine L. Stewart, Davenport; G. I. Tenney, Des Moines; E. V. Tuttle, Lanesboro; Fred Vorhies, Iowa City; Everett Wells, Cresco; Fred B. York, Iowa City; George M. Young, Jr., Des Moines.

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

NAMES OF THOSE IN ATTENDANCE.

M. F. Arey, W. E. Anderson, T. R. Ball, J. A. Baker, F. C. Brown, Fred Berninghausen, R. E. Buchanan, T. J. Burrill, C. E. Bartholomew, A. L. Bakke, Perry A. Bond, Henry S. Conard, E. J. Cable, James A. Cass, A. W. Dox, Paul H. Dike, H. L. Dodge, W. H. Davis, Wesley Greene, J. E. Guthrie, Ira N. Gabrielson, R. W. Getchell, Ada Hayden, S. F. Hersey, E. A. Jenner, C. N. Kinney, Wm. Kunerth, Charlotte M. King, G. F. Kay, James H. Lees, D. W. Morehouse, J. N. Martin, Ray E. Neidig, L. H. Pammel, Herbert J. Plagge, F. W. Paige, J. N. Pearce, L. S. Ross, H. E. Summers, L. B. Spinney, T. C. Stevens, L. P. Seig, Harold Stiles, W. H. Stevenson, G. W. Stewart, F. C. Stanley, Dayton Stoner, John L. Tilton, E. W. Wentworth, R. L. Webster, Fred R. York.

PROGRAM.

The meetings of the Academy were held in Alumni Hall, Iowa State College, Ames, beginning at 1:30 p. m., Friday, April 25. A business meeting was held, after which scientific papers were read. The time Saturday forenoon was occupied with the presentation of the remaining scientific papers and with the final business meeting.

President Pearson of the Iowa State College extended a welcome to the Academy at 8:00 p. m., Friday. After this the public address on "Wealth from Worthlessness" was given by Dr. Thomas J. Burrill, Professor Emeritus of Botany, University of Illinois.

A reception was given to the members of the Academy and friends after the address.

TITLES OF PAPERS PRESENTED.

The Contamination of Public Water Supplies Through Fissures in Rocks .... Henry Albert

Bacterial Activities of Crop Production .... P. E. Brown

Tramping About Puget Sound .... T. H. Macbride

The Conifers of Monterey Peninsula .... T. H. Macbride

The Diclinous Flowers of Iva Xanthiifolia .... Clifford H. Farr

(Introduced by R. B. Wylie)

Pure Lines and What They Mean to Iowa's Grain Crop .... L. C. Burnett

Quercus borealis Michx. f. .... B. Shimek

The Sedges of Henry County, Iowa .... John T. Bucholz

The Effect of Smoke and Gases Upon Vegetation .... A. L. Bakke

PROGRAM (Continued)

The Variation of the Resistance of Antimonite Cells with the Current Flowing, and the Probable Interpretation of This Variation..F. C. Brown

The Change of Young's Modulus of a Soft Steel Wire with Electric Current and External Heating..................................H. L. Dodge

Are the Photo-Electric High Potentials Genuine....Paul H. Dike and F. R. York

Variation of Correspondence of Phase Relations and Sound Beats, the Two Sounds Being Presented One to Each Ear.................G. W. Stewart

Some Dangers in Statistical Methods.........................Arthur G. Smith

The Problem of the Vision of an Illuminated Surface................L. P. Sieg

An Experimental Investigation of the Relation Between the Aperture of a Telescope and the Quality of the Image Obtained by It....Fred Vorhies

On the Existence of a Minimum Volume Solution...............LeRoy D. Weld

Destruction of the Blue Bird by the Yellow Hammer......Fred Berninghausen

A Further Study of the Home Life of the Brown Thrasher, Toxostoma Rufum Linn ....Ira N. Gabrielson

On Certain Points in the Anatomy of Siren Lacertina............H. W. Norris

The Food Habits of the Skunk................................Frank C. Pellett

Nest Boxes for Woodpeckers.................................Frank C. Pellett

Life History Notes on the Plum Curculio in Iowa.............R. L. Webster

Color Inheritance in Horses..............................Edward Wentworth

Some Factors in Foetal Development...........................J. M. Evvard

Additional Mammal Notes ....T. Van Hyning

Appearance of a Case of Urticaria Factitia in the Coe College Psychological Laboratory ....Walter S. Newell

THE POLLUTION OF UNDERGROUND WATERS WITH SEWAGE THROUGH FISSURES IN ROCKS.

BY HENRY ALBERT.

The possibility of pollution of underground waters through fissures in rocks has long been a well established fact. The actual demonstration of such as the source of cases or epidemics of disease in Iowa has until recently not been proved. It is with the idea of reporting an epidemic of typhoid fever due to pollution of this kind and of calling attention to the need of a sanitary water survey in Iowa, that I present this paper.

The more superficial rocks of the state present many joints or fissures, through which pollution with sewage material may pass. Many of the springs of the state which issue from such fissures, have their source of water supply from the superficial layers of soil not far away which means that such water has not been subject to very much filtration or in case the water has entered sink-holes which are especially common in the northeastern corner of the state, has probably not been filtered at all.

THE CEDAR FALLS EPIDEMIC OF TYPHOID FEVER.

During the fall of 1911 there occurred at Cedar Falls, an epidemic of typhoid fever during which about 100 persons were affected, and about 20 died. The water supply of Cedar Falls previous to the time of the epidemic was from a spring in the valley of Dry Run, a small intermittent tributary of Cedar river. It comes from a fissure in the Devonian lime-stone. That this water was the source of infection was shown by both the epidemiological data and laboratory examinations indicating contamination of the water with sewage material. That the water comes in part at least from surface soil is shown by the fact that it becomes turbid after a heavy rain and high river floods. It was at first believed that the water issuing from the spring was contaminated, and that the contamination had occurred through fissures in rocks. Many repeated tests with fluorescein have however all been negative. Prof.

Arey informed me recently that in case of high water, although the city water was turbid, the water from the spring remained clear. He believes that the contamination probably occurred entirely while the water was being conducted from the spring to the collecting system at the pumping station through an old wooden conduit buried in the ground subject to overflow from the river. The fact, however, that the number of bacteria in the water directly from the spring varied from 40 to 480 per cubic centimeter and that the water in many of the neighboring deep wells with pipes extending into the limestone of the surrounding country becomes turbid in times of high water, would indicate that there is some contamination of the water through the fissures in the rocks with material of the neighboring stream or surface soil.

It is worthy of note that the public generally regards all spring water as pure. The people of Cedar Falls were astounded when it was announced that their water supply was the source of the infection. When in 1904, after Waterloo had experienced an epidemic of typhoid fever, that city was casting about for a new water supply, many of the citizens suggested the construction of an aqueduct to the spring at Cedar Falls.

THE FORT DODGE EPIDEMIC.

An epidemic of typhoid fever occurred at Fort Dodge, during the summer and fall of 1912. About 100 persons were affected by the disease of whom four died.

The water supply of Fort Dodge comes principally from the deep wells. They also take the water from pipes beneath the river. The source of infection was apparently from both the pipes beneath the river and from one of the deep wells. The feature of interest is in connection with the latter. This well (Well No. 1) which was the first of the three wells as also the deep stone—being 1,827½ feet deep and extending to the Jordan sandstone, was started at the bottom of a large shaft which was constructed several years previously for the purpose of supplying the city with water. This shaft which measures 10x10 feet across extends down for 90 feet. From the west side of the lower end of this shaft, a tunnel, 9 feet in diameter, was extended under the Des Moines river. This tunnel was driven in sandstone, so required but few timbers for support, whereas the shaft has a wooden casing for almost its entire extent. The shaft extends successively from above downward through the following layers of earth:

Alluvial gravely soil and clay	31 ft.
Limestone	6 ft.
Shale, blue	27 ft.
Limestone	6 ft.
Sandstone	42 ft. (tunnel in this formation.)

There are only about 20 feet of gravel, alluvial soil and clay from the bottom of the river to the first layer of limestone. Through this the water from the river and surrounding soil will probably pass quite readily and without efficient filtration. It then comes to a layer of limestone which is known to contain many fissures, through which water may readily enter the shaft. Beneath the limestone is a layer of blue shale, 27 feet in thickness. This is relatively impermeable to water, hence tends to keep the water from passing directly downward and so hastens the passage of water laterally along the limestone fissures—in the direction of drainage—namely, toward the shaft. Previous to the construction of the tunnel the seepage into the shaft was at the rate of about 55 gallons per minute. This was increased to 80 gallons per minute by the construction of the tunnel. This would seem to indicate that the water which enters the shaft is of recent surface origin. That the water must have come principally through such fissures in the rocks is indicated by the fact that when the shaft was constructed, but little water appeared until after the limestone layer with its fissures had been entered.

That the water which comes from the shaft is polluted with sewage material has been shown repeatedly by chemical and bacteriological examinations. When the first artesian well was drilled (Well No. 1) it was started from the bottom of the above mentioned shaft. The casing of this well extends through the shaft and projects at the top several feet above the level of the water in the shaft. The water flowing from the artesian well fell into the shaft which became filled with water to the top of the discharge pipe. In this manner the water from the artesian well and the seepage water from the shaft and tunnel were mixed. Soon after the completion of this artesian well, a sample of this water was sent to us for examination. We expected to find either no bacteria or only a very few. We found, however, that the bacterial count went up to 42 per cubic centimeter with 2 colonies of colon bacilli. Chemical examination likewise showed evidence of contamination with sewage material. The reason for this was not explained until after a personal inspection and subsequent examinations showed that the contamination occurred in the large shaft with water from the shaft and tunnel. The water taken directly from the well did not show any evidence of pollution. We believe that the water of the tunnel and shaft comes largely quite directly from the river through fissures in the rocks and hence is not properly filtered.

CONCLUSION.

We believe that the pollution of water through fissures in rocks occurs more frequently than is generally thought to be the case. But whether from that source or some other, pollution of public water supplies in Iowa is of common occurrence. With polluted water supplies, the question of epidemics of typhoid fever is, of course, a possibility at any time. There is great need for a thorough sanitary water survey of the state. The State Geological Survey has accomplished a most meritorious work in its study of underground waters. The report will be of great service to sanitarians, but there is now an urgent need for a survey, the prime purpose of which will be to determine whether or not a given water supply may be the source of disease.

I desire to acknowledge my obligations for most of the data upon which this paper was based, to A. L. Grover, of our laboratory, who made the epidemiological investigation of the outbreak of typhoid fever at Cedar Falls; to A. M. Alden, also of our laboratory, who made a similar investigation of the epidemic of typhoid fever at Fort Dodge and to M. F. Arey of Cedar Falls; W. H. Norton of Mt. Vernon and G. F. Kay of Iowa City for geological data.

TRAMPING IN WESTERN WASHINGTON.

BY THOMAS H. MACBRIDE.

The prosperity of our extreme northwestern commonwealth is largely dependent upon the products of its primeval forests. The present notes are intended to convey some impression of the present condition of the forest vegetation of western Washington as observed by a passing traveler during the winter of 1912-13.

For purposes of natural-history-study the great state of Washington presents several very distinct biologic regions. Of these, three determined mainly by topography, lie west of the Cascade mountains. These as delineated by Professor C. V. Piper, are the Pacific coastal plain, the Olympic mountains, and the Puget Sound basin.

The present discussion concerns chiefly the region around Puget Sound, not excluding however occasional reference to the western slopes of the Cascades.

All biologic conditions depend so completely upon moisture that our survey may well be introduced by reference to the remarkable meteorology of the case, a meteorology I believe unique, at least within the limits of the United States.

In popular parlance two seasons obtain in western Washington; the wet and the dry. But whatever this may signify in other parts of the globe so conditioned, in Washington the dry season is not without showers, sometimes for several days together, and the wet winter is by no means without many sunny, beautiful days.

About Puget Sound the rainfall is very peculiar. It is commonly reported that the precipitation here is very great, and that heavy forests are associated with the fact; but such is not quite the case. Precipitation over western Washington is extremely uneven; varies between 30 inches or *less* and 120 or *more!* Thus west of the Olympic mountains along the ocean the rainfall is reported as attaining sometimes 130 inches in a single 12-month; at Olympia it is about 50 and at Seattle 30; while on the south end of Whidby Island, nearly in the middle of Puget Sound, the rainfall is so slight that the region is a desert, with cacti and all sorts of xerophytic plants.

The topography of western Washington ranges from tide-flats to mountain heights among the highest on the continent; but the temperature at any altitude is uniform, varying regularly in summer and winter within moderate limits. Mt. Rainier, however, carries its burden of perpetual snow with half a dozen real glaciers, and its high slopes are liable at all seasons to violent winds and storms. As fierce a thunder storm as it has been my lot to witness prevailed in August last on Mt. Rainier at an altitude of 8,000 feet and upward. But rain in winter in western Washington generally, tho sometimes very persistent, is ordinarily of the gentlest sort. It rains, and rains and rains, but, as would appear, there occurs nothing comparable to what we should call a cloud-burst, nothing torrential, at least, east of the Olympic mountains.

It remains to mention one other factor in the problem, if the stage on which Life's drama is unrolled is to be at all adequately described; we must mention the terrene; what the Germans fortunately call the "*Boden*," the groundwork of rocks and soils whose variety of form and composition everywhere determines to greater or less extent the facies, the final expression of the living world.

We may not here go far, may not discuss the geology of our region further than to say that almost everywhere we have to do with soils of glacial origin, so that the Iowa student is at once very much at home. Curiously enough, too, we have about Puget Sound evidence of at least two invasions of glacial ice with the usual interglacial interval, and the oldest deposit in sight, the Admiralty Till, is tough and bluish, suggesting instantly the famous blue clay of our valley states.

The drift about Puget Sound then, covers practically the whole country from the Cascades to the sea, and is enormously thick; exposures hundreds of feet in thickness may be seen almost anywhere near the water-edge. Interglacial deposits and modified drift-sheets make up the bulk of what appears above the basal till; how thick that is, and what may be immediately beneath is still uncertain. But if one may judge by the amount of erosion suffered, the upper till, the so-called Vashon drift, is very recent indeed. Where well exposed, it is sculptured by the most precipitous short ravines, cutting back through all the interglacial assorted sands and gravels, in most singular fashion; all well displayed within the city of Tacoma. In fact, it appears that this great mass of drift, notwithstanding its remarkable thickness, is nevertheless extremely loose and porous. Even the water-laid sheets of sand, often very solid, are lenticular and so articulated with beds of gravel as not at all to interfere with the ultimate descent of surface water. The result of the entire structure is a universal seepage around the Sound, just above the "blueclay" issuing at times in springs of considerable volume. Such springs undermine the overlying deposits, cause constant slides of the loose material, so that in many cases, at least, the short ravines above mentioned are due to such causes and not to erosion by storm-water acting in the ordinary way.

It must not be inferred that there is not erosion of the ordinary sort; there is plenty of it, of course; the most valuable agricultural lands of the whole district here considered are alluvial plains, filled up swamps and tide-flats; but the topography of the country is structural rather than erosional; there are ravines and streams in plenty, but they follow old time ice-stream valleys, many of them the outflow of still existing glacial remnants clinging to the steeps of Mt. Rainier.

However, this all may be, there are wide areas of comparatively level drift uncut by streams or at most by slow moving and insignificant waters that have not yet cut to base level. Besides there are many outwash terraces and plains. Every glacier-born river, the Nisqually for instance, is at this moment bringing from Mt. Rainier and spreading along a filling and widening channel, and especially in fan-shaped flats far down its course, vast quantities of water-rounded stones, pebbles, gravel, sand. Just such material, sometimes spread over many square miles forming considerable plains, occurs in different places all about the Sound, representing the deposition of far larger glacial floods in days not so very long gone by. A notable example is the famous lake region, the so-called "prairie" south of Tacoma, a plain of water-worn material precisely like that now forming the bed of the Nisqually, the Steilacoom gravel.

Upon the terrene thus so briefly sketched and under the meteorological conditions described, there stood until very recently one of the most remarkable forests of the world, associated with a wealth of non-arboreal species almost unrivalled in any area of equal size. Of flowering plants and ferns along there have been listed some 2,000 species, perhaps 25 per cent more than are reported from the whole state of Iowa. In the entire state of Washington the students expect to list some day 4,000 species of flowering plants. Such also is the variety of condition of soil, location, altitude, that plant-societies of every sort abound. We have a starving flora, consisting of but a few adventurous species near the very summit of Rainier, say 14,500 ft. A. T.; we have the sedgy tide-flats, vast marshes covered with rushes and every sort of herbaceous green; we have forest-shaded swamps crowded with skunk-cabbage and curious alders or maples knee-deep sometimes in water, and supporting tons of moss in various species, covering trunk and branch almost to the farthest twigs; we have the San Juan and other islands of the Sound, hills and mountains of glaciated rock, now largely submerged by the sea; we have the Olympic mountains with their unusual rainfall and constant exposure to the western ocean; in all these places there are peculiar plant-formations and generally species and types unique to the locality.

The prairie districts, already referred to, appear to have been primarily regions treeless or nearly so, and treeless for probably different reasons in different localities. Thus the famous Steilacoom prairie, already described, probably owed its treelessness to the thinness of its stony soil. It seems to have been when first observed, dotted everywhere with a peculiar oak, *Quercus garryana* Douglas, isolated or in small clusters, hardly groves. Single aged trees of this species here are two or three feet thick, but short and evidently stunted. They seem part of a xerophytic flora, and in the text of the Tacoma Quadrangle Folio U. S. Geol. Surv. 1899, the Steilacoom gravels are put down as entirely sterile. The old resident, however, reports that thirty or forty years ago these same gravels bore crops of wheat for a succession of years. After the fashion of Pacific coast farming, the oaks were not removed. Continuous cropping without rotation probably soon exhausted the little fertility for wheat. However this may be, the soils are now considered fertile; and strange as it may seem the Douglas spruce is rapidly and surely occupying all the prairie; the fallowed wheat-lands offering to the spruce seed, evidently, opportunity which the original surface with its competing flora did not afford. Furthermore, the aggressive immigrants have developed a habit of early maturity very surprising, almost varietal in character, trees six to ten feet high may be seen covered with cones. Is this a xerophytic response?

The Steilacoom plain is furthermore marked by beautiful glacial lakes, just like those of northern Iowa, and about these lakes are fringes of coniferous forest presenting the species characteristic of the country in usual form. This also is an interesting fact whose explanation remains for future study.

Space suffices not to enter upon all the problems suggesting themselves to one tramping for weeks about these plains and hills. To some of these with your permission, the writer may seek to call your attention at some future day. But the great, the literally overshadowing factor, in all this western world is the forest itself, great in every sort of economy, ecologically, biologically, sociologically, wonderful in its scientific aspects, nor less in that which concerns the welfare of men. This great Puget Sound forest is still a phenomenon in itself and may well occupy us for the few remaining pages permitted to this paper.

In the first place it may be noted that the vast beds of drift, already described as mantling the country, seem specially suited to forest growth. Glacial plowing is apparently just right for trees. The only beds particularly unsuited seem to be plains of water-washed gravel. Here the amount of finely ground material seems to be insufficient. The glacial flour is gone. But where the drift is typical, left as the glacier mixed it, although generally far too stony for our feeble harvests, it affords the great conifers conditions all ideal. The loosely constructed, porous strata receive and hold the gently descending rains and the same offer an easy passage-way for root and rootlets in every possible direction.

The development of forest conifers upon glacial soils throughout the western mountains is something simply marvelous. In many places, as, for instance, in various parts of the Rainier National Park the traveler may see in cluster, stupendous columns of gigantic trees standing side by side often within a few feet of each other, a titanic harvest. To see tons of matter thus heaped up in pillars side by side, apparently from the same soil, is a suggestive comment of the relative contributions made by soil and atmosphere in the building of a tree.

The principal conifers about Pugent Sound are:

Pseudotsuga macrocarpa (Raf.) Sudw.
Thuja plicata Don.
Tsuga heterophylla Sarg.
Abies nobilis Lindl.
Abies amabilis (Dougl.) Forbes.
Abies grandis Lindl.
Pinus contorta Dougl.
Pinus monticola Dougl.

Of these trees the first two are the common lumber trees of the region, although on occasion hemlock and fir also contribute; especially in these later days when the cutting is much closer than in times gone by. But the first tree named is the great tree, makes up the bulk of all the forests and has really made the wealth of this part of the world. It should be called the Douglas spruce; its lumber is known as Oregon pine; at the mills men talk of the "red fir" because for some reason not clear, some logs yield before the saw slabs of distinctly reddish tint. The same species of tree, however, yields "yellow fir" lumber. The matter needs investigation.

The traveler is impressed by the comparative fewness of great trees, for such the species affords. Trees six and eight feet in diameter were not rare. Trees ten feet thick and 300 feet high have been cut. But at present such trees are not common. Even in the forest-reserve and the national park the trees are seldom more than two or three feet in diameter and often much less.

The same statements may be made concerning the second species on our list, the Oregon cedar. This tree was always much less common, occurred in rich soils, along stream-banks and lake-shores, and in commercial size is now rare. In fact the *big* logs are now everywhere lying on the ground. These great ruins, like some other time-defying structures, seem to last indefinitely. This is particularly true of the cedar; logs that have lain perhaps for centuries make lumber and shingles to-day equal to the best. I found one spruce log in the national park 150 feet long, five feet thick inside the bark at base. Throughout the park there is more lumber on the ground than in the standing forest, a wholly primeval condition; and the prostrate logs are all gigantic. Tradition has it that these great firs and cedars were overwhelmed by fire, before the advent of the white man; at any rate, the trees that reach the mills to-day and those that make up the forest reserve, are not old; many logs carry less than one hundred rings.

If circumstances are at all favorable, the Douglas spruce is a tree of unusually rapid growth. The largest log seen shows in sections less than 500 annual rings. This section is about nine feet in diameter inside the bark but the growth was mostly made in 350 years. To tree-culture, for lumber purposes, no other tree lends itself with such splendid promise.

This of course, suggests the problem of reforestation about Puget Sound. The great natural forest that spread from the ocean to Rainier, has been almost entirely swept away; largely by lumbering, perhaps as largely by fire, following our barbarous lumbering methods. But such is the peculiar adaptability of these soils, such the gentle beneficence of the rain, and above all, such the wonderful vigor of the species here discussed, that, fires once controlled, natural reforestation is almost certain over all this vast area. There are some exceptions. Wherever the soil can be used for profitable agriculture, reforestation is of course prevented. There are, however, evidently many abandoned farms. Even in localities where, owing to topographical conditions, ordinary agriculture is not profitable some men use goats to clean from rock and cliff-side every living thing, until the land will no longer maintain even goats. Then there are steep mountain slopes on which, for reasons not apparent, the fire has been destructive even of the soil; and such "burns" are not speedily recovered.

The forest resources to which the cities of Seattle and Tacoma are so greatly indebted, have been vast, but, as it is at last evident to the least observant, they are not exhaustless. How fortunate that by the generosity of nature only ordinary prudence will suffice, as we have just seen, to renew the face of the world! Today the efforts of the United States government, of the state government, supported everywhere by public sentiment, the consensus of opinion of all intelligent men, are sure to find reward in recurring harvests of the finest lumber ever garnered to the profit of enlightened men.

THE MONTEREY CONIFERS.

BY THOMAS H. MACBRIDE.

A little peninsula projecting but slightly from the coast of California and forming by its northern front the south shore of the Bay of Monterey has for botany-lovers many attractive features. The little city, named of the Bay, was the first capital of this western commonwealth, long before Sacramento, or San Francisco even, had a place in the geography of the world. This little town was accordingly the port of entry for all this western coast. To it came traders in slow-sailing ships; to it also came the enthusiastic naturalist still stirred perhaps by the impulse of Linnaeus; Douglas, 1832; Coulter, 1830; Don in 1837 and Hartweg in 1846.

In consequence of the activity of these early collectors, type-specimens of many of the flowering plants must be sought on the sandy or rocky slopes of this little peninsula, or in the immediate neighborhood. As it happens several of the rarest conifers in the world have here their habitation, and a note as to their present state and distribution may be of interest to members of this academy.

The peninsula above referred to, about 10 or 12 square miles, shows four coniferous species.

Cupressus macrocarpa Hartweg.
Cupressus goveniana Don.
Pinus muricata Don.
Pinus radiata Don—(*Pinus insignis* Douglas).

Of these the first is the famous Monterey cypress, now planted all over California for hedges and wind-breaks, and even common in Europe and in other parts of the world. This tree occupies a narrow stretch of sea-coast, a slender grove on each side of the little stream by courtesy called the Carmel river. Some of the trees on Point Lobos, the south bank of the Carmel estuary, are possible sixty feet above the sea level, but the greater number of trees are near the shore at an average altitude of less than 50 feet above the tide.

The soil, in which most of these old trees are standing, in many places is of unusual richness. In origin it may at bottom be perhaps not unlike so much of the soil of the peninsula, rotten granite; but to this along the shore has long ago been added considerable quantities of fine sea sand with more or less calcareous matter from ground-up sea shells, etc. To this mixture has come, probably from the adjoining higher levels, abundance of organic matter; so that, where the trees are finest, the soil is surely marked by great fertility. Where the largest trees now stand vast quantities of sea-shells in all stages of decomposition are to be seen to a depth of two feet or more. Local tradition assigns these deposits to food habits of an earlier humanity. However this may be, the presence of this material certainly contributes to the character of the littoral beds, to make them unlike any other soils farther inland.

The competition at Cypress Point is with *Pinus radiata* and the competition in some places is keen. Young plants of both species, back a few rods from the sea, are closely intermingled; on the richer (lower) soils the cypress has the best of it; immediately the terrene rises, the pine prevails.

At Point Lobos, south of the mouth of the Carmel river, the case is essentially the same. The same species are in contact in one part of the little grove, the cypress apparently holding its own at lower levels, the pines topping the high rocks and cliffs. To the east and south the station is checked by a southwest exposure formerly occupied by all sorts of xerophytes, *Quercus, Ceanothus,* lupines, *Artemisia,* various grasses, etc. This territory neither conifer invades. The cypress colony has been divided at no very distant date, by erosion of the shore, partly by gnawing of the restless sea, partly by cutting back in the surface drainage of the land. The trees cut off to the north by this misfortune, cling with precarious tenacity to the margins of a deep ravine, an indenture of the shore. One such has been often photographed and figured in popular accounts of the Monterey cypress. At this point also are to be seen scattered specimens higher up on the rocky cliff disputing a dangerous foothold with the pines that still o'er-top them.

Of seedling cypresses at Point Lobos at present I find none. In fact the present condition of the grove is bad; very much more hazardous than when the writer saw it first some twenty years ago. At that time everything was in its primeval state. Nature had reached an equilibrium in which the cypress had a part, and the tree seemed likely to endure. Since then the grove has been made part of an over-stocked cow-pasture and the trees are suffering greatly. The location is one of great natural beauty and is made the objective point for picnic excursions. It is permissible to build fires; so that between the hungry tramping cows, and the careless pleasure-seeking multitude, the trees, already weary with age-long struggle against adverse conditions, are likely presently to succumb.

The second species named, Gowen's cypress, is a shrub or low tree, perhaps twenty feet high at the maximum and in this locality occupying an even more restricted range than *C. macrocarpa*. The little trees cling to a southwestern exposure, on the east side of a little valley called at length Saw-mill gulch. The total extent of the original limits of the colony does not exceed forty rods in length and three or four in width! I say the original limits, because, by reason of a fire which swept the hillside some ten years since, the boundaries of the grove have been somewhat extended. In that forest fire, many of the older cypresses and nearly all associated pines, chinquapins and other shrubby vegetation, perished. Seedling cypresses, have had for a time therefore, a wider field for occupancy, and thousands of crowded slender young trees about ten feet high occupy in large part the original territory and extend in solid phalanx here and there a little beyond. Scattered seedlings also to-day may be found many rods to the northeast of the grove, standing in the company of the Bishop pine, showing that wide distribution is not here determined by any lack of ability of the seeds to travel. As noted later, the young trees are fruitful at an astonishingly early age, about two or three years, if I correctly estimate from data at hand; but a rival in this regard is the Bishop pine which seems almost equally precocious. Whether this precocity is in form rather than function, is yet an open question. It is possible that seeds of such youthful parentage may not be viable. But however this may be, the plant offers another factor in the problem of perpetuity equally surprising: these little trees simply exhaust themselves in the matter of inflorescence. As I saw them on February first many of the trees were so covered with pollen as to be yellow as gold from top to bottom. The species is monœcious, but with a tendency to diœcism. Some trees accordingly were simply burdened with pollen, while others showed an equally marvellous number of cones, cones generally at the ends of twig-like branches; occasionally single or scattered; more commonly densely clustered. Since the cones in evidence were already a year or more old, it is possible that during the time of their development the energy of the plant is so consumed, and little pollen on such trees accordingly appears. On a tree a foot high were two apparently mature cones, each about an inch in diameter; but on the same tree were a few fertile cones just opening and one or two small sprays dusty with pollen.

The plant seems so wholly given to reproduction that little attention is paid to the development of the individual. The old trees are not without foliage but their annual increment in height, or spread, to say nothing of trunk diameter, must be very small indeed. Where the young saplings are crowded they still bloom altho the inflorescence is less conspicuous. In short, the plant is a typical xerophyte.

The two species may be now thus conpared:

	Cupressus macrocarpa.	*Cupressus goveniana.*
Distribution	Sea-coast by the mouth of Carmel river only.	Small area at Monterey, two or three miles from the sea also reported on dry plains, Cape Mendocino.
Habitat	Immediately overlooking the sea; along the water edge; grove 20 rods in width at widest, generally much less. Soil generally rich, in places extremely fertile and calcareous; average altitude about 50 ft.	Dry western sun-burned slope; soil thin, decomposing granite. Altitude near 500 ft.; occupying but a few square rods.
Meteorologic conditions	Annual rainfall supplemented by evaporation from the sea: fogs at all seasons, in dry season especially relieving drought.	Annual rainfall almost the only water supply; fogs rendered much less efficient by reason of situation.
Morphology	Large trees; stunted specimens; the best 125 ft. in height, the largest seven feet in diameter.	Small trees; shrubby; the largest 15 to 20 feet in height.
Inflorescence	Less abundant; few trees in bloom, Feb. 8, 1913.	Abundant, exhaustive, tending to diœcism (?), Feb. 1, 1913.
Fruit	Not abundant; the cones scattered or in dense clusters; when clustered, often proportionately smaller.	Very abundant; cones generally clustered; when isolated proportionately larger.

	Cupressus macrocarpar	*Cupressus goveniana*
Cones	From 6-12 lines in diameter. The largest 14 lines long; size conditioned as above.	From 6-12 lines in diameter; globose; conditioned as above.
Seeds	Roughish, varying in color dark brown to black.	Roughish; maroon, brown to black.
Maturity	Fruiting early; at the age of 3 or 4 years.	Fruiting very early; at the age of 3 or 4 years.

I have presented this field-study of these two most interesting forms for two reasons. First; both species are evidently remnantal; they have seen probably better days and had once much greater prominence in the forests of this western world. They are very closely related, have somewhere a common history, and the minor form might almost be regarded as a starved, depauperate shadow of the larger. At any rate, differences in habitat and environment are such as might account for all the morphological and physiological distinctions noted. However, the adaptation to environment seems now undoubtedly established, *C. macrocarpa,* widely transplanted though it be, does not endure hardship, especially when it comes in the form of heat and drought, as in the great valley of California, where in summer the wide plains fairly glow with heat. Whether the lesser species could stand prosperity has not been tested; perhaps it might; some Californian should find out.

Second: An interesting parallel may be drawn by students of our prairie flora, if the case of our common Bur oak, *Q. macrocarpa* Mx., be well considered. In passing across Iowa, from the Mississippi to the Missouri, we have a change in form and habit of this well-marked species not unlike that I have attempted to bring out by portraying these two old conifers. If one should compare (contrast) the great forest trees with their enormous over-cup acorns until lately to be seen along the Mississippi bottoms, near Muscatine, with the mere shrubs, one foot high or less, on the xerophytic hills about Sioux City, he would certainly regard the two forms as presenting *species,* distinct, well defined, if not remote. And yet, as we all know, between the one locality and the other, *Q. macrocarpa* of the east, passes through all sorts of phases intermediate, winding up in a distance of less than four hundred miles in the pygmean form bearing its acorns within a few inches of the ground.

But these time-honored forms might, so far as can be seen, persist yet for centuries in their peculiar locations and environments, challenging the admiration and wondering inquiry of every intelligent man. As already suggested in this paper, such are the delicate adjustments of nature that even such limited types may indefinitely hold their own. In such cases, unfortunately, the activity of civilized humanity is a factor for which Nature has made no provisions. The mollusc-eating native was here a part of the forest and contributed, as we have seen, to the balance of Nature's equilibrium; but the beef-eating importation is too intense. He thrusts his starving herds among these aged trees and their treading and crowding are likely to bring speedy extinction to these wondrous plants, of lineage remote, the last survivors of America's most ancient forest types.

The greatest natural enemy of the shore-cypress seems to be the lichen, particularly the filmy strands of *Ramalina* sp. These flourish under the same moisture-laden breezes which seem to vivify the cypress. But here again there were compensations. Young cypress trees are less afflicted, and the life of the species is accordingly not specially endangered. Species of Lecanora and Buellia plague the lesser xerophytic species, but as the moralist might say; the torment is perhaps not greater than may avail for discipline!

Concerning the two pines named at the outset of this brief story there is less to be said. The Monterey pine is also very limited in its natural distribution, though now planted in distant parts of the world. *Pinus muricata* has a wider range scattered up and down this coast. It has cones in shape and habit not unlike those of *P. radiata,* but they are persistently prickly. The cone looks like a cross between *P. radiata* and *P. murryana.* All these pines have the curious habit of holding their cones, holding them attached to stem and branches for years. Specimens of the Monterey pine a foot thick may be seen with cones, perhaps the earliest set, still, necklace-like, encircling the trunk a few feet from the ground.

Cupressus goveniana has the same habit. *P. muricata* occupies the higher part of the peninsula, from 500 to 800 ft.; it comes into immediate, but not threatening competition with *C. goveniana;* is in fact a scrub-pine in that locality and is early fruiting. *P. radiata* succeeds both species on the lower slopes. One passes out of a pure stand of the prickly-cone type to an equally pure stand of the Monterey pine almost at a step. Probably some slight change in the constitution of the soil determines the prevalence of one species or the other at their line of delimitation. Between the Monterey pine and the cypress the line of demarcation is, as noted, one of altitude chiefly.

All North American cypresses are interesting in distribution. They are all littoral species; they fringe the continent. Along the Pacific shore half a dozen rare and curious pines, as here, join with the cypresses in such select behavior. But the meaning of this rarity, this aloofness, lies no doubt in the changing topography and meteorology of the past, and shall become evident only as the geologist and the botanist, in presence of a wider survey than either possibly has yet attained, reason together and so reconstruct and make to live again these later chapters in the history of the world.

Cupressus goveniana Don.—Bishop pine to the left.

Cupressus goveniana Don.—In full fruit.

Cupressus goveniana Don.—Staminate trees in full bloom.

Cupressus goveniana Don.—Sterile Branches, to show the flower-clusters.

NOTES ON THE FLORA OF JOHNSON COUNTY, IOWA.

M. P. SOMES.

Johnson County lies in the southeastern quarter of Iowa, its eastern boundary being about forty-five miles from the Mississippi River reckoning from Davenport and owing to the curvature of the river to the westward about eighteen miles from Muscatine. The county has an area of about 618 square miles and the elevation ranges from slightly over six hundred feet in the southeastern corner to nearly eight hundred at Solon.

The peculiar topographical conditions have been described by Calvin (Ia. Geol. Survey, VII, p. 39) as follows: "Johnson county lies within the area of anomalous topographic forms described by McGee (11th Ann. Rep. U. S. Geol. Sur.) ; an area in which drift plain interdigitates with loess ridge; an area in which rivers go out of their way to avoid low lying plains and cut channels longitudinally through ranges of hills that rise forty, sixty and eighty feet above broad lowland surfaces that apparently might have been traversed with less difficulty, and certainly would have afforded a shorter and more direct course, an area in which the divides are low and the highlands border the river valleys. The county presents an unusual number of topographic phenomena for the reason that it is traversed by terminal deposits of the Iowan glaciers, deposits forming irregular sinuous ridges that may possibly deserve to rank as moraines. Along the northern border of the county there are therefore some small lobes of the Iowan drift sheet continuous with the gently undulating plains characteristic with regions occupied by deposits of Iowan age in the counties north of Johnson. In the southern part of the county all stream valleys are wider and deeper, and the relief in general bolder than in the drift plains north of the Iowa moraine. The greater age of the Kansan deposits has afforded larger opportunities for the agents of erosion to carve and otherwise modify the surface. All of the county south of a line drawn from east to west through the middle of Scott and Hardin townships may be said to constitute one area exhibiting the physiographic features of the Kansan drift; but through this area the Iowa River has cut a valley from north to south and has developed a broad flood plain with flat alluvium covered surface that is in striking contrast with the irregularities of the typical drift surface on either side.

"Characteristic loess topography is exhibited throughout the broad belt of deep loess which passes across the middle of the county from east to west; in the interlobular space between the Solon and North Liberty areas of the Iowan drift; in a small area in the southwestern part of Monroe township; and in the high bluffs near the Cedar river northeast of the Solon lobe."

Regarding this loess topography in Johnson county we may summarize by saying that it is in general a region of rather high ridges eroded to a complex series of hills with steep and rather sharply rounded surfaces.

From the above it may be readily seen that Johnson county presents a region of considerable topographical variation and thus also of necessity presents a variety of ecological conditions resulting in a flora of much interest to those of us who love flowers as flowers rather than as mere masses of cells in various mitotic stages. After a residence of several years in Johnson County during which period almost continuous collecting was done, the following list of species observed within that area is presented for the benefit of those who may wish to know something of the groups to be found here. These records are based in almost every case by specimens now deposited in the herbarium of the Webster County Botanical Club at Fort Dodge, Iowa. The identifications of doubtful species were verified by Prof. Aven Nelson of Wyoming, Prof. P. A. Rydberg of New York Botanical Garden, or Dr. Wm. Trelease of Shaw Botanical Gardens to all of whom my thanks are here extended for various favors. **This list includes 1,005 species, representing 413 genera** included in 101 families.

NOTE: Since the presentation of this paper, a series of "common" or popular names has been added at the request of Governor Clarke.

In preparing this list of "common names" care has been taken to use wherever possible the name by which the plant is best known in Iowa. It must be stated, however, that common names are, for the most part, merely local and a plant may be quite generally known, in one locality, by a name which in another section of the country applies to an entirely different plant. Thus, for instance, in certain parts of the country *Aquilegia canadensis* L. is called "Wild Honeysuckle"—yet in another locality this name is applied to *Lonicera glaucescens* Rydb., while in parts of the South the "Honeysuckle" is instead *Rhododendron calendulaceum* (Mx.) Torr.

However, as requested by Gov. Clarke we have endeavored to supply names which may be familiar to the people of Iowa.

PTERIDOPHYTA.

POLYPODIACEAE.

POLYPODIUM (Tourn) L.

1. *Polypodium vulgare* L. Common Polypody. Found in wooded places along Iowa River.

PHEGOPTERIS (Presl.) Fee.

2. *Phegopteris polypodioides* Fee. Beech Fern.
3. *Phegopteris hexagonoptera* (Michx.) Fee. Rare in rich woods.

ADIANTUM (Tourn) L.

4. *Adiantum pedatum* L. Maiden Hair. Common everywhere in wooded places.

PTERIS L.

5. *Pteris aquilina* L. Brake. Abundant in woodlands.

PELLAEA Link.

6. *Pellaea atropurpurea* (L.) Link. Cliff Brake. Locally plenty at State Quarries, etc.

CRYPTOGRAMMA R. Br.

7. *Cryptogramma stelleri* (Gmel) Prantl. Rock Brake. Plenty on limestone cliffs, etc.

ASPLENIUM L.

8. *Asplenium Filix foemina* (L.) Bernh. Lady Fern. Not uncommon in woods.
9. *Asplenium acrostichoides* Sw. Silvery Spleenwort. Rather rare in woods.

CAMPTOSORUS Link.

10. *Camptosorus rhizophyllus* (L.) Link. Walking Fern. Not rare on limestone exposures.

ASPIDIUM Sw.

11. *Aspidium thelypteris* (L.) Sw. The Marsh Fern. In marshy places, often abundant.
12. *Aspidium goldianum* Hook. Goldie's Fern. In rich woodlands.
13. *Aspidium spinulosum* (O. F. Mill) Sw. Spinulose Shield Fern. In woodlands along Iowa River.

CYSTOPTERIS Bernh.

14. *Cystopteris bulbifera* (L.) Bernh. Bulbiferous Bladder Fern. Very plenty on limestone exposures.
15. *Cystopteris fragilis* (L.) Bernh. Common Bladder Fern. Common in woodlands.

WOODSIA R. Br.

16. *Woodsia obtusa* (Spreng) Torr. The Obtuse Woodsia. Common in densely wooded places.

ONOCLEA L.

17. *Onoclea sensibilis* L. Sensitive Fern. Very plenty in woodlands.
18. *Onoclea struthiopteris* (L.) Hoffm. Ostrich Fern. Not rare in moist woodlands.

OSMUNDIACEAE.

OSMUNDA (Tourn) L.

19. *Osmunda claytoniana* L. Interrupted Fern. Very plenty in woodlands.

OPHIOGLOSSACEAE.

BOTRYCHIUM Sw.

20. *Botrychium virginianum* (L.) Sw. Rattlesnake Fern. Not rare in woodlands.

EQUISETACEAE.

EQUISETUM (Tourn) L.

21. *Equisetum arvense* L. Common Horsetail. Common in sandy soil.
22. *Equisetum sylvaticum* L. Woodland Horsetail. Not rare in damp and shaded spots.
23. *Equisetum robustum* (A. Br.) A. A. Eaton. Stout Scouring Rush. Plenty in gravels.
24. *Equisetum laevigatum* A. Br. Smooth Horsetail. In fields and roadsides.

SPERMATOPHYTA.

CLASS I—GYMNOSPERMAE.

PINACEAE.

JUNIPERUS (Tourn) L.

25. *Juniperus virginiana* L. Red Cedar. Formerly plenty, now almost extinct.

CLASS II—ANGIOSPERMAE.

TYPHACEAE.

TYPHA

26. *Typha latifolia* L. Cat-tail. Common in marshy places.

SPHARGANIACEAE.

SPHARGANIUM

27. *Spharganium eurycarpum* Engelm. Bur-reed. Common in marshy places.
28. *Spharganium androcladum* (Engelm.) Fern. & Eames. Branching Bur-reed. Rare.

NAJADACEAE.

POTAMOGETON (Tourn) L.

29. *Potamogeton americanus* C. & S. Long Leaved Pondweed. Common in streams.
30. *Potamogeton illinoensis* Morong. Illinois Pondweed. Scarce; Old Man Creek.
31. *Potamogeton foliosus* Raf. Leafy Pondweed. In ponds and bayous.

ZANNICHELLIA (Michx) L.

32. *Zannichellia palustris* L. Horned Pondweed. Scarce in bayous and sluggish streams.

NAJAS L.

33. *Najas flexilis* (Willd.) Rostk. & Schm. Soft Naiad. In ponds and springs.

ALISMACEAE.

SAGITTARIA L.

34. *Sagittaria longirostra* (Mitch.) J. G. Sm. Long-beaked Arrowhead. A peculiar form with obovate achenes, winged all around and the beak nearly erect, has been taken rarely. It is placed here with some hesitation but can fit no other described species.

35. *Sagittaria latifolia* Willd. Broad Leaved Arrowhead. Common in marshy places.

36. *Sagittaria arifolia* Nutt. Arum Leaved Arrowhead. Not rare in marshes along the Iowa River.

HYDROCHARITACEAE.

ELODEA Michx.

37. *Elodea canadensis* Michx. Water Weed. In bogs and marshes.

GRAMINEAE.

ANDROPOGON (Royen) L.

38. *Andropogon scoparius* Michx. Broom Beard Grass. Abundant in dry soils.

39. *Andropogon tennesseensis* Scrib. Tennessee Beard Grass. Dry meadows.

40. *Andropogon furcatus* Muhl. Forked Beard Grass. Very common.

SORGHASTRUM Nash.

41. *Sorghastrum nutans* (L.) Nash. Indian Grass. Common in dry soils.

DIGITARIA Scop.

42. *Digitaria humifusa* Pers. Low Finger Grass. Not rare.

43. *Digitaria sanguinalis* (L.) Scop. Crab-grass. Abundant everywhere.

PASPALUM L.

44. *Paspalum ciliatifolium* Michx. Ciliate Paspalum. Common in sandy soils and along streams.

PANICUM L.

45. *Panicum capillare* L. Witch Grass. Common.

46. *Panicum miliaceum* L. European Millet. Occasional as an escape along railways.

47. *Panicum dichotomiflorum* Michx. Spreading Panicum. Very common and an extremely variable species, the forms of rich and sterile soils being widely dissimilar in appearance.

48. *Panicum virgatum* L. Tall Panicum. An abundant species throughout the area.

49. *Panicum depauperatum* Muhl. Starved Panicum. Rare and local in dry soils.

50. *Panicum perlongum* Nash. Narrow Leaved Panicum. A very similar but much more common species.

51. *Panicum huachucae* Ashe. Velvety Panicum. Not rare in sandy soils.

52. *Panicum huachucae silvicola* Hitchc. & Chase. Woodland Velvety Panicum. Rare, at Riverside Park.

53. *Panicum tennessense* Ashe. Tennessee Panicum. Rather scarce along streams.

54. *Panicum praecosius* Hitchc. & Chase. Branching Panicum. Not rare in dry soils.

55. *Panicum villosissimum* Nash. Villous Panicum. Scarce in dry soil near Hill's Siding.

56. *Panicum scribnerianum* Nash. Scribner's Panicum. Very abundant.

57. *Panicum liebergii* (Vasey) Scrib. Lieberg's Panicum. Scarce, locally abundant at Hills.

58. *Panicum clandestinum* L. Hispid Panicum. Not scarce.

59. *Panicum latifolium* L. Broad Leaved Panicum. Not rare in woods.

ECHINOCHLOA Beauv.

60. *Panicum philadelphicum* Bernh. Least Panicum. Not scarce in fields.
61. *Echinochloa crusgalli* (L.) Beauv. Barnyard Grass. An abundant and variable species.
62. *Echinochloa walteri* (Pursh) Nash. Walter's Coxspur Grass. Not rare in marshy places.

SETARIA Beauv.

63. *Setaria glauca* (L.) Beauv. Yellow Foxtail. Common weedy grasses found in cultivated fields and waste places throughout our area.
64. *Setaria varidis* (L.) Beauv. Green Foxtail. Common weedy grasses found in cultivated fields and waste places throughout our area.
65. *Setaria verticillata* (L.) Beauv. Foxtail. Common weedy grasses found in cultivated fields and waste places throughout our area.
66. *Setaria italica* (L.) Beauv. Italian Millet. Less common.

CENCHRUS L.

67. *Cenchrus carolinianus* Walt. Sand Bur. Common in sandy soils.

LEERSIA Sw.

68. *Leersia virginica* Willd. White Grass. In marshy places.
69. *Leersia oryzoides* (L.) Sw. Rice Cut Grass. In marshy places and along streams and ditches.
70. *Leersia lenticularis* Michx. Catchfly Grass. Scarce in marshy woods.

PHALARIS L.

71. *Phalaris canariensis* L. Canary Grass. Occasional as an escape.
72. *Phalaris arundinacea* L. Reed Canary Grass. Not uncommon in marshy places.

HIEROCHLOE (Gmel) R. Br.

73. *Hierochloe odorata* (L.) Wahl. Holy Grass. Wooded hillsides.

ORYZOPSIS Michx.

74. *Oryzopsis racemosa* (Sm.) Ricker. Black-fruited Mountain Rice. Rather scarce in woodlands.

STIPA L.

75. *Stipa spartea* Trin. Porcupine Grass. Common in dry places.

ARISTIDA L.

76. *Aristida basiramea* Engelm. Forked Aristida. Common in sandy places.

77. *Aristida intermedia* Scribn. & Ball. Intermediate Aristida. Taken but once, near Morse.

78. *Aristida oligantha* Michx. Few Flowered Aristida. Scarce in gravelly fields.

MUHLENBERGIA Schreb.

79. *Muhlenbergia sobolifera* (Muhl.) Trin. Rock Muhlenbergia. Rather scarce, in rocky woodlands.

80. *Muhlenbergia sylvatica* Torr. Wood Muhlenbergia. In moist wooded places.

81. *Muhlenbergia tenuiflora* (Willd.) B. S. P. Slender Muhlenbergia. Not plenty.

82. *Muhlenbergia mexicana* (L.) Trin. Meadow Muhlenbergia. Very common everywhere in dry soils.

83. *Muhlenbergia racemosa* (Michx.) B. S. P. Marsh Muhlenbergia. Plenty in moist places.

84. *Muhlenbergia schreberi* J. F. Gmel. Dropseed Grass. Common everywhere.

BRACHYELYTRUM Beauv.

85. *Brachyelytrum erectum* (Schreb.) Beauv. Brachyelytrum. Rather scarce in rocky woods.

PHLEUM L.

86. *Phleum pratensis* L. Timothy. Common in meadows and fields.

ALOPECURUS L.

87. *Alopecurus geniculatus* L. Marsh Foxtail. Common in marshy places.

SPOROBOLUS R. Br.

88. *Sporobolus neglectus* Nash. Small Rush Grass. Not scarce in dry soils.

89. *Sporobolus vaginiflorus* (Torr.) Wood. Sheathed Rush Grass. In dry soils.

90. *Sporobolus cryptandrus* (Torr.) Gray. Sand Dropseed. In sandy places; scarce.

91. *Sporobolus heterolepis* Gray. Northern Dropseed. Rather scarce in dry places.

92. *Sporobolus asper* (Michx.) Kunth. Rough Rush Grass. Not common.

CALAMAGROSTIS Adans.

93. *Calamagrostis canadensis* (Michx.) Beauv. Blue Joint Grass. Common in fields and meadows.

94. *Calamagrostis inexpansa* Gray. Bog Reed Grass. Scarce in moist meadows.

AGROSTIS L.

95. *Agrostis alba* L. Red Top. Abundant everywhere.

96. *Agrostis perennans* (Walt.) Tuck. Thin Grass. Common especially in moist places.

97. *Agrostis hyemalis* (Walt.) Beauv. Rough Hair Grass. Common in fields and open woods.

CINNA L.

98. *Cinna arundinacea* L. Wood Reed Grass. Common in moist woodlands.

SPHENOPHOLIS Scribn.

99. *Sphenopholis obtusata* (Michx.) Scrib. Blunt-scaled Sphenopholis. Abundant.

100. *Sphenopholis pallens* (Spreng.) Scrib. Pale Sphenopholis. Equally plenty.

KOELERIA Pers.

101. *Koeleria cristata* (L.) Pers. Dog-tail Grass. Abundant in dry soil.

DANTHONIA DC.

102. *Danthonia spicata* (L.) Beauv. Wild Oat Grass. On dry wooded hillsides, rare.

SPARTINA Schreb.

103. *Spartina michauxiana* Hitchc. Slough Cut Grass. Abundant in marshes.

BOUTELOUA Lag.

104. *Bouteloua hirsuta* Lag. Hairy Mesquite Grass. Quite common in dry soils.

105. *Bouteloua curtipendula* (Michx.) Torr. Grama Grass. Plenty on clay or sandy soils.

PHRAGMITES Trin.

106. *Phragmites communis* Trin. Reed. Abundant in marshy places.

TRIPLASIS Beauv.

107. *Triplasis purpurea* (Walt.) Chapm. Sand Grass. Plenty in areas of almost clear sand.

ERAGROSTIS Beauv.

108. *Eragrostis hypnoides* (Lam.) B. S. P. Creeping Eragrostis. Common along streams.

109. *Eragrostis capillaris* (L.) Nees. Capillary Eragrostis. In dry places.

110. *Eragrostis frankii* (Fisch. Mey. & Lall.) Steud. Frank's Eragrostis. Abundant.

111. *Eragrostis pilosa* (L.) Beauv. Tufted Eragrostis. Common everywhere.

112. *Eragrostis megastachya* (Koeler) Link. Stink Grass. Roadsides and waste places.

113. *Eragrostis pectinacea* (Michx.) Steud. Purple Eragrostis. Common in low sandy fields.

MELICA L.

114. *Melica mutica* Walt. Narrow Melic Grass. Rare in woodlands.

115. *Melica nitens* Nutt. Tall Melic Grass. Common in rocky wooded places.

116. *Melica porteri* Scribn. Small Melic Grass. Scarce in woodlands.

DIARRHENA Beauv.

117. *Diarrhena diandra* (Michx.) Wood. Wood Rice Grass. Scarce on wooded hillsides.

DACTYLIS L.

118. *Dactylis glomerata* L. Orchard Grass. Not common in waste places and along roadsides.

POA L.

119. *Poa chapmaniana* Scribn. Chapman's Spear Grass. Locally plenty near Tiffin.

120. *Poa compressa* L. English Blue Grass. Very common about Iowa City.

121. *Poa pratensis* L. Kentucky Blue Grass. Common throughout our area.

122. *Poa triflora* Gilib. Fowl Meadow Grass. Taken but once in a low field near Oxford.

GLYCERIA R. Br.

123. *Glyceria nervata* (Willd.) Trin. Nerved Manna Grass. Abundant in marshy places.

124. *Glyceria grandis* Wats. Reed Meadow Grass. Common in moist soil.

125. *Glyceria septentrionalis* Hitchc. Northern Manna Grass. Not so common but found in marshes.

FESTUCA L.

126. *Festuca octoflora* Walt. Slender Fesque Grass. Not scarce in sandy soils.

127. *Festuca elatior* L. Meadow Fesque Grass. Sparingly as an escape.

128. *Festuca nutans* Spreng. Nodding Fesque Grass. Common in woodlands.

129. *Festuca shortii* Kunth. Short's Fesque Grass. Rare in woodlands.

BROMUS L.

130. *Bromus secalinus* L. Chess. Not uncommon in fields and waste places.

131. *Bromus tectorum* L. Downy Brome Grass. Sparingly introduced.

132. *Bromus ciliatus* L. Fringed Brome Grass. Abundant in woodlands.

133. *Bromus purgans* L. Hairy Brome Grass. Less common.

134. *Bromus altissimus* Pursh. Tall Brome Grass. Not rare in woodlands.

135. *Bromus incanus* (Shear) Hitchc. Velvety Brome Grass. Scarce in rocky wooded places.

136. *Bromus kalmii* Gray. Kalm's Chess. Scarce in dry soil.

AGROPYRON Gaertn.

137. *Agropyron smithii* Rydb. Western Wheat Grass. Railway right of way near Elmira.

138. *Agropyron repens* (L.) Beauv. Quack Grass. Very common especially along railways.

139. *Agropyron tenerum* Vasey. Slender Wheat Grass. Possibly our most abundant native species.

140. *Agropyron richardsonii* Schrad. Richardson's Wheat Grass. Rare on dry hills near Mid River.

HORDEUM (Tourn) L.

141. *Hordeum jubatum* L. Squirrel Tail Grass. A very common and widespread weed.

142. *Hordeum pusillum* Nutt. Little Barley. Locally plenty in sandy areas.

143. *Hordeum nodosum* L. Meadow Barley. Not abundant but taken at Iowa City and Oxford.

144. *Hordeum pammeli* Scrib. & Ball. Pammel's Barley. A tall erect perennial found rarely at Iowa City is placed here upon the suggestion of Dr. Trelease of Shaw Botanical Garden.

ELYMUS L.

145. *Elymus striatus* Willd. Slender Wild Rye. Plenty in woodlands.

146. *Elymus striatus* Var. *balli* Pam. With the typical form.

147. *Elymus striatus* Var. *villosus* Gray. With the typical form.

148. *Elymus virginicus* L. Virginia Wild Rye. Common in woods and fields.

149. *Elymus canadensis* L. Nodding Wild Rye. Also common, especially in sandy soils.

150. *Elymus virginicus* Var. *submuticus* Hook. Awnless Wild Rye. Quite common.

151. *Elymus macounii* Vasey. Macoun's Wild Rye. Rare as an escape along a railway.

HYSTRIX Moench.

152. *Hystrix patula* Moench. Bottle Brush Grass. Common in woods and wooded marshes.

CYPERACEAE.

CYPERUS (Tourn) L.

153. *Cyperus diandrus* Torr. Low Cyperus. Abundant along streams.

154. *Cyperus rivularis* Kunth. Shining Cyperus. Almost equally common.

155. *Cyperus aristatus* Rottb. Awned Cyperus. Not rare along streams.

156. *Cyperus schweinitzii* Torr. Schweinitz's Cyperus. Very common in sandy soils.

157. *Cyperus erythrorizos* Muhl. Red Rooted Cyperus. Common in wet meadows.

158. *Cyperus erythrorhizos* Var. *pumilus* Engelm.

159. *Cyperus ferax* Rich. Michaux's Cyperus. Plenty in marshy places.

160. *Cyperus strigosus* L. Straw Colored Cyperus. Abundant.

161. *Cyperus strigosus* Var. *robustior* Kunth.

162. *Cyperus strigosus* Var. *compositus* Britt.

163. *Cyperus filiculmis* Vahl. Slender Cyperus. Locally plenty in dry rocky woodlands.

ELEOCHARIS R. Br.

164. *Eleocharis ovata* (Roth) R. & S. Ovoid Spike Rush. Not rare.

165. *Eleocharis engelmanni* Var. *detonsa* Gray. Engelman's Spike Rush. Local near Oxford.

166. *Eleocharis palustris* (L.) R. & S. Creeping Spike Rush. Very common in marshy places.

167. *Eleocharis palustris glaucescens* (Willd.) Gray. Less common.

168. *Eleocharis avicularis* (L.) R. & S. Needle Spike Rush. Common on muddy shores.

169. *Eleocharis acuminata* (Muhl.) Nees. Flat Stemmed Spike Rush. Rare, State Quarry.

SCIRPUS (Tourn) L.

170. *Scirpus validus Vahl.* Great Bullrush. Common in marshes.

171. *Scirpus fluviatilis* (Torr.) Gray. River Bullrush. Common along streams.

172. *Scirpus atrovirens* Muhl. Dark-Green Bullrush. Very abundant in fields and meadows.

173. *Scirpus lineatus* Michx. Reddish Bullrush. Rather scarce, State Quarries.

174. *Scirpus cyperinus* (L.) Kunth. Wool Grass. Plenty in marshes.

175. *Scirpus atrocinctus* Fern. Dark Wool Grass. With the last named above but much less common.

ERIOPHORUM L.

176. *Eriophorum angustifolium* Var. *majus* Schultz. Cotton Grass. Not rare in bogs.

FUIRENA Rottb.

177. *Fuirena squarrosa* Michx. Umbrella Grass. Not rare on sandy banks.

HEMICARPA Nees & Arn.

178. *Hemicarpa micrantha* (Vahl.) Britt. Creeping Nut Grass. Plenty along streams.

SCLERIA Bergius.

179. *Scleria triglomerata* Michx. Tall Nut Rush. Not rare; locally abundant at Morse.

CAREX (Ruppius) L.

180. *Carex scoparia* Schk. Broom Sedge. Quite common in marshes and along bayous.

181. *Carex straminea* Willd. Var. *echinoides* Fern. Straw Sedge. Fields and prairies.

182. *Carex festucacea* Schk. Fesque Sedge. Common in fields and prairies.

183. *Carex festucacea brevior* (Dew.) Fern. With the above.

184. *Carex rosea* Schk. Stellate Sedge. Scarce in rolling woodlands.

185. *Carex rosea radiata* Dewey. Much more plenty in moist woodland soil.

186. *Carex muhlenbergii* Schkr. Muhlenberg's Sedge. Rare on gravel hills.

187. *Carex cephalophora* Muhl. Oval Headed Sedge. Not uncommon in woods.

188. *Carex leavenworthii* Dewey. Leavenworth's Sedge. Rare in a woodland marsh near Iowa City.

189. *Carex spharganioides* Muhl. Bur-reed Sedge. Rather local in woodlands.

190. *Carex gravida* Bailey. Heavy Sedge. Scarce in dry soil.

191. *Carex vulpinoidea* Michx. Fox Sedge. Our most abundant sedge, common everywhere.

192. *Carex conjuncta* Boot. Soft Fox Sedge. Rather scarce in marshes.

193. *Carex stipata* Muhl. Awl Fruited Sedge. Common in dry soil and marshes alike.

194. *Carex stricta* Lam. Tussock Sedge. Common in marshes.

195. *Carex stricta angustata* (Boott.) Bailey. With the last but less common.

196. *Carex davisii* Schwein. Davis's Sedge. Scarce on dry hillsides.

197. *Carex pennsylvanica* Lam. Pennsylvania Sedge. Common in woodlands. The first of our sedges to bloom.

198. *Carex tetanica* Var. *Meadii* (Dewey) Bailey. Wood's Sedge. Locally plenty near Morse.

199. *Carex digitalis* Willd. Slender Wood Sedge. Rare; found but once in extreme N. E. corner of the County in Cedar Twp. on wooded bluff along the Cedar River.

200. *Carex laxiflora* Lam. Var. *varians*. Bailey. Loose flowered Sedge. Rare at Turkey Creek.

201. *Carex laxiflora* Lam. Var *blanda* (Dew) Boott. Common in woodlands.

202. *Carex laxiflora* Lam. Var *latifolia* Boott. Rare in damp woods.

203. *Carex grisea* Wahl. Gray Sedge. Rather scarce in woods.

204. *Carex longiristris* Torr. Long beaked Sedge. Common in woods and thickets.

205. *Carex lanuginosa* Michx. Woolly Sedge. Common in swamps and marshes.

206. *Carex trichocarpa* Muhl. Hairy Fruited Sedge. Plenty in marshes.

207. *Carex aristata* (R. Br.) Bailey. Awned Sedge. Very abundant.

208. *Carex lupulina* Muhl. Hop Sedge. Very common along streams and ditches.

209. *Carex grayi* Carey. Gray's Sedge. Not common but found along streams and ditches.

210. *Carex hystricina* Muhl. Porcupine Sedge. Common in bogs and marshes.

211. *Carex comosa* Boott. Bristly Sedge. In marshes and along muddy banks.

212. *Carex oligocarpa* Schkr. Few Fruited Sedge. Rather scarce in dry woodlands.

213. *Carex bicknellii* Britt. Bicknell's Sedge. Scarce on rocky hillsides.

214. *Carex vesicaria* L. Var. *monile.* (Tuckherm) Fern. Necklace Sedge. Not uncommon in marshes and along ditches and streams.

215. *Carex retrorsa* Schwein. Retrorse Sedge. In bogs and marshes.

216. *Carex grisea* Wahlenb. Var. *angustifolia* Boott. Narrow-leaved Sedge. Rare in woodlands.

ARACEAE.

ARISAEMA Martius.

217. *Arisaema triphyllum* (L.) Schott. Jack-in-the-Pulpit. Common in woodlands.

218. *Arisaema dracontium* (L.) Schott. Green Dragon. Less common but plenty.

LEMNACEAE.

SPIRODELA Schleid.

219. *Spirodela polyrhiza* (L.) Schleid. Greater Duckweed. Not common in ponds.

LEMNA L.

220. *Lemna trisulca* L. Ivy-leaved Duckweed. Common in ponds and bayous.

221. *Lemna minor* L. Lesser Duckweed. Less common.

COMMELINACEAE.

TRADESCANTIA (Rupp) L.

222. *Tradescantia reflexa* Raf. Reflexed Spiderwort. Common, especially in sandy soils.

223. *Tradescantia virginiana* L. Spiderwort. Much less common, locally.

JUNCACEAE.

JUNCUS (Tourn) L.

224. *Juncus tenuis* Willd. Slender Rush. Common everywhere.
225. *Juncus secundus* Beauv. Secund Rush. Rare, Iowa City, Oxford.
226. *Juncus effusus L.* Common Rush. Common in marshy places.
227. *Juncus nodosus* L. Knotted Rush. Common in sandy areas.
228. *Juncus torreyi* Cov. Torrey's Rush. Common in sandy areas.
229. *Juncus acuminatus* Michx. Sharp-fruited Rush. Rather scarce, Oxford.

LILIACEAE.

MELANTHIUM L.

230. *Melanthium virginicum* L. Bunch Flower. Locally plenty at Oxford.

UVULARIA L.

231. *Uvularia grandiflora* Sm. Large Flowered Bellwort. Common in woods and thickets.

OAKESIA Wats.

232. *Oakesia sessiliflora* (L.) Wats. Sessile-leaved Bellwort. Scarce in woods and thickets.

ALLIUM (Tourn) L.

233. *Allium cernuum* Roth. Nodding Wild Onion. Not common.
234. *Allium tricoccum* Ait. Wild Leek. Common in woodlands.
235. *Allium canadense* L. Wild Garlic. Common, especially in open places.

HEMEROCALLIS L.

236. *Hemerocallis fulva* L. Common Day Lily. Rare as an escape; a colony near North Liberty is apparently persistent, having been noted during three seasons.

LILIUM (Tourn) L.

237. *Lilium philadelphicum* L. Red Lily. Common throughout the county.
238. *Lilium philadelphicum* Var. *andinum* (Nutt) Kerr. This is the same as L. *lanceolatum* Fitzp. and is found commonly with the above.

239. *Lilium superbum* L. Turk's Cap Lily. Rather scarce.

240. *Lilium canadense* L. Wild Yellow Lily. Common in open places.

ERYTHRONIUM L.

241. *Erythronium albidum* Nutt. Dog-tooth Violet. Abundant in woodlands.

ASPARAGUS (Tourn) L.

242. *Asparagus officinalis* L. Common Asparagus. Occasional as an escape.

SMILACINA Desf.

243. *Smilacina racemosa* (L.) Desf. Racemose False Solomon's Seal. Common.

244. *Smilacina stellata* (L.) Desf. Stellate False Solomon's Seal. Common.

MAIANTHEMUM (Webber) Wigg.

245. *Maianthemum canadense* Desf. False Lily-of-the-Valley. Scarce in rich woods.

POLYGONATUM (Tourn) Hill.

246. *Polygonatum commutatum* (R. & S.) Dietr. Smooth Solomon's Seal. Common.

TRILLIUM L.

247. *Trillium nivale* Riddell. Dwarf Trillium, Wake Robin. Common in woodlands.

248. *Trillium cernuum* L. Nodding Wake Robin. Scarce in deep woods—State Quarries.

249. *Trillium sessile* L. Sessile Flowered Wake Robin. Rare along Old Man's Creek.

SMILAX (Tourn) L.

250. *Smilax herbacea* L. Carrion Flower. Plenty in woods.

251. *Smilax ecirrhata* (Engelm) Wats. Upright Smilax. Common.

252. *Smilax hispida* Muhl. Hispid Green Brier. Abundant in thickets.

253. *Smilax pseudo-china* L. Long Stalked Green Brier. Scarce, Elmira.

DIOSCOREACEAE.

DIOSCOREA (Plumier) L.

254. *Dioscorea villosa* L. Wild Yam Root. Common in woods and thickets.

AMARYLLIDACEAE.

HYPOXIS L.

255. *Hypoxis hirsuta* (L.) Coville. Yellow Star Grass. Common in moist soil.

IRIDACEAE.

IRIS (Tourn) L.

256. *Iris versicolor* L. Blue Flag. In swamps and marshes.

SISYRINCHIUM L.

257. *Sisyrinchium angustifolium* Mill. Northern Blue-eyed Grass. Common in moist places.
258. *Sisyrinchium gramineum* Curtis. Common Blue-eyed Grass. Much less common; sandy soils.

ORCHIDACEAE.

CYPRIPEDIUM L.

259. *Cypripedium parviflorum* Salisb. Yellow Lady's Slipper. Not rare in woodlands.
260. *Cypripedium parviflorum* Var. *pubescens* (Willd.) Knight. Downy Lady's Slipper. Less common.

ORCHIS (Tourn) L.

261. *Orchis spectabilis* L. Showy Orchis. Scarce in rich woodlands.

HABENARIA Willd.

262. *Habenaria leucophaea* (Nutt) Gray. Prairie White Fringed Orchis. Scarce in moist meadows.

CALOPOGON R. Br.

263. *Calopogon pulchellus* (Sw.) R. Br. Grass Pink. Rare; found but once near Oxford.

SPIRANTHES Richards.

264. *Spiranthes cernua* (L.) Richard. Lady's Tresses. Common in moist meadows.

EPIPACTIS (Haller) Boehm.

265. *Epipactis pubescens* (Willd.) A. A. Eaton. Rattle Snake Plantain. Rare in woodlands along the Iowa River.

LIPARIS Richard.

266. *Liparis lilifolia* (L.) Rich. Large Twayblade. Not rare in rocky woodlands; State Quarry.

APLECTRUM (Nutt) Torr.

267. *Aplectrum hyemale* (Muhl.) Torr. Putty Root. Rare in woodlands along Iowa River.

SALICACEAE.

SALIX (Tourn) L.

268. *Salix nigra* Marsh. Black Willow. Rather scarce in bogs.
269. *Salix amygdaloides* Anders. Peach-leaved Willow. Very common especially along streams.
270. *Salix lucida* Muhl. Shining Willow. Rare.
271. *Salix fragilis* L. Crack Willow. Cultivated and occasional as an escape.
272. *Salix alba* Var. *vitellina* (L.) Koch. White Willow. Common in cultivation.
273. *Salix babylonica* L. Weeping Willow. Cultivated and rarely as an escape; Riverside.
274. *Salix cordata* Muhl. Heart-leaved Willow. Not scarce in bogs and marshy woods.
275. *Salix longifolia* Muhl. Sand-bar Willow. Common along streams.
276. *Salix missouriensis* Bebb. Missouri Willow. Plenty along streams.
277. *Salix discolor* Muhl. Glaucous Willow. Rather scarce along streams.
278. *Salix humilis* Marsh. Prairie Willow. Common in hillside thickets.

POPULUS (Tourn) L.

279. *Populus alba* L. White Poplar. Cultivated.

280. *Populus tremuloides* Michx. American Aspen. Quite common in sandy woodlands.

281. *Populus grandidentata* Michx. Large Toothed Aspen. Very common in woodlands.

282. *Populus deltoides* Marsh. Cottonwood. Very common especially along streams.

JUGLANDACEAE.

JUGLANS L.

283. *Juglans cinerea* L. Butternut. Not scarce in woods.
284. *Juglans nigra* L. Black Walnut. Not scarce in woods.

CARYA Nutt.

285. *Carya ovata* (Mill) K. Koch. Shell Bark Hickory. Common in woods.

286. *Carya alba* (L.) K. Koch. White Heart Hickory. Not scarce.

287. *Carya microcarpa* Nutt. Small Fruited Hickory. Rare in deep woods; State Quarries.

288. *Carya glabra* (Mill) Spach. Pignut. Not uncommon in lowland woods.

289. *Carya cordiformis* (Wang) K. Koch. Bitternut or Swamp Hickory. Rare.

BETULACEAE.

CORYLUS (Tourn) L.

290. *Corylus americana* Walt. Hazelnut. Very common in woods and thickets.

OSTRYA (Mich) Scop.

291. *Ostrya virginiana* (Mill) K. Koch. Iron Wood or Hop Hornbeam. Common in woods.

CARPINUS (Tourn) L.

292. *Carpinus caroliniana* Walt. Blue Beech. Rather scarce on wooded hillsides.

BETULA (Tourn) L.

293. *Betula nigra* L. Red or River Birch. Common along streams.

294. *Betula pendula* Roth. White or Canoe Birch. A colony of young trees escaped from cultivation is established along Iowa River near Iowa City.

FAGACEAE.

QUERCUS (Tourn) L.

295. *Quercus alba* L. White Oak. Common in woods.

296. *Quercus macrocarpa* Michx. Burr Oak. Very common.

297. *Quercus bicolor* Willd. Swamp White Oak. Rather scarce in woods.

298. *Quercus muhlenbergii* Engelm. Chestnut Oak. Common on wooded hillsides.

299. *Quercus rubra* L. Red Oak. Common.

300. *Quercus velutina* Lam. Black Oak. Plenty in woodlands.

301. *Quercus imbricaria* Michx. Shingle Oak. Rare.

URTICACEAE.

ULMUS (Tourn) L.

302. *Ulmus americana* L. White Elm. Very abundant.

303. *Ulmus fulva* Michx. Red or Slippery Elm. Abundant in woodlands.

CELTIS (Tourn) L.

304. *Celtis occidentalis* L. Hackberry. Common along streams.

CANNABIS (Tourn) L.

305. *Cannabis sativa* L. Hemp. Common in waste places.

HUMULUS L.

306. *Humulus lupulus* L. Common Hops. Very abundant.

MACLURA Nutt.

307. *Maclura pomifera* (Raf.) Schn. Osage Orange. Cultivated in hedges, etc.

BROUSSONETIA L'Her.

308. *Broussonetia papyrifera* (L.) Vent. Paper Mulberry. Rare but established near Riverside.

MORUS L.

309. *Morus rubra* L. Red Mulberry. Cultivated and sparingly occurring in woods.

URTICA (Tourn) L.

310. *Urtica gracilis* Ait. Nettle. Common in waste places.

LAPORTEA Gaud.

311. *Laportea canadensis* (L.) Gaud. Wood Nettle. Scarce in damp woodlands.

PILEA Lindl.

312. *Pilea pumila* (L.) Gray. Clear Weed. Common about springs and streams in woodlands.

BOEHMERIA Jacq.

313. *Boehmeria cylindrica* (L.) Sw. False Nettle. Scarce in damp wooded places.

PARIETARIA (Tourn) L.

314. *Parietaria pennsylvanica* Muhl. Pellitory. Not uncommon in woodlands.

SANTALACEAE.

COMANDRA Nutt

315. *Comandra umbellata* (L.) Nutt. Bastard Toad Flax. Very common in open places and edges of thicket.

ARISTOLOCHIACEAE.

ASARUM (Tourn) L.

316. *Asarum canadense* L. Var. *reflexum* (Bick.) Rob. Reflexed Wild Ginger. Not scarce in woods.

317. *Asarum canadense* L. Var. *acuminatum* Ashe. Acuminate Wild Ginger. Abundant in woodlands.

POLYGONACEAE.

RUMEX L.

318. *Rumex acetosella* L. Field Sorrel. A common weed in waste places.
319. *Rumex hastataulus* Baldw. Engelmann's Sorrel. Rare as a weed along railways.
320. *Rumex occidentalis* Wats. Western Dock. Rare in bogs.
321. *Rumex altissimus* Wood. Peach-leaved Dock. Very common.
322. *Rumex verticillatus* L. Swamp Dock. Scarce in marshes.
323. *Rumex mexicanus* Meisn. Willow-leaved Dock. Common.

POLYGONUM (Tourn) L.

324. *Polygonum aviculare* L. Yard Knot Grass. Common everywhere.
325. *Polygonum aviculare* Var. *littorale* (Link) Koch. Shore Knot Grass. With the above.
326. *Polygonum erectum* L. Erect Knot Grass. Roadsides and waste places.
327. *Polygonum ramosissium* Michx. Bushy Knot Grass. Dry Soil, not common.
328. *Polygonum tenue* Michx. Slender Knotweed. Rather scarce in dry rocky places.
329. *Polygonum lapathifolium* L. Pale Persicaria. Plenty in marshes.
330. *Polygonum muhlenbergii* (Meisn.) Wats. Swamp Persicaria. In marshes.
331. *Polygonum pennsylvanicum* L. Pennsylvania Persicaria. Common in marshes.
332. *Polygonum hydropiper* L. Smartweed or Water Pepper. Not abundant.
333. *Polygonum acre* HBK. Water Smartweed. Scarce in marshes; Hills.
334. *Polygonum orientale* L. Prince's Feather. Scarce in waste places.
335. *Polygonum persicaria* L. Lady's Thumb. Abundant in marshy places.
336. *Polygonum hydropiperoides* Michx. Mild Water Pepper. Abundant in marshy places.
337. *Polygonum virginianum* L. Virginia Knotweed. Common in woodlands.

338. *Polygonum sagittatum* L. Arrow-leaved Tear-thumb. Abundant in marshes and marshy fields.

339. *Polygonum convolvulus* L. Black Bindweed. In thickets and along railway tracks.

340. *Polygonum scandens* L. Climbing False Buckwheat. Same localities as the above.

341. *Polygonum dumetorum* L. Hedge Buckwheat. Similar to and found with the two preceding.

342. *Polygonum cuspidatum* Sieb & Zucc. Japanese Knotweed. Cultivated and locally established at Iowa City.

FAGOPYRUM (Tourn) L.

343. *Fagopyrum esculentum* Moensch. Buckwheat. Occasionally in waste places and along fields.

CHENOPIDIACEAE.

CYCLOLOMA Moq.

344. *Cycloloma atriplicifolium* (Spreng) Coult. Winged Pigweed. Not scarce in sandy soil.

CHENOPODIUM (Tourn) L.

345. *Chenopodium ambrosioides* L. Var. *anthelminticum* (L.) Gray. Wormseed. A weed in waste places.

346. *Chenopodium capitatum* (L.) Ashe. Strawberry Blite. Rare; streets of Iowa City.

347. *Chenopodium glaucum* L. Oak-leaved Goosefoot. Abundant in waste places.

348. *Chenopodium album* L. Lambs Quarter. Abundant everywhere; very variable.

349. *Chenopodium hybridum* L. Maple-leaved Goosefoot. Common in waste places.

350. *Chenopodium album* Var. *viride* (L.) Moq. Quite common.

351. *Chenopodium boscianum* Moq. Bosc's Goosefoot. Common in woodlands.

352. *Chenopodium leptophyllum* Nutt. Narrow-leaved Goosefoot. Rare on sand bars of Iowa River.

ATRIPLEX (Tourn) L.

353. *Atriplex patula* L. Spreading Orache. A common weed in waste places.

354. *Atriplex hastata* (L.) Gray. Halberd-leaved Orache. In similar places.

SALSOLA L.

355. *Salsola kali* L. Var. *tenuifolia* G. F. W. Mey. Russian Thistle. Common in sandy soils.

AMARANTHACEAE.

AMARANTHUS (Tourn) L.

356. *Amaranthus retroflexus* L. Green Amaranth. Abundant everywhere.

357. *Amaranthus hybridus* L. Amaranth. Common in waste places.

358. *Amaranthus paniculatus* L. Purple Amaranth. Not rare.

359. *Amaranthus blitoides* Wats. Prostrate Amaranth. Very common everywhere.

ACNIDA L.

360. *Acnida tamariscina* (Nutt) Wood. Water Hemp. Common in light soils.

361. *Acnida tuberculata* Moq. Var. *subnuda* Wats. Glomerate Water Hemp. Plenty in low sandy fields.

FROELICHIA Moench.

362. *Froelichia floridana* (Nutt) Moq. Shoestrings or Florida Froelichia. Rare within our borders though common in adjoining counties.

NYCTAGINACEAE.

OXYBAPHUS L'Her.

363. *Oxybaphus nyctagineus* (Michx.) Sweet. Heart-leaved Umbrellawort. Very common in waste places.

ILLECEBRACEAE.

ANYCHIA Michx.

364. *Anychia canadensis* (L.) BSP. Forked Chickweed. Not rare in woodlands.

AIZOACEAE.

MOLLUGO L.

365. *Mollugo verticillata* L. Carpetweed. Abundant in sandy soils.

CARYOPHYLLACEAE.

ARENARIA L.

366. *Arenaria lateriflora* L. Blunt-leaved Moehringia. Plenty in woodlands.

STELLARIA L.

367. *Stellaria longifolia* Muhl. Long-leaved Stitch-wort. Scarce in open woods.
368. *Stellaria media* (L.) Cyrill. Common Chickweed. A common weed.

CERASTIUM L.

369. *Cerastium vulgatum* L. Mouse-ear Chickweed. Abundant in waste places.
370. *Cerastium nutans* Raf. Nodding Chickweed. Scarce.

AGROSTEMMA L.

371. *Agrostemma githago* L. Corn Cockle. Occasional, especially along the railways.

LYCHNIS (Tourn) L.

372. *Lychnis alba Mill.* White Campion. Not rare.

SILENE L.

373. *Silene antirrhina* L. Sleepy Catchfly. Common in sandy soil.
374. *Silene noctiflora* L. Night Flowering Catchfly. Rare, Iowa City.
375. *Silene stellata* (L.) Ait. f. Starry Campion. Common in woods and thickets.
376. *Silene nivea* (Nutt) Otth. Notched Campion. Rare; Turkey Creek.

SAPONARIA L.

377. *Saponaria officinalis* L. Bouncing Bet. Occasional as an escape.

378. *Saponaria vaccaria* L. Cow Herb. Not common but occasionally in fields and along railways.

PORTULACACEAE.

CLAYTONIA (Gron) L.

379. *Claytonia virginica* L. Spring Beauty. Common in moist woodlands.

380. *Claytonia multicaulis* A. Nels. Var. *robusta* Somes. Robust Spring Beauty. Locally not rare in woods.

PORTULACA (Tourn) L.

381. *Portulaca oleracea* L. Purslane or Pursley. A common weed in fields and waste places.

382. *Portulaca retusa* Engelm. Notched Purslane. Rare; taken once in Fremont Twp. along Iowa River.

NYMPHACEAE.

NYMPHAEA (Tourn) L.

383. *Nymphaea advena* Ait. Cow Lily. Common in ponds and marshes.

CASTALIA Salisb.

384. *Castalia tuberosa* (Paine) Greene. Pond Lily. Not uncommon in ponds.

RANUNCULACEAE.

RANUNCULUS (Tourn) L.

385. *Ranunculus circinatus* Sibth. Stiff White Water Crowfoot. Rare; Oxford.

386. *Ranunculus cymbalaria* Pursh. Seaside Crowfoot. Abundant on muddy shores.

387. *Ranunculus delphinifolius* Torr. Yellow Water Crowfoot. Not uncommon in ponds and marshes.

388. *Ranunculus delphinifolius* Var. *terrestris* Gray. Occasional with the above.

389. *Ranunculus rhomboideus* Goldie. Dwarf Buttercup. Common in fields and thickets.

390. *Ranunculus abortivus* L. Small Flowered Crowfoot. Common in woods.

391. *Ranunculus recurvatus* Poir. Hooked Crowfoot. Scarce in rocky woods.

392. *Ranunculus fascicularis* Muhl. Early Buttercup. Not uncommon in fields and thickets.

393. *Ranunculus septentrionalis* Poir. Swamp Buttercup. Very common in woods.

394. *Ranunculus hispidus* Michx. Hispid Buttercup. Rather scarce in rocky woods.

395. *Ranunculus repens* L. Creeping Buttercup. Locally plenty at Iowa City.

396. *Ranunculus acris* L. Tall Crow Foot. Occasional as an escape; Iowa City.

THALICTRUM (Tourn) L.

397. *Thalictrum dioicum* L. Early Meadow Rue. Rare; State Quarries.

398. *Thalictrum revolutum* DC. Purplish Meadow Rue. Common in fields and thickets.

399. *Thalictrum dasycarpum* Fisch. & Lall. Stinking Meadow Rue. More scarce but found with the above.

ANEMONELLA Spach.

400. *Anemonella thalictroides* (L.) Spach. Rue Anemone. Common in woodands.

HEPATICA (Rupp) Hill.

401. *Hepatica acutiloba* DC. Acute Liverleaf. Very common in woodlands.

ANEMONE (Tourn) L.

402. *Annemone cylindrica* Gray. Long fruited Anemone. Not uncommon in woods and thickets.

403. *Anemone virginiana* L. Tall Anemone. Common in fields and thickets.

404. *Anemone canadensis* L. Canada Anemone. Very abundant in fields and roadsides.

405. *Anemone quinquefolia* L. Wind-Flower or Wood Anemone. Common in woodlands.

CLEMATIS L.

406. *Clematis virginiana* L. Virgins Bower. Common in thickets.

407. *Clematis pitcheri* T. & G. Sim's Clematis or Leather Flower. Common in sandy soil along Iowa River.

ISOPYRUM L.

408. *Isopyrum biternatum* (Raf.) T. & G. False Rue Anemone. Plenty in woodlands.

CALTHA (Rupp) L.

409. *Caltha palustris* L. Marsh Marigold or Cowslip. Common in bogs and marshes.

AQUILEGIA (Tourn) L.

410. *Aquilegia canadensis* L. Columbine. Common in woods, especially in rocky places.

DELPHINIUM (Tourn) L.

411. *Delphinium tricorne* Michx. Dwarf Larkspur. Not rare.

412. *Delphinium azureum* Michx. Pale Larkspur. Common in fields and open places.

413. *Delphinium penardi* Huth. Prairie Larkspur. Rather scarce in fields, thickets and open woods.

ACTAEA L.

414. *Actaea rubra* (Ait.) Willd. Red Baneberry. In woods, quite plenty.

415. *Actaea alba* (L.) Mill. White Baneberry. In woods, less common.

MAGNOLIACAEAE.

LIRIODENDRON L.

416. *Liriodendron tulipifera* L. Tuliptree. Cultivated; Iowa City.

MENISPERMACEAE.

MENISPERUM (Tourn) L.

417. *Menispermum canadense* L. Moonseed. Common in woods and thickets.

BERBERIDACEAE.

PODOPHYLLUM L.

418. *Podophyllum peltatum* L. May Apple. Abundant in open woods.

CAULOPHYLLUM Michx.

419. *Caulophyllum thalictroides* (L.) Michx. Blue Cohosh or Pappoose Root. Locally plenty in woodlands.

BERBERIS (Tourn) L.

420. *Berberis vulgaris* L. Common Barberry. Cultivated and sparingly established.

PAPAVERACEAE.

SANGUINARIA (Dill) L.

421. *Sanguinaria canadensis* L. Bloodroot. Abundant in woodlands.

ARGEMONE L.

422. *Argemone mexicana* L. Prickly Poppy. Rarely found along railways but not persisting.

FUMARIACEAE.

ADLUMIA Raf.

423. *Adlumia fungosa* (Ait.) Greene. Climbing Fumitory. Cultivated and rarely established.

DICENTRA Bernh.

424. *Dicentra cucullaria* (L.) Bernh. Dutchman's Breeches. Very common in low woodlands.

CORYDALIS (Dill) Medic.

425. *Corydalis micrantha* (Engelm) Gray. Small Flowered Corydalis. In sandy soils.

426. *Corydalis curvusiliqum* (Engelm) Kuntze. Curved-fruited Corydalis. Common in sandy soils. .

CRUCIFERAE.

DRABA (Dill) L.

427. *Draba caroliniana* Walt. Smooth Carolina Whitlow Grass. Common in sandy soils.

428. *Draba caroliniana* Var. *micrantha* Nutt. Hairy Carolina Whitlow Grass. With the above.

ALYSSUM (Tourn) L.

429. *Alyssum alyssoides* L. Yellow or Small Alyssum. Rare; Iowa City.

THLASPI (Tourn) L.

430. *Thlaspi arvense* L. Field Penny Cress or Frenchweed. Becoming established especially along railways.

LEPIDIUM (Tourn) L.

431. *Lepidium virginicum* L. Wild Pepper Grass. Roadsides and waste places.

432. *Lepidium apetalum* Willd. Apetalous Peppergrass. In similar places but more common.

CAPSELLA Medic.

433. *Capsella bursa-pastoris* (L.) Medic. Shepherd's Purse. A common weed of fields and waste places.

CAMELINA Crantz.

435. *Camelina sativa* (L.) Crantz. False Flax or Gold-of-pleasure. An introduced weed, not rare in fields.

NESLIA Desv.

436. *Neslia paniculata* (L.) Desv. Ball Mustard. Rare; persistent in one locality near Iowa City.

RAPHANUS (Tourn) L.

437. *Raphanus sativus* L. Radish. Occasionally established in waste places.

CONRINGIA (Heist) Link.

438. *Conringia orientalis* (L) Dumort. Hare's Ear Mustard. Scarce but becoming established.

BRASSICA (Tourn) L.

439. *Brassica arvensis* (L) Ktze. Charlock. Not uncommon in waste places.

440. *Brassica nigra* (L) Koch. Black Mustard. A common weed.

441. *Brassica alba* (L) Boiss. White Mustard. Rare; along railway, Iowa City.

442. *Brassica juncea* (L) Coss. Indian Mustard. Not uncommon as a roadside weed.

SISYMBRIUM (Tourn) L.

443. *Sisymbrium officinale* (L) Scop. Hedge Mustard. A common weed of waste places.

444. *Sisymbrium altissimum* L. Tumbling Mustard. Common in roadsides and waste places.

445. *Sisymbrium canescens* Nutt. Tansy Mustard. Common in sandy soils.

446. *Sisymbrium canescens* Var. *incisum* Engelm. Tansy Mustard. With the above.

HESPERIS (Tourn) L.

447. *Hesperis matronalis* L. Dame's Violet. Occasional.

ERYSIMUM (Tourn) L.

448. *Erysimum cheiranthoides* L. Worm-Seed Mustard. Not uncommon in thickets.

RADICULA (Dill) Hill.

449. *Radicula nasturtium-aquaticum* (L) Britt. & Rendle. True Water Cress. Common in springs, bogs.

450. *Radicula sessiliflora* (Nutt) Gr. Sessile-flowered Cress. Not uncommon along streams.

451. *Radicula obtusa* (Nutt) Gr. Blunt-leaved Yellow Cress. With the above.

452. *Radicula obtusa* Var. *sphaerocarpa* (Gray) Rob. Scarce in similar places.

453. *Radicula palustris* (L) Moench. Marsh or Yellow Cress. Common in moist soils.

454. *Radicula palustris* Var. *hispida* (Desv) Rob. With the above but scarce.

IODANTHUS T. & G.

455. *Iodanthus pinnatifidus* (Michx) Steud. Purple or False Rocket. Scarce in waste places along streams.

DENTARIA (Tourn) L.

456. *Dentaria laciniata* Muhl. Pepper-root or Toothwort. Common in woodlands.

CARDAMINE (Tourn) L.

457. *Cardamine bulbosa* (Schreb) BSP. Spring Cress. Common in bogs and springs.

458. *Cardamine pennsylvanica* Muhl. Pennsylvania Bitter Cress. Common in moist soils.

ARABIS L.

459. *Arabis dentata* T. & G. Toothed Rock-cress. Not rare in woodlands.

460. *Arabis canadensis* L. Sickle-pod. Very common in rocky woods.

461. *Arabis laevigata* (Muhl.) Poir. Smooth Rock-cress. Not uncommon in woodlands.

462. *Arabis hirsuta* (L.) Scop. Hairy Rock-cress. Not uncommon.

463. *Arabis drummondi* Gray. Drummond's Rock-cress. Rare in rocky wooded places: State Quarries.

CAPPARIDACEAE.

POLANISIA Raf.

464. *Polanisia graveolens* Raf. Clammy Weed. Rather scarce in sandy soils.

465. *Polanisia trachysperma* T. & G. Large-flowered Clammy Weed. In similar places.

CRASSULACEAE.

PENTHORUM (Gronov) L.

466. *Penthorum sedoides* L. Ditch Stonecrop. Common along ditches and in moist soils.

SAXIFRAGACEAE.

SAXIFRAGA (Tourn) L.

467. *Saxifraga pennsylvanica* L. Swamp Saxifrage. Not rare in moist woodlands.

HEUCHERA L.

468. *Heuchera hispida* Pursh. Hairy Alum-root. Common in high gravelly soils.

MITELLA (Tourn) L.

469. *Mitella diphylla* L. Mitrewort. Common in rich moist woodlands.

RIBES L.

470. *Ribes cynosbati* L. Prickly Gooseberry. Common in woods.
471. *Ribes gracile* Michx. Missouri Gooseberry. Common in woods.
472. *Ribes oxyacanthoides* L. Smooth Gooseberry. Not uncommon in woodlands.
473. *Ribes floridum* L'Her. Wild Black Currant. Rather scarce in woodlands.

PLATANACEAE.

PLATANUS (Tourn) L.

474. *Platanus occidentalis* L. Sycamore. Common especially in low woods.

ROSACEAE.

PHYSOCARPUS Max.

475. *Physocarpus opulifolius* (L.) Max. Nine-bark. Locally plenty along streams.
476. *Physocarpus opulifolius* Var. *intermedius* (Ryd.) Rob. Nine-bark. Rare; Cedar Township.

SPIRAEA (Tourn) L.

477. *Spiraea salicifolia* L. Meadow Sweet. Not uncommon in low meadows.

PYRUS (Tourn) L.

478. *Pyrus ioensis* (Wood) Bailey. Western Wild Crab. Common in woods and thickets.

AMELANCHIER Medic.

479. *Amelanchier canadensis* (L.) Medic. Service Berry or June Berry. Common on high banks.

480. *Amelanchier botryapium* (L. f.) T. & G. Shad-bush. Locally plenty.

CRATAEGUS L.

481. *Crataegus crusgalli* L. Cockspur Thorn. Very common in woods.

482. *Crataegus punctata* Jacq. Large-fruited Thorn. Abundant in woods and thickets.

483. *Crataegus coccinea* L. Rough Thorn. Less common but not scarce.

484. *Crataegus rotundifolia* Moench. Glandular Thorn. Rare; State Quarries.

485. *Crataegus macrosperma* Ashe. Large-seeded Thorn. Scarce in low rich woods. Hills Siding.

486. *Crataegus pruinosa* (Wendl.) C. Koch. Pruinose Thorn. Common in woods and thickets.

487. *Crataegus mollis* (T. & G.) Scheele. Red Fruited Thorn. Common in woods and thickets.

488. *Crataegus macracantha* Lodd. Long Spined Thorn. Scarce in woods.

489. *Crataegus tomentosa* L. Pear Thorn. Rare in rocky places.

FRAGRARIA (Tourn) L.

490. *Fragraria virginiana* Var. *illinoensis* (Prince) Gray. Wild Strawberry. Very abundant.

491. *Fragraria vesca* Var. *americana* Porter. Wood Strawberry. Not rare in woodlands.

POTENTILLA L.

492. *Potentilla arguta* Pursh. Glandular Cinquefoil. Common in rocky and gravelly soils.

493. *Potentilla monspeliensis* L. Rough Cinquefoil. Common in waste places.

494. *Potentilla rivalis* Nutt. Var. *millegrana* (Engelm.) Wats. Diffuse Cinquefoil. Scarce in moist places.

495. *Potentilla canadensis* L. Five Finger. Common.

FILIPENDULA (Tourn) Hill.

496. *Filipendula rubra* (Hill) Rob. Queen-of-the-Prairie. Very rare in meadows; Cedar Township.

GEUM L.

497. *Geum canadensis* Jacq. White Avens. Abundant in rich woods.

498. *Geum virginianum* L. Rough Avens. Not uncommon in meadows.

499. *Geum strictum* Ait. Yellow Avens. Rather scarce in woods and thickets.

RUBUS (Tourn) L.

500. *Rubus idaeus* L. Var. *aculeatissimus* (C. A. Mey) R. & T. Wild Red Raspberry. Common.

501. *Rubus occidentalis* L. Wild Black Raspberry. Common in thickets.

AGRIMONIA (Tourn) L.

502. *Agrimonia gryposepala* Wallr. Tall Hairy Agrimony. Scarce in low woods.

503. *Agrimonia striata* Michx. Woodland Agrimony. Not uncommon in woods and thickets.

504. *Agrimonia mollis* (T. & G.) Robins. Soft Agrimony. Rather scarce in woods and thickets.

ROSA (Tourn) L.

505. *Rosa blanda* Ait. Smooth Wild Rose. Not rare in dry or rocky soils.

506. *Rosa pratincola* Greene. Thorny Wild Rose. Rather plenty.

507. *Rosa woodsii* Lindl. Low Wild Rose. Not rare in clay soils.

PRUNUS (Tourn) L.

508. *Prunus serotina* (L.) Reich. Wild Black Cherry. Not uncommon in woods.

509. *Prunus virginiana* L. Choke Cherry. Very common in dry wooded places.

510. *Prunus pennsylvanica* L. f. Wild Red Cherry or Bird Cherry. Rather scarce.

511. *Prunus americana* Marsh. Wild Plum. Common in woods and thickets.

LEGUMINOSAE.

GYMNOCLADUS Lam.

512. *Gymnocladus dioica* (L.) Koch. Kentucky Coffee Tree. Cultivated and not uncommon in woods.

GLEDITSIA L.

513. *Gleditsia triacanthos* L. Honey Locust. Very common in woods and along streams.

CASSIA (Tourn) L.

514. *Cassia medsgeri* Shafer. Wild Senna. Scarce in sandy soils.
515. *Cassia chamaecrista* L. Partridge Pea. Very abundant in sandy soils.

CERCIS L.

516. *Cercis canadensis* L. Red Bud. Rare; a few scattered trees near our southern border in Fremont Township.

BAPTISIA Vent.

517. *Baptisia bracteata* (Muhl.) Ell. Large-bracted Wild Indigo. Not common in meadows.
518. *Baptisia leucantha* T. & G. Large White Wild Indigo. Common in meadows.

CROTALARIA (Dill) L.

519. *Crotalaria sagittalis* L. Rattle-box. Locally plenty near Iowa City.

LUPINUS (Tourn) L.

520. *Lupinus perennis* L. Lupine. Rare; Iowa City.

TRIFOLIUM (Tourn) L.

521. *Trifolium repens* L. White Clover. Common everywhere.
522. *Trifolium reflexum* L. Buffalo Clover. Scarce in woods and thickets.
523. *Trifolium procumbens* L. Low Hop Clover. Not uncommon in open places.
524. *Trifolium pratense* L. Red Clover. Common everywhere.
525. *Trifolium hybridum* L. Alsike Clover. Common.

MELILOTUS (Tourn) Hill.

526. *Melilotus officinalis* (L.) Lam. Yellow Sweet Clover. Plenty in waste places.

527. *Melilotus alba* Desr. White Sweet Clover. A common roadside weed.

MEDICAGO (Tourn) L.

528. *Medicago sativa* L. Alfalfa. Common as an escape along railways.

529. *Medicago lupulina* L. Black Medick. Locally plenty near Iowa City.

HOSACKIA Dougl.

530. *Hosackia americana* (Nutt.) Piper. Prairie Bird's-foot Trefoil. Not scarce in sandy soils.

PSORALEA L.

531. *Psoralea tenuiflora* Pursh. Few flowered Psoralea. Scarce in sandy soils.

532. *Psoralea argophylla* Pursh. Silvery Psoralea. Abundant in open places.

AMORPHA L.

533. *Amorpha canescens* Pursh. Lead Plant or Shoe Strings. Abundant in woods, especially in dry soils.

534. *Amorpha fruiticosa* L. False Indigo Bush. Abundant along streams.

DALEA Juss.

535. *Dalea alopecuroides* Willd. Pink Dalea. Locally abundant near Iowa City in sandy soil.

PETALOSTEMON Michx.

536. *Petalostemon purpureum* (Vent.) Rydb. Violet Prairie Clover. Abundant in open places.

537. *Petalostemon candidum* Michx. White Prairie Clover. Abundant in open places.

TEPHROSIA Pers.

538. *Tephrosia virginiana* (L.) Pers. Goat's Rue or Catgut. Scarce in sandy and open woods.

ROBINA L.

539. *Robinia pseudo-acacia* L. Common Locust or False Acacia. Cultivated and escaped.

ASTRAGALUS (Tourn) L.

540. *Astragalus caryocarpus* Ker. Ground Plum. Common in dry soils in open places.

541. *Astragalus canadensis* L. Canada Milk Vetch. Common in open places.

DESMODIUM Desv.

542. *Desmodium grandiflorum* (Walt.) DC. Pointed-leaved Tick Trefoil. Common in moist woods.

543. *Desmodium paniculatum* (L.) DC. Panicled Tick Trefoil. Rather scarce in woods and thickets.

544. *Desmodium bracteosum* Var. *longifolium* (T. & G.) Rob. Long-leaved Tick Trefoil. Not rare.

545. *Desmodium illinoense* Gray. Illinois Tick Trefoil. Common in open places.

546. *Desmodium dillenii* Darl. Dillen's Tick Trefoil. Common in open places.

547. *Desmodium canadensis* (L.) DC. Showy Tick Trefoil. Common in open woods and thickets.

LESPEDEZA Michx.

548. *Lespedeza repens* (L.) Bart. Creeping Bush Clover. Common in rocky wooded places.

549. *Lespedeza reticulata* Pers. Nodding Bush Clover. Local; State Quarries.

550. *Lespedeza hirta* (L.) Hornem. Hairy Bush Clover. Not uncommon in open woods and thickets.

551. *Lespedeza capitata* Michx. Round Headed Bush Clover. Very common in dry soils.

552. *Lespedeza leptostachya* Engelm. Prairie Bush Clover. Scarce in dry woods.

VICIA (Tourn) L.

553. *Vicia cracca* L. Cow Vetch or Blue Vetch. Sparingly as an escape in dry open places.

554. *Vicia carolina* Walt. Carolina Vetch. Very rare in moist woods; Oxford.

555. *Vicia americana* Muhl. American Vetch or Pea Vine. Common in moist places.

LATHYRUS (Tourn) L.

556. *Lathyrus palustris* L. Marsh Vetchling. Very common in moist soils.

557. *Lathyrus palustris* Var. *pilosus* (Cham.) Ledeb. Winged Marsh Vetchling. Locally plenty with above.

558. *Lathyrus palustris* Var. *myrtifolius* (Muhl.) Gray. Myrtle-leaved Marsh Vetchling. Common with above.

559. *Lathyrus ochroleucus* Hook. Cream Colored Vetchling. Rare in deep woods.

APIOS (Boerh) Lud.

560. *Apios tuberosa* Moench. Ground Nut. Common in bogs and marshes.

STROPHOSTYLES Ell.

561. *Strophostyles helvola* (L.) Britton. Trailing Wild Bean. Common in open places in sandy soil.

562. *Strophostyles pauciflora* (Britt) Wats. Small Wild Bean. Abundant in similar locations.

AMPHICARPA Ell.

563. *Amphicarpa monoica* (L.) Ell. Hog Peanut. Common in woods.

564. *Amphicarpa pitcheri* T. & G. Pitcher's Hog Peanut. Less common but not rare.

LINACEAE.

LINUM (Tourn) L.

565. *Linum sulcatum* Riddell. Grooved Yellow Flax. Common in dry soil in open places.

566. *Linum usitatissimum* L. Flax or Linseed. Common as an escape along railways.

OXALIDACEAE.

OXALIS L.

567. *Oxalis violacea* L. Violet Wood Sorrel. Common in woods and fields.

568. *Oxalis stricta* L. Upright Yellow Wood Sorrel. More abundant than the above, in dry or sandy soils.

569. *Oxalis corniculata* L. Tall Yellow Wood Sorrel. Common in fields and thickets.

GERANIACEAE.

GERANIUM (Tourn) L.

570. *Geranium maculatum* L. Wild Geranium. Common in woodlands, and as a weed in open places.

571. *Geranium carolinianum* L. Carolina Cranesbill. Much less common; occurs in sandy soils.

RUTACEAE.

ZANTHOXYLUM L.

572. *Zanthoxylum americanum* Mill. Prickly Ash. Common in woods and thickets.

POLYGALACEAE.

POLYGALA (Tourn) L.

573. *Polygala verticillata* L. Whorled Milkwort. Not uncommon in dry soils in open places.

574. *Polygala senega* L. Seneca Snakeroot. Common in woods and thickets.

575. *Polygala sanguinea* L. Field or Purple Milkwort. Common in moist meadows.

EUPHORBIACEAE.

CROTON L.

576. *Croton glandulosus* L. Var. *septentrionalis* Muell, Arg. Glandular Croton. Locally abundant in sandy places.

ACALYPHA L.

577. *Acalypha virginica* L. Three Seeded Mercury. Common in fields and wooded places.

EUPHORBIA L.

578. *Euphorbia polygonifolia* L.. Seaside Spurge. Not rare in sandy places.

579. *Euphorbia geyeri* Engelm. Geyer's Spurge. Common everywhere.

580. *Euphorbia serpens* H. B. K. Round-leaved Spreading Spurge. Scarce on moist banks.

581. *Euphorbia serpyllifolia* Pers. Thyme-leaved Spurge. In sandy fields.

582. *Euphorbia glyptosperma* Engelm. Ridge Seeded Spurge. Rare; Elmira.

583. *Euphorbia preslii* Guss. Upright Spotted Spurge. A common weed of sandy soils.

584. *Euphorbia hirsuta* (Torr) Weig. Hairy Spurge. With the above.

585. *Euphorbia maculata* L. Milk Purslane. Not uncommon in fields and gardens.

586. *Euphorbia hexagona* Nutt. Angled Spurge. Rare within our borders; Fremont Twp.

587. *Euphorbia marginata* Pursh. Snow-on-the-Mountain. Common as a wayside weed in dry places.

588. *Euphorbia corollata* L. Flowering Spurge. Abundant in open places.

589. *Euphorbia dentata* Michx. Toothed Spurge. Not scarce in sandy soil.

590. *Euphorbia heterophylla* L. Various-leaved Spurge or Fiddle Spurge. Common in woods, especially those of hilly clay soils.

591. *Euphorbia obtusata* Pursh. Blunt-leaved Spurge. Not common, in damp woods.

ANACARDIACEAE.

RHUS L.

592. *Rhus glabra* L. Smooth Sumach. Common in dry soils.

593. *Rhus toxicodendron* L. Poison Ivy or Poison Oak. Common in woodlands.

594. *Rhus toxicodendron* Var. *radicans* (L.) Torr. With the above.

CELASTRACEAE.

EVONYMUS (Tourn) L.

595. *Evonymus atropurpureus* Jacq. Burning Bush or Wahoo. Rare in rocky wooded places.

CELASTRUS L.

596. *Celastrus scandens* L. Climbing Bitter Sweet. Common in thickets and along fences.

STAPHYLACEAE.

STAPHYLEA L.

597. *Staphylea trifolia* L. Bladder Nut. Common in woods.

ACERACEAE.

ACER (Tourn) L.

598. *Acer saccharinum* L. White or Silver Maple. Common.
599. *Acer saccharum* Var. *nigrum* (Michx. f.) Britt. Rock or Sugar Maple. Not common in woods.
600. *Acer rubrum* L. Red or Swamp Maple. Scarce in low ground.
601. *Acer negundo* L. Box Elder. Common everywhere.

BALSAMINACEAE.

IMPATIENS (Rivinius) L.

602. *Impatiens pallida* Nutt. Pale Touch-me-not. Rather scarce in moist wooded places.
603. *Impatiens biflora* Walt. Spotted Touch-me-not. Abundant in springs and bogs.

RHAMNACEAE.

RHAMNUS (Tourn) L.

604. *Rhamnus lanceolata* Pursh. Buckthorn. Local; Turkey Creek.

CEANOTHUS L.

605. *Ceanothus americanus* L. New Jersey Tea. Common on dry hills.

VITACEAE.

PSEDERA Neck.

606. *Psedera quinquefolia* (L.) Greene. Virginia Creeper. Common in woodlands.

607. *Psedera vitacea* (Knerr) Greene. With the above.

VITIS (Tourn) L.

608. *Vitis cinerea* Engelm. Sweet or Downy Grape. Rare in woodlands.

609. *Vitis cordifolia* Michx. Frost Grape. Not common.

610. *Vitis vulpina* L. Riverside Grape. Common in woods.

TILIACEAE.

TILIA (Tourn) L.

611. *Tilia americana* L. Basswood. Common in woodlands.

MALVACEAE.

ABUTILON (Tourn) Mill.

612. *Abutilon theophrasti* Medic. Velvet Leaf. Common in waste places.

SIDA L.

613. *Sida spinosa* L. Prickly Sida. Not uncommon in sandy fields.

MALVA (Tourn) L.

614. *Malva rotundifolia* L. Cheeses, Dwarf Mallow. Very abundant everywhere, in yards and fields.

HIBISCUS L.

615. *Hibiscus militaris* Cav. Halberd-leaved Rose Mallow. Not rare in marshy places.

616. *Hibiscus trionum* L. Bladder Ketmia, Flower-of-an-Hour. Common in fields and roadsides.

HYPERICACEAE.

HYPERICUM (Tourn) L.

617. *Hypericum ascyron* L. Giant St. John's-wort. Plenty in open woods, in marshy spots.
618. *Hypericum punctatum* Lam. Spotted St. John's-wort. Scarce in damp woods.
619. *Hypericum cistifolium* Lam. Round Podded St. John's-wort. Common in open places, especially along streams.
620. *Hypericum mutilum* L. Dwarf St. John's-wort. Common in low or moist fields and woods.

CISTACEAE.

HELIANTHEMUM (Tourn) L.

621. *Helianthemum majus* BSP. Hoary Frostweed. Common on dry hills.

LECHIA (Kalm) L.

622. *Lechia stricta* Leggett. Bushy Pinweed. Common in dry soils in open places.
623. *Lechia tenuifolia* Michx. Narrow-leaved Pinweed. Not uncommon in similar places.

VIOLACEAE.

VIOLA (Tourn) L.

624. *Viola pedata* L. Bird's-foot Violet. Not common but occurring on sandy wooded hills.
625. *Viola pedata* Var. *linearilobi* DC. Scarce; found with the above.
626. *Viola cucullata* Ait. Hooded or Marsh Violet. Common in moist places.
627. *Viola papilionacea* Pursh. Meadow Violet. Common.
628. *Viola palmata* L. Early or Palmate Violet. Not uncommon in rich woodlands.
629. *Viola sororia* Willd. Wood Violet. Common in woods and fields.
630. *Viola fimbriatula* Sm. Ovate-leaved Violet. Locally abundant near Hills Siding.

631. *Viola sagittata* Ait. Arrow-leaved Violet. With the above but less common.

632. *Viola pedatifida* G. Don. Prairie Cut-leaved Violet. Common on dry soils in open places.

633. *Viola pubescens* Ait. Downy Yellow Violet. Abundant in moist woodlands.

LYTHRACEAE.

AMMANNIA (Houst) L.

634. *Ammannia coccinea* Rothb. Long-leaved Ammannia. Common in sandy soils.

LYTHRUM L.

635. *Lythrum alatum* Pursh. Wing-angled Loosestrife. Common in marshes.

MELASTOMACEAE.

RHEXIA L.

636. *Rhexia virginica* L. Meadow Beauty, Deer Grass. Rare; Oxford. In a marshy meadow.

ONAGRACEAE.

LUDVIGIA L.

637. *Ludvigia alternifolia* L. Seed Box or Rattle Box. Common in marshy places.

638. *Ludvigia polycarpa* Short & Peter. Many-fruited Ludvigia. Common in marshes.

639. *Ludvigia palustris* (L.) Ell. Water Purslane. Scarce and local; Oxford, Elmira.

EPILOBIUM L.

640. *Epilobium angustifolium* L. Great Willow-herb or Fireweed. Rather scarce in thin woods and along streams.

641. *Epilobium coloratum* Muhl. Purple-leaved Willow-herb. Common in marshy places.

OENOTHERA L.

642. *Oenothera biennis* L. Common Evening Primrose. Common in meadows and open places.

643. *Oenothera rhombipetala* Nutt. Rhombic Evening Primrose. Not rare in sandy soil.

644. *Oenothera laciniata* Hill. Sinuate-leaved Evening Primrose. Quite common in sandy soils.

645. *Oenothera pratensis* (Small) Rob. Sun Drops. Locally plenty near Iowa City.

646. *Oenothera serrulata* Nutt. Toothed-leaved Primrose. Common in dry open places.

GAURA L.

647. *Gaura parviflora* Dougl. Small Flowered Gaura. Not common.

CIRCAEA (Tourn) L.

648. *Circaea lutetiana* L. Enchanter's Nightshade. Common in moist woodlands.

649. *Circaea intermedia* Ehrh. Not uncommon with the above.

HALORAGIDACEAE.

MYRIOPHYLLUM (Vaill) L.

650. *Myriophyllum spicatum* L. Spiked Water Milfoil. Not rare in bogs and slow streams.

ARALIACEAE.

ARALIA (Tourn) L.

651. *Aralia racemosa* L. Spikenard. Not scarce in rich woodlands.

652. *Aralia nudicaulis* L. Wild Sarsaparilla. Abundant in rich woodlands.

653. *Aralia spinosa* L. Hercules Club. Very rare; several specimens in cultivation in Iowa City are authentically reported as having come from wild stock taken within Johnson County.

UMBELLIFERAE.

ERYNGIUM (Tourn) L.

654. *Eryngium yuccifolium* Michx. Button Snakeroot. Common in low open places.

SANICULA (Tourn) L.

655. *Sanicula marilandica* L. Black Snakeroot. Common in woods and thickets.
656. *Sanicula gregaria* Bick. Clustered Snakeroot. Not rare in woods and thickets.
657. *Sanicula canadensis* L. Canada Snakeroot. More scarce than the above.
658. *Sanicula trifoliata* Bickn. Large Fruited Snakeroot. Rare in rich woods; State Quarries.

CHAEROPHYLLUM (Tourn) L.

659. *Chaerophyllum procumbens* (L.) Crantz. Spreading Chervil. Rare in wet places.

OSMORRHIZA Raf.

660. *Osmorrhiza claytoni* (Michx.) Clarke. Woolly Sweet Cicely. Common in woods.
661. *Osmorrhiza longistylis* (Torr) DC. Smooth Sweet Cicely. Scarcer in woods.

CICUTA L.

662. *Cicuta maculata* L. Water Hemlock or Musquash Root. Rare in bogs and marshes.

CARUM L.

663. *Carum carvi* L. Caraway. Escaped and apparently thoroughly established.

SIUM (Tourn) L.

664. *Sium cicutaefolium* Schrank. Water Parsnip. Not uncommon in marshy places.

CRYPTOTAENIA DC.

665. *Cryptotaenia canadensis* (L.) DC. Honewort. Common in woodlands.

ZIZIA Koch.

666. *Zizia aurea* (L.) Koch. Golden Alexanders or Meadow Parsnip. Common in woods, fields and waste places.

TAENIDIA Drude.

667. *Taenidia intergerrima* (L.) Drude. Yellow Pimpernel. Common in dry woods.

THASPIUM Nutt.

668. *Thaspium barbinode* (Michx.) Nutt. Hairy-jointed Meadow Parsnip. Common in moist soils.

PASTINACA L.

669. *Pastinaca sativa* L. Wild Parsnip. Commonly established in old fields.

ANETHUM (Tourn) L.

670. *Anethum graveolens* L. Dill. Established and persistent at Iowa City.

HERACLEUM L.

671. *Heracleum lanatum* Michx. Cow Parsnip. Common in moist wooded places.

OXYPOLIS Raf.

672. *Oxypolis rigidior* (L.) Coult & Rose. Cowbane. Scarce in marshy places.

POLYTAENIA DC.

673. *Polytaenia nuttallii* DC. Polytaenia. Rare in dry open woods; Cedar Twp.

ANGELICA L.

674. *Angelica atropurpurea* L. Purple-stemmed Angelica. Scarce in swamps and marshes.

DAUCUS (Tourn) L.

675. *Daucus carota* L. Wild Carrot. Not scarce in fields.

CORNACEAE.

CORNUS (Tourn) L.

676. *Cornus circinata* L'Her. Round-leaved Dogwood. Not uncommon in rocky woods.

677. *Cornus amomum* Mill. Kinnikinnik. In wet places, especially along streams.

678. *Cornus asperifolia* Michx. Rough-leaved Dogwood. Scarce in sandy soil.

679. *Cornus stolonifera* Michx. Red Osier Dogwood. Common along streams.

680. *Cornus candidissima* Marsh. Panicled Dogwood. Common along streams.

681. *Cornus alternifolia* L. f. Alternate-leaved Dogwood. Scarce in woods and thickets.

ERICACEAE.

PYROLA (Tourn) L.

682. *Pyrola elliptica* Nutt. Shin Leaf. Scarce and local in rich woods.

MONOTROPA L.

683. *Monotropa uniflora* L. Corpse Plant or Indian Pipe. Not rare, sometimes abundant in rich woods.

PRIMULACEAE.

ANDROSACE (Tourn) L.

684. *Androsace occidentalis* Pursh. Androsace. Abundant along streams on sandy spots.

LYSIMACHIA (Tourn) L.

685. *Lysimachia quadrifolia* L. Crosswort. Common in marshy places.

686. *Lysimachia nummularia* L. Moneywort. Escaped and established at Iowa City.

STEIRONEMA Raf.

687. *Steironema ciliatum* (L.) Raf. Fringed Loosestrife. Common in meadows.

688. *Steironema lanceolatum* (Walt) Gray. Lance-leaved Loosestrife. Not rare in moist fields and meadows.

689. *Stieronema quadriflorum* (Sims) Hitchc. Prairie Moneywort. Abundant in moist places.

DODECATHEON L.

690. *Dodecatheon meadia* L. Shooting Star. Common in woods and thickets.

OLEACEAE.

FRAXINUS (Tourn) L.

691. *Fraxinus pennsylvanica* Var. *lanceolata* (Borkh) Sarg. Green Ash. Common in woods.

692. *Fraxinus americana* L. White Ash. Cultivated but very rare as native. This species has been several times reported as common in this as in many other counties of Iowa but is really one of our most rare trees. A few trees may be found near State Quarries and Turkey Creek.

GENTIANACEAE.

GENTIANA (Tourn) L.

693. *Gentiana crinita* Froel. Fringed Gentian. Rare in moist meadow; Fremont Twp.

694. *Gentiana puberula* Michx. Downy Gentian. Common in open places in dry soil.

695. *Gentiana andrewsii* Griseb. Closed Gentian. Abundant in marshes.

696. *Gentiana quinquefolia* L. Var. *occidentalis* (Gray) Hitchc. Stiff Gentian. Plenty in woods.

697. *Gentiana linearis* Froel. Narrow-leaved Gentian. Rare in bogs; State Quarries.

698. *Gentiana flavida* Gray. Yellowish Gentian. Not uncommon in open woods and thickets.

APOCYNACEAE.

APOCYNUM (Tourn) L.

699. *Apocynum androsaemifolium* L. Spreading Dogbane. Common in dry woods and thickets.

700. *Apocynum cannabinum* L. Indian Hemp. Common in dry open places.

ASCLEPIDACEAE.

ASCLEPIAS (Tourn) L.

701. *Asclepias tuberosa* L. Butterfly Weed. Common on prairies.
702. *Asclepias purpurasecns* L. Purple Milkweed. Rather scarce in dry places.
703. *Asclepias incarnata* L. Swamp Milkweed. Common in swamps and marshes.
704. *Asclepias syriaca* L. Common Milkweed. Common everywhere in open places.
705. *Asclepias sullivantii* Engelm. Sullivant's Milkweed. Much less common but not rare.
706. *Asclepias amplexicaulis* Sm. Blunt-leaved Milkweed. Locally abundant in sandy soils.
707. *Asclepias phytolaccoides* Pursh. Poke Milkweed. Rare in thickets; Turkey Creek.
708. *Asclepias ovalifolia* Dcne. Oval-leaved Milkweed. Not rare in woods and thickets.
709. *Asclepias verticillata* L. Whorled Milkweed. Rather scarce in dry soils.
710. *Asclepias stenophylla* Gray. Narrow-leaved Milkweed. Rather scarce in dry open places.

ACERATES Ell.

711. *Acerates viridiflora* Ell. Green Milkweed. Common in dry meadows.
712. *Acerates lanuginosa* (Nutt.) Dcne. Woolly Milkweed. Scarce in sandy fields.

CONVOLVULACEAE.

IPOMOEA L.

713. *Ipomoea coccinea* L. Small Red Morning Glory. Sparingly introduced in waste places.
714. *Ipomoea hederacea* Jacq. Ivy-leaved Morning Glory. Not uncommon in waste places.
715. *Ipomoea purpurea* (L.) Roth. Morning Glory. Common along streams and in waste places.

CONVOLVULUS (Tourn) L.

716. *Convolvulus sepium* L. Great Bindweed. Abundant in moist fields and along streams.

717. *Convolvulus arvensis* L. Small Bindweed. Sparingly introduced along railways; Tiffin.

CUSCUTA (Tourn) L.

718. *Cuscuta obtusiflora* HBK. Dodder. Common on Polygonaceae, etc.

719. *Cuscuta arvensis* Beyr. Field Dodder. Not common but occasional.

720. *Cuscuta cephalanthi* Engelm. Button Bush Dodder. Not uncommon; on tall Compositae.

721. *Cuscuta glomerata* Chois. Glomerate Dodder. Very distinct and conspicuous on tall Compositae.

POLEMONIACEAE.

PHLOX L.

722. *Phlox pilosa* L. Wild Phlox. Abundant in rich woodlands and meadows.

723. *Phlox divaricata* L. Sweet William or Wild Blue Phlox. Abundant in rich moist woodlands.

POLEMONIUM (Tourn) L.

724. *Polemonium reptans* L. Greek Valerian or Blue Bells. Common in rich moist woodlands.

HYDROPHYLLACEAE.

HYDROPHYLLUM (Tourn) L.

725. *Hydrophyllum virginicum* L. Virginia Waterleaf. Very common in woods.

726. *Hydrophyllum appendiculatum* Michx. Appendaged Waterleaf. Abundant in moist rich woodlands.

ELLISIA L.

727. *Ellisia nyctelea* L. Nyctelea. Abundant everywhere.

BORAGINACEAE.

CYNOGLOSSUM (Tourn) L.

728. *Cynoglossum officinale* L. Hound's Tongue. Scarce in waste places.

LAPPULA (Rivin) Moench.

729. *Lappula lappula* (L.) Karst. European Stickseed. Not rare in waste places.
730. *Lappula virginianum* (L.) Greene. Virginia Stickseed. Common in dry woods.
731. *Lappula deflexa* Var. *americana* (Gray) Greene. Nodding Stickseed. Scarce on limestone cliffs.
732. *Lappula redowskii* (Hornem) Greene Var. *occidentalis* (Wats) Rydb. Hairy Stickseed. Not rare.

MYOSOTIS (Rupp) L.

733. *Myosotis virginica* (L.) BSP. Spring Scorpion Grass. Common in sandy fields.

MERTENSIA Roth.

734. *Mertensia virginica* (L.) Link. Blue Bells or Virginia Cowslip. Common in moist rich woodlands.

LITHOSPERMUM (Tourn) L.

735. *Lithospermum canescens* (Michx.) Lehm. Hoary Puccoon. Common in dry open places.
736. *Lithospermum angustifolium* Michx. Narrow-leaved Puccoon. Common in sandy or gravelly soils.
737. *Lithospermum gmelini* (Michx.) Hitchc. Hairy Puccoon. Less common but not rare in dry open places.
738. *Lithospermum latifolium* Michx. American Gromwell. Scarce in dry open woods.

ONOSMODIUM Michx.

739. *Onosmodium carolinianum* (Lam.) Dec. Shaggy False Gromwell. Common in gravelly soils in open places.

VERBENACEAE.

VERBENA (Tourn) L.

740. *Verbena angustifolia* Michx. Narrow-leaved Vervain. Common in dry sandy fields.

741. *Verbena hastata* L. Blue Vervain. Abundant in fields.

742. *Verbena urticifolia* L. White or Nettle-leaved Vervain. Common in fields and roadsides.

743. *Verbena stricta* Vent. Hoary Vervain. Abundant in open places.

744. *Verbena bracteosa* Michx. Large Bracted Vervain. Abundant in sandy soil.

LIPPIA (Houst) L.

745. *Lippia lanceolata* Michx. Fog Fruit. Common in low marshy fields and bogs.

LABIATAE.

TEUCRIUM (Tourn) L.

746. *Teucrium canadense* L. American Germander. Common in bogs and marshes.

ISANTHUS Michx.

747. *Isanthus brachiatus* (L.) B. S. P. False Pennyroyal. Common in sandy fields.

SCUTELLARIA L.

748. *Scutellaria lateriflora* L. Mad Dog Skullcap. Common in marshy places.

749. *Scutellaria versicolor* Nutt. Heart-leaved Skullcap. Rather scarce in hilly and rocky woods.

750. *Scutellaria galericulata* L. Marsh Skullcap. Common in marshy places.

751. *Scutellaria parvula* Michx. Small Skullcap. Common in dry open places.

752. *Scutellaria campestris* Britt. Prairie Skullcap. Local in sandy open places.

AGASTACHE Clayt.

753. *Agastache nepetoides* (L.) Ktze. Catnip Giant Hyssop. Rather scarce in woods and thickets.

754. *Agastache scrophulariaefolia* (Willd.) Ktze. Figwort Giant Hyssop. Much more common in similar places.

NEPETA L.

755. *Nepeta cataria* L. Catnip. Common in waste places and sparingly in open woods.

756. *Nepeta hederacea* (L.) Trev. Ground Ivy or Gill-over-the-Ground. Common everywhere in waste places and yards.

PRUNELLA L.

757. *Prunella vulgaris* L. Self Heal. Common everywhere in woods and fields.

PHYSOSTEGIA Benth.

758. *Physostegia virginiana* (L.) Benth. False Dragon Head. Common in marshy places.

759. *Physostegia parviflora* Nutt. Western Lion's Heart. Scarce in similar places.

LEONURUS L.

760. *Leonurus cardiaca* L. Motherwort. Common in yards and waste places.

STACHYS (Tourn) L.

761. *Stachys ambigua* (Gray) Britt. Dense-flowered Hedge Nettle. Scarce in marshy places.

762. *Stachys palustris* L. Hedge Nettle. Abundant in wet soils everywhere.

763. *Stachys tenuifolia* Willd. Smooth Hedge Nettle. Rare in a bog at Hill's Siding.

MONARDA L.

764. *Monarda fistulosa* L. Wild Bergamot. Common in open places of dry soil.

765. *Monarda punctata* L. Horse Mint. Less common but not scarce in sandy soils.

BLEPHILA Raf.

766. *Blephila hirsuta* (Pursh.) Benth. Hairy Blephila. Rare in woodlands; State Quarries.

HEDEOMA Pers.

767. *Hedeoma pulegioides* (L.) Pers. American Pennyroyal. Common in dry soils.

768. *Hedeoma hispida* Pursh. Rough Pennyroyal. Abundant in dry soils.

PYCNANTHEMUM Michx.

769. *Pycnanthemum flexuosum* (Walt.) BSP. Narrow-leaved Mountain-mint. Common in marshy meadows.

770. *Pycnanthemum virginianum* (L.) Dur. & Jack. Virginia Mountain-mint. Abundant in fields and woods.

771. *Pycnanthemum pilosum* Nutt. Hairy Mountain-mint. Local on dry wooded hillsides.

772. *Pycnanthemum muticum* (Michx.) Pers. Short-toothed Mountain-mint. Not uncommon in dry woods.

LYCOPUS (Tourn) L.

773. *Lycopus virginicus* L. Purple Bugle Weed. Common in marshy places and wet soils.

774. *Lycopus uniflorus* Michx. Bugle Weed. Not rare on muddy banks.

775. *Lycopus americanus* Muhl. Cut-leaved Water Hoarhound. Common on banks of streams and marshes.

MENTHA (Tourn) L.

776. *Mentha spicata* L. Spearmint. Rarely established.

777. *Mentha citrata* Erhr. Bergamot Mint. Rare; Elmira.

778. *Mentha arvensis* L. Var. *canadensis* (L.) Briq. American Wild Mint. Abundant in moist places.

SOLANACEAE.

SOLANUM (Tourn) L.

779. *Solanum nigrum* L. Black Nightshade. In thickets and shaded waste places.

780. *Solanum carolinense* L. Horse Nettle. Abundant in sandy soil in open places.

781. *Solanum rostratum* Dunal. Beaked Nightshade or Buffalo-Bur. Rare; Iowa City.

PHYSALIS L.

782. *Physalis pruinosa* L. Tall Hairy Ground Cherry. Rather scarce in sandy fields.

783. *Physalis subglabrata* Mack. & Bush. Philadelphia Ground Cherry. Not uncommon in fields and thickets.

784. *Physalis virginiana* Mill. Virginia Ground Cherry. Dry gravelly soils; not uncommon.

785. *Physalis heterophylla* Nees. Clammy Ground Cherry. Common in sandy fields.

786. *Physalis lanceolata* Michx. Prairie Ground Cherry. Not uncommon in clay or sandy soils.

DATURA L.

787. *Datura stramonium* L. Stramonium or Jimson Weed. Not common but occurring in waste places.

788. *Datura tatula* L. Purple Thorn-apple or Purple Stramonium. Not common but occurring in waste places.

SCROPHULARIACEAE.

VERBASCUM (Tourn) L.

789. *Verbascum thapsus* L. Common Mullein. Common in fields and other areas of gravelly soils.

790. *Verbascum phlomoides* L. Clasping-leaved Mullein. Rare but established at Iowa City and Hill's Sidings.

791. *Verbascum blattaria* L. Moth Mullein. Not uncommon in waste places.

LINARIA (Tourn) Hill.

792. *Linaria vulgaris* Hill. Butter-and-eggs. Not rare in fields and waste places.

COLLINSIA Nutt.

793. *Collinsia verna* Nutt. Blue-eyed Mary. Scarce in marshy places.

SCROPHULARIA (Tourn) L.

794. *Scrophularia marilandica* L. Maryland Figwort. Not uncommon in fields, waste places and open woods.

795. *Scrophularia leporella* Bickn. Hare Figwort. Much more common; usually in open places.

PENTSTEMON (Mitchell) Ait.

796. *Pentstemon laevigatus* Ait. Var. *digitalis* (Sweet) Gray. Foxglove Beard-tongue. Common in dry soils.

CHELONE (Tourn) L.

797. *Chelone glabra* L. Turtle Head. Not rare but rather local in marshes.

MIMULUS L.

798. *Mimulus ringens* L. Monkey Flower. Very common in wet soils.

ILYSANTHES Raf.

799. *Ilysanthes dubia* (L.) Barnh. Long Stalked False-Pimpernel. Scarce in bogs and marshes.

GRATIOLA L.

800. *Gratiola virginiana* L. Clammy Hedge Hyssop. Scarce on muddy banks of streams and ponds.

VERONICA (Tourn) L.

801. *Veronica virginica* L. Culver's Root. Abundant in fields and open places.

802. *Veronica anagallis-aquatica* L. Water Speedwell. Common in wet soil.

803. *Veronica peregrina* L. Purslane Speedwell. Abundant in fields and waste places.

804. *Veronica arvensis* L. Corn or Wall Speedwell. Rare and local near Iowa City.

GERARDIA (Plumier) L.

805. *Gerardia paupercula* (Gray) Britt. Small-flowered Gerardia. Not uncommon on dry hills.

806. *Gerardia aspera* Dougl. Rough Purple Gerardia. Common in dry and gravelly soils.

807. *Gerardia tenuifolia* Vahl. Slender Gerardia. Common in open places of sandy soil.

808. *Gerardia auriculata* Michx. Auricled Gerardia. Not uncommon in moist meadows.

CASTILLEJA Mutis.

809. *Castilleja coccinea* (L.) Spreng. Scarlet Painted Cup. Not rare on wooded hillsides.

PEDICULARIS (Tourn) L.

810. *Pedicularis canadensis* L. Wood Betony or Lousewort. Abundant in fields and thickets.

811. *Pedicularis lanceolata* Michx. Swamp Lousewort. Common in swamps.

LENTIBULARIACEAE.

UTRICULARIA L.

812. *Utricularia vulgaris* L. Greater Bladderwort. Common in swamps and marshes.

OROBANCHACEAE.

OROBANCHE (Tourn) L.

813. *Orobanche uniflora* L. One-flowered Cancer-root. Rare in woodlands; Iowa City.

BIGNONIACEAE.

TECOMA Juss.

814. *Tecoma radicans* (L.) Juss. Trumpet Vine. Not uncommon in woods and thickets.

CATALPA Scop.

815. *Catalpa bignonioides* Walt. Catalpa or Indian Bean Tree. Cultivated.

ACANTHACEAE.

RUELLIA (Plumier) L.

816. *Ruellia ciliosa* Pursh. Hairy Ruellia. Abundant in dry soils, especially in thickets.

PHRYMACEAE.

PHRYMA L.

817. *Phryma leptostachya* L. Lopseed. Common in woodlands.

PLANTAGINACEAE.

PLANTAGO (Tourn) L.

818. *Plantago major* L. Common Plantain. Common everywhere.
819. *Plantago rugellii* Dcsne. Rugel's Plantain. With the above and nearly as common.
820. *Plantago lanceolata* L. Rib-grass. Not uncommon in yards and waste places.
821. *Plantago purshii* R. & S. Pursh's Plantain. Common in dry sandy soil.
822. *Plantago aristata* Michx. Large Bracted Plantain. Much less common but occasional in dry fields.

RUBIACEAE.

GALIUM L.

823. *Galium aparine* L. Cleavers or Goosegrass. Common in low thickets and waste places.
824. *Galium circaezans* Michx. Wild Liquorice. Not uncommon in rich woodlands.
825. *Galium boreale* L. Northern Bedstraw. Locally abundant on rocky banks.
826. *Galium concinnum* T. & G. Shining Bedstraw. Not uncommon on dry soils.
827. *Galium asprellum* Michx. Rough Bedstraw. Scarce in dry fields.

CEPHALANTHUS L.

829. *Cephalanthus occidentalis* L. Button Bush. Locally plenty along streams and shores.

HOUSTONIA L.

829. *Houstonia minima* Beck. Least Bluets. Plenty in scattered spots in sandy soil along streams.

CAPRIFOLIACEAE.

LONICERA L.

830. *Lonicera sullivantii* Gray. Sullivant's Honeysuckle. Rare in rocky wooded places; State Quarries.

831. *Lonicera glaucescens* Rydb. Douglas' Honeysuckle. Rather common in rich woods.

832. *Lonicera dioica* L. Glaucous Honeysuckle. Common in rich woods.

TRIOSTEUM L.

833. *Triosteum perfoliatum* L. Feverwort or Horse Gentian. Common in rich woodlands.

834. *Triosteum auriantiacum* Bick. Scarlet Fruited Feverwort. Less common and found in drier woods.

VIBURNUM (Tourn) L.

835. *Viburnum pubescens* (Ait.) Pursh. Downy-leaved Arrow-wood. Common in rocky wooded places.

836. *Viburnum molle* Michx. Soft-leaved Arrow-wood. Not uncommon in similar places.

837. *Viburnum lentago* L. Nanny-Berry. Common in woods and thickets.

838. *Viburnum prunifolium* L. Black Haw. Rather scarce in rich woodlands.

SAMBUCUS (Tourn) L.

839. *Sambucus canadensis* L. American Elder. Common in thickets and along streams.

CUCUBITACEAE.

SICYOS L.

840. *Sicyos angulatus* L. One-seeded Bur-Cucumber. Common in low thickets.

ECHINOCYSTIS T. & G.

841. *Echinocystis lobata* (Michx.) T. & G. Wild Cucumber, Wild Balsam Apple. Common in thickets and along streams.

CAMPANULACEAE.

SPECULARIA (Heist) Fab.

842. *Specularia perfoliata* (L.) A. DC. Venus' Looking Glass. Common in dry soil in open places.

CAMPANULA (Tourn) L.

843. *Campanula americana* L. Tall Bellflower. Abundant in rich woodlands.

844. *Campanula aparinoides* Pursh. Marsh or Bedstraw Bellflower. Not rare in marshy places.

845. *Campanula rotundifolia* L. Hare Bells or Blue Bells. Rather scarce but locally abundant in rocky places.

LOBELIACEAE.

LOBELIA (Plumier) L.

846. *Lobelia cardinalis* L. Cardinal Flower. Not abundant within our borders but found occasionally on muddy banks of streams and bogs.

847. *Lobelia siphilitica* L. Great Lobelia. Common in wet soil.

848. *Lobelia spicata* Lam. Pale Spiked Lobelia. Common in moist meadows.

849. *Lobelia leptostachys* A. DC. Spiked Lobelia. Not uncommon in meadows.

850. *Lobelia inflata* L. Indian Tobacco. Abundant in woodlands.

COMPOSITAE.

VERNONIA Schreb.

851. *Vernonia fasciculata* Michx. Western Iron Weed. Abundant in marshy meadows.

852. *Vernonia illinoensis* Gleason. Illinois Iron Weed. Not common but locally plenty in dry meadows near Riverside.

853. *Vernonia novaboracensis* Willd. New York Iron Weed. Rather common in moist meadows.

EUPATORIUM (Tourn) L.

854. *Eupatorium purpureum* L. Joe Pye Weed. Common in open woods and thickets.

855. *Eupatorium purpureum* Var. *maculatum* (L.) Darl. Spotted Joe Pye Weed. Common in swamps and marshes.

856. *Eupatorium altissimum* L. Tall Thoroughwort. Common in dry soils and on clay banks.

857. *Eupatorium perfoliatum* L. Thoroughwort or Boneset. Abundant in swamps and marshes.

858. *Eupatorium ageratoides* L. f. White Snakeroot. Abundant in rich woodlands.

KUHNIA L.

859. *Kuhnia eupatoroides* L. False Boneset. Very common in dry soils and upon clay banks.

LIATRIS Schreb.

860. *Liatris squarrosa* Willd. Scaly Blazing Star. Common in dry soils in open places.

861. *Liatris punctata* Hook. Dotted Button Snakeroot. Common in dry soils in open places.

862. *Liatris scariosa* Willd. Large Button Snakeroot. Common in dry open woods.

863. *Liatris pycnostachya* Michx. Prairie Button Snakeroot. Common in dry soils in open places.

864. *Liatris cylindracea* Michx. Cylindric Blazing Star. Scarce in high open woods; Curtis.

GRINDELIA Willd.

865. *Grindelia squarrosa* (Pursh) Dunal. Broad-leaved Gum Plant. Common in Muscatine County, but rather rare in Johnson County, occurring sparsely at Oxford.

SOLIDAGO L.

866. *Solidago flexicaulis* L. Zig-zag Goldenrod. Common in deep rich woods.

867. *Solidago hispida* Muhl. Hairy Goldenrod. Scarce in rocky wooded places as State Quarries, etc.

868. *Solidago speciosa* Nutt. Showy Goldenrod. Rather scarce in open places.

869. *Solidago speciosa* Var. *angustata* T & G. Slender Showy Goldenrod. Much more common in similar places.

870. *Solidago ulmifolia* Muhl. Elm-leaved Goldenrod. Common in rich woods.

871. *Solidago rugosa* Mill. Wrinkle-leaved Goldenrod. Scarce in open woods and thickets.

872. *Solidago missouriensis* Nutt. Missouri Goldenrod. Very common in sandy soils and open places.

873. *Solidago nemoralis* Ait. Gray Goldenrod. Common on dry unwooded hills.

874. *Solidago mollis* Bartl. Velvety Goldenrod. Scarcer with the above. Intermediate forms appear.

875. *Solidago canadensis* L. Canada Goldenrod. Common in thickets and open places everywhere.

876. *Solidago canadensis* Var. *gilvocanescens* Rydb. Yellowish Canada Goldenrod. With the above.

877. *Solidago serotina* Ait. Late or Saw-toothed Goldenrod. Common in woods and thickets.

878. *Solidago rigida* L. Stiff Goldenrod. Abundant in dry soil and open places.

879. *Solidago riddelli* Frank. Riddell's Goldenrod. Rare in moist meadows; Oxford.

880. *Solidago graminifolia* (L.) Salisb. Bushy Goldenrod. Common in moist open places.

BOLTONIA L'Her.

881. *Boltonia asteroides* (L.) L'Her. Aster-like Boltonia. Common in marshy places.

ASTER (Tourn) L.

882. *Aster oblongifolius* Nutt. Aromatic Aster. Common in dry open places.

883. *Aster novae-angliae* L. New England Aster. Abundant in moist soil.

884. *Aster novae angliae* Var. *roseus* (Desf.) DC. Rosy New England Aster. Rare with the above; Tiffin.

885. *Aster sericeus* Vent. Silky Aster. Common in dry soils in open places.

886. *Aster anomalus* Engelm. Many-rayed Aster. Rare in rocky wooded places; Turkey Creek.

887. *Aster azureus* Lindl. Sky-blue Aster. Common in open woods and thickets, also in open places.

888. *Aster shortii* Lindl. Short's Aster. Rather scarce on wooded hills.

889. *Aster cordifolius* L. Heart-leaved Aster. Common in woodlands.

890. *Aster drummondii* Lindl. Drummond's Aster. Very common with the above.

891. *Aster laevis* L. Smooth Aster. Very abundant in moist soils.

892. *Aster laevis* Var. *amplifolius* Porter. Large-leaved Smooth Aster. Not uncommon with the above.

893. *Aster ericoides* L. White Heath Aster. Common in dry open places.

894. *Aster depauperatus* (Port) Fern. Var. *parviceps* (Burg) Fern. Depauperate Aster. More common in dry soil.

895. *Aster amethystinus* Nutt. Amethyst Aster. Rather scarce in dry open places; Elmira.

896. *Aster multiflorus* Ait. Dense Flowered Aster or Frost Weed. Abundant in open places and even in thickets.

897. *Aster lateriflorus* (L.) Britt. Starved Aster. Rather scarce in moist places.

898. *Aster lateriflorus* Var. *thrysoideus* (Gray) Sheld. Calico Aster. More common in similar places.

899. *Aster tradescanti* L. Michaelmas Daisy. Abundant in fields and thickets.

900. *Aster paniculatus* Lam. Tall White or Panicled Aster. Very common in moist soils.

901. *Aster paniculatus* Var. *simplex* (Willd.) Burgess. Common with the above.

902. *Aster salicifolius* Ait. Willow Aster. Common in fields and open places.

903. *Aster salicifolius* Var. *subasper* (Lindl.) Gray. Rough Willow Aster. Scarce in dry soil in open places.

904. *Aster junceus* Ait. Rush Aster. Locally plenty at Oxford in marshy meadows.

905. *Aster longifolius* Lam. Long-leaved Aster. Not uncommon in fields and open places.

906. *Aster puniceus* L. Purple-stemmed Aster. Not uncommon in low wet thickets.

907. *Aster umbellatus* Mill. Tall Flat-Topped White Aster. Common in bogs and marshes.

ERIGERON L.

908. *Erigeron pulchellus* Michx. Robin's Plantain. Common in rich woodlands.

909. *Erigeron philadelphicus* L. Philadelphia Fleabane. Common in low woods, thickets and open places.

910. *Erigeron annuus* (L.) Pers. Daisy Fleabane. A common weed in open places.

911. *Erigeron ramosus* (Walt) BSP. Fleabane. Common in fields and open places.

912. *Erigeron canadensis* L. Horse Weed. Abundant in waste places everywhere.

913. *Erigeron divaricatus* Michx. Low Horse Weed. Rather scarce in open woods and thickets.

ANTENNARIA Gaertn.

914. *Antennaria plantaginifolia* (L.) Rich. Mouse-ear Everlasting. Abundant in dry woods and thickets.

915. *Antennaria campestris* Rydb. Prairie Cat's Foot. Not uncommon on dry hillsides.

916. *Antennaria neglecta* Greene. Field Cat's Foot. Dry fields, woods and thickets.

ANAPHALIS DC.

917. *Anaphalis margaritacea* (L.) B. & H. Pearly Everlasting. A common weed in thickets and open woods.

INULA L.

918. *Inula helenium* L. Elecampane or Horseheal. Rare along railway track; Oxford.

SILPHIUM L.

919. *Silphium laciniatum* L. Compass Plant. Common in fields and meadows.

920. *Silphium trifoliatum* L. Whorled Rosin Weed. Not uncommon in dry open places.

921. *Silphium integrifolium* Michx. Entire-leaved Rosin Weed. Common in dry open places.

922. *Silphium perfoliatum* L. Cup-Plant or Indian Cup. Abundant in fields and meadows.

PARTHENIUM L.

923. *Parthenium integrifolium* L. American Fever-Few. Scarce and local; Riverside and Elmira.

IVA L.

924. *Iva xanthifolia* Nutt. Bur-weed Marsh Elder. A common weed, especially along streams.

AMBROSIA (Tourn) L.

925. *Ambrosia trifida* L. Bitter-weed or King Head. A common weed of waste places.

926. *Ambrosia trifida* Var. *integrifolia* (Muhl.) T. & G. With the above but less common.

927. *Ambrosia artemisiifolia* L. Ragweed. An abundant weed of fields and roadsides.

928. *Ambrosia psilostachya* DC. Western Ragweed. Also abundant but more common in dry soils.

XANTHIUM (Tourn) L.

929. *Xanthium canadense* Mill. American Cocklebur. A common weed in waste places and along streams.

HELIOPSIS Pers.

930. *Heliopsis scabra* Dunal. Rough Ox-eye. A common weed of fields and roadsides.

ECLIPTA L.

931. *Eclipta alba* (L.) Hassk. Mud Daisy. Common along streams; introduced put persisent.

RUDBECKIA L.

932. *Rudbeckia triloba* L. Thin-leaved Cone Flower. Very common in moist wooded places.

933. *Rudbeckia subtomentosa* Pursh. Sweet Cone Flower. Common in moist fields and meadows.

934. *Rudbeckia hirta* L. Black Eyed Susan. Very abundant in fields, roadsides and meadows.

935. *Rudbeckia laciniata* L. Tall or Green Headed Cone Flower. Common in moist wooded places.

BRAUNERIA Neck.

936. *Brauneria angustifolia* (DC.) Heller. Narrow-leaved Purple Cone-Flower. Common in dry soils in open places.

937. *Brauneria pallida* (Nutt) Britt. Pale Purple Cone-Flower. Common in similar places.

LEPACHYS Raf.

938. *Lepachys pinnata* (Vent) T. & G. Gray Headed Cone-Flower. Very common, dry soil in open places.

939. *Lepachys columnaris* (Sims) T. & G. Longheaded or Prairie Cone-Flower. Local but well established; Iowa City.

940. *Lepachys columnaris* Var. *pulcherrima* T. & G. With the above.

HELIANTHUS L.

941. *Helianthus annuua* L. Common Sunflower. Plenty in waste places.

942. *Helianthus petiolaris* Nutt. Prairie Sunflower. Common in open places.

943. *Helianthus scaberrimus* Ell. Stiff Sunflower. Common in dry fields and meadows.

944. *Helianthus occidentalis* Riddell. Few-leaved Sunflower. Common in open sandy woods.

945. *Helianthus mollis* Lam. Hairy Sunflower. Rare in dry wooded places; Mid River Park.

946. *Helianthus tracheliifolius* Mill. Throatwort Sunflower. Rare in wooded and rocky places; State Quarry.

947. *Helianthus maximiliani* Schrad. Maximilian's Sunflower. Abundant in dry fields and clay banks.

948. *Helianthus grosse-serratus* Maertens. Saw-tooth Sunflower. Common in dry fields.

949. *Helianthus decapetalus* L. Thin-leaved Sunflower. Moist wooded places—rather common.

950. *Helianthus tuberosus* L. Jerusalem Artichoke. Not uncommon in moist soil.

ACTINOMERIS Nutt.

951. *Actinomeris alternifolia* (L.) DC. Actinomeris. Rare in fields, probably introduced; Tiffin.

COREOPSIS L.

952. *Coreopsis palmata* Nutt. Stiff Tickseed. Common in fields and meadows.

953. *Coreopsis tripteris* L. Tall Tickseed. Common in moist fields and open places.

BIDENS L.

954. *Bidens frondosa* L. Black Beggar Ticks. Common in moist soils.

955. *Bidens vulgata* Greene. Beggar Ticks or Stick Tight. More abundant than the preceding in similar soils.

956. *Bidens comosa* (Gray) Wieg. Leafy Bracted Tickseed. Common in sandy soils especially along streams.

957. *Bidens cernua* L. Nodding Bur Marigold. Common on muddy shores of streams and ponds.

958. *Bidens involucrata* (Nutt) Britt. Long Bracted Sunflower Tickseed. Rare in swampy places. Hills Siding.

HELENIUM L.

959. *Helenium autumnale* L. Sneezeweed. Abundant in moist fields and meadows.

DYSSODIA Cav.

960. *Dyssodia papposa* (Vent) Hitchc. Foetid Marigold. Locally plenty in moist open places.

ACHILLEA (Vail) L.

961. *Achillea lanulosa* Nutt. Western Yarrow. Common in fields and open places. This has commonly been listed as the following species.

962. *Achillea millefolium* L. Yarrow or Milfoil. Relatively scarce in fields and open places.

ANTHEMIS (Mich) L.

963. *Anthemis cotula* L. Dog-fennel or Foetid Camomile. A roadside weed, formerly very abundant but recently rather scarce.

CHRYSANTHEMUM (Tourn) L.

964. *Chrysanthemum leucanthemum* L. Var. *pinnatifidum* Lecoq & Lamotte. Ox-eye Daisy. Scarce in fields and along railways; introduced.

TANACETUM M.

965. *Tanacetum vulgare* L. Common Tansy. Not rare in fields and waste places.

ARTEMISIA L.

966. *Artemisia canadensis* Michx. Canada Wormwood. Common in yards and waste places.

967. *Artemisia dracunculoides* Pursh. Linear-leaved Wormwood. Common in dry open places.

968. *Artemisia serrata* Nutt. Saw-leaf Mugwort. Not uncommon in fields and open woods.

969. *Artemisia ludoviciana* Nutt. Lobed Cud-weed. Common in dry fields.

ERICHTITES Raf.

970. *Erechtites hieracifolia* (L.) Raf. Fire-weed. Common in thickets and clearings.

CACALIA L.

971. *Cacalia tuberosa* Nutt. Tuberous Indian Plantain. Abundant in wet meadows and bogs.

972. *Cacalia atriplicifolia* L. Pale Indian Plantain. Not uncommon in rich woods and occasional in moist open meadows.

973. *Cacalia reniformis* Muhl. Great Indian Plantain. Rare in deep woodlands; State Quarries.

SENECIO (Tourn) L.

974. *Senecio balsamitae* Muhl. Balsam Groundsel. Common in moist meadows and bogs.

975. *Senecio aureus* L. Golden Ragwort. With the above but less common.

976. *Senecio plattensis* Nutt. Prairie Ragwort. Common in dry sandy soils.

ARCTIUM L.

977. *Arctium lappa* L. Great Burdock. Rather scarce in waste places.

978. *Arctium minus* Bernh. Common Burdock. Much more common in similar places.

CIRSIUM (Tourn) Hill.

979. *Cirsium lanceolatum* (L.) Hill. Common Bur Thistle. Common in fields and waste places.

980. *Cirsium discolor* (Muhl.) Spreng. Field Thistle. Common in fields and meadows.

981. *Cirsium altissimum* (L.) Spreng. Tall or Roadside Thistle. Common in fields, woods and thickets.

982. *Cirsium iowense* (Pam.) Fern. Iowa Thistle. Not common in fields.

983. *Cirsium hillii* (Canby) Fern. Hill's Thistle. Scarce in dry sandy fields near Hills Siding.

984. *Cirsium arvense* (L.) Scop. Canada Thistle. Scarce along railways and in fields.

CICHORIUM (Tourn) L.

985. *Cichorium intybus* L. Chicory or Wild Succory. Scarce in fields and along railways.

KRIGIA Schreb.

986. *Krigia virginica* (L.) Willd. Cynthia or Virginia Goats-Beard. Common in rich woodlands.

TRAGOPOGON (Tourn) L.

987. *Tragopogon porrifolius* L. Oyster Plant or Purple Goats-Beard. Sparingly escaped from cultivation.

988. *Tragopogon pratensis* L. Meadow Salsify. Locally plenty near Iowa City.

TARAXACUM (Haller) Lud.

989. *Taraxacum officinale* Web. Dandelion. A common weed everywhere.

990. *Taraxacum erythrospermum* Andrz. Red Seeded Dandelion. Less common and in drier soils.

SONCHUS (Tourn) L.

991. *Sonchus arvensis* L. Corn Sow Thistle. An introduced weed not uncommon in waste places.

992. *Sonchus oleraceus* L. Annual Sow Thistle. Also common as a weed of waste places.

993. *Sonchus asper* (L.) Hill. Spiny Sow Thistle. Common along railways, clay banks, etc.

LACTUCA (Tourn) L.

994. *Lactuca scariola* L. Prickly Wild Lettuce.

995. *Lactuca scariola* Var. *integrata* Gren. & Godr.

996. *Lactuca canadensis* L. Tall Wild Lettuce. This with the above are common as introduced weeds in fields and waste places.

997. *Lactuca ludoviciana* (Nutt) Riddell. Western Wild Lettuce.

998. *Lactuca floridana* (L.) Gaertn. False or Florida Lettuce.

999. *Lactuca villosa* Jacq. Hairy Veined Blue Lettuce. This species and the two preceding are common in thickets and low wooded places.

1000. *Lactuca spicata* (Lam.) Hitchc. Tall Blue Lettuce. Occasional in low fields.

AGOSERIS Raf.

1001. *Agoseris cuspidata* (Pursh) Steud. Cuspidate False Calais. Not uncommon on dry hillsides.

PRENANTHES (Vaill) L.

1002. *Prenanthes aspera* Michx. Rough White Wild Lettuce. Common in low meadows.

1003. *Prenanthes alba* L. White Wild Lettuce. Common in woods and thickets.

1004. *Prenanthes racemosa* Michx. Glaucous White Wild Lettuce. Not uncommon in moist fields and meadows.

HIERACIUM (Tourn) L.

1005. *Hieracium canadensis* Michx. Canada Hawkweed. Rather scarce in clearings, etc., in dry woods.

SEDGES OF HENRY COUNTY.

BY JOHN THEODORE BUCHHOLZ.

Henry County lies in the southeastern part of Iowa, in one of the most fertile sections of the state. It has an area of 432 square miles or rather open prairie, except the borders of the streams, which were originally fringed with native forests.

The Skunk River with its tributaries drains the whole county. It enters the county near the northwest corner, a few miles south of Wayland. Thence, it wends its way southward mostly on the other side of the border line to within a few miles north of Rome, where it resumes its southeasterly course. After making a bend toward the northeast, it deviates little from its general diagonal course through the south half of the county. In the upper part of this section of its course, it flows through an old pre-glacial valley which it abandons a short distance south of Rome. From this place, to the point at which it leaves the county, it occupies a newer, narrower and less eroded valley.

This newer part of the valley near Oakland Mills and east along the river bottom contains many lowlands both open and wooded, which were visited at different times. Many of the swamp and lowland species of the sedges are found here.

Big Cedar Creek is the largest tributary to the Skunk River within the limits of the county. It enters near the southwest corner of Salem township, and after making a few turns, enters the "Grand Valley." Here it receives the waters of the Little Cedar Creek and flows meanderingly northward until it joins the Skunk River near Rome.

Big Creek is the second largest tributary. It drains the open prairies of the north central part of the county. It arises just beyond the borders of Canaan township, flows westward until within a few miles northwest of Mt. Pleasant, when it turns south, and a little later, southeast. Here it flows parallel to the Skunk River about ten miles, joining the latter three miles west of Lowell. The headwaters of Big Creek are within ten miles of its mouth, and yet this winding stream has a length of more than seventy miles. Big Creek is a comparatively new stream. Its channel has been carved since the Kansan drift spread over this area.

This valley and the territory enclosed by this stream received most attention in the work. All but a few species found elsewhere in the county were duplicated within its drainage system. On account of its meandering course its current is slow and its bottom lands are rich in alluvium. All along its course it offers many bogs and swales, or low rich ground so favorable to sedges.

Crooked Creek drains the country around Winfield, and numerous other small streams all pay tribute to the Skunk River system.

Two distinct topographical areas are recognized in the county. The first consists of an undulating prairie, moderately well drained and occupying the north and northeastern portion of the county. This region belongs mostly to the Kansan drift plain, but it is not well eroded, due to its distance from any stream of considerable size. Rounded ridges of irregular hills mark the marginal moraine of the Illinoisan drift sheet in the eastern part of the county. These hills extend northward from Baltimore to New London townships and may be seen from Canaan. They pass out of the county in a northeasternly direction. Further south, in Baltimore township, they are crossed by the Skunk River and lost in the eroded surface.

The second distinct topographical area is represented by the southern and western portion of the county and is well eroded. The topography here has been impressed upon it largely by the Skunk River and its dendritic branches. These streams have intersected the region in all directions, cutting their channels entirely through the drift into the underlying rock. This gives us here a very rugged country, a diversified landscape of hills, upland, and valley.

The central portion of the county lies between these two topographical areas and combines the characters of both. Beginning a few miles north of Mt. Pleasant, as one goes south, the topography of these two areas gradually blends from the prairie upland type to the rugged hills and bluffs of the Skunk River. Thus it is possible that this area which was most extensively studied is quite representative of the whole county in its floral conditions.

Big Creek and its valley, the Skunk River south of Mt. Pleasant, and the intervening prairies receive considerable attention. This area affords a variety of conditions. The prairies north offer many bogs and swales; the low bottom lands of the Skunk River and Big Creek with their timber, offer swamps and marshes in alluvial soil, and the forested hillsides and open prairies bordering these streams, offer a great variety of conditions, all within a rather small area.

As has already been noted, the greater part of the surface deposits are of Kansan drift origin. This is a bluish clay where it is exposed in a thick bed, and contains numerous small boulders. However, where it is exposed along streams or roadsides it is usually of a red or reddish brown color, due to oxidation. All this drift sheet is covered by a thin mantle of loess, except where eroded and removed by streams.

The valleys of the Skunk River and the Big Cedar Creek are broad, averaging about one mile in width in this county. Most of the surface of this flood plain has received a rich alluvium deposit of sand and finer soil particles. Big Creek also flows through a rich alluvial plain in the lower part of its course. The soils of the prairies are dark colored and vey rich in humus.

The genus Carex is the largest of the sedge family (Cyperaceae) comprising probably more than two-thirds of the species. They are a very difficult group because the unisexual, monoecious or dioeceous flowers offer so little variation; hence the specific characters are founded on the mature fruit, the character and inflorescence of the spikes, on the size and shape of the achene, on the scales, and on the character and width of the leaves. These differences are often so slight and indefinite and the characters so variable, that they make the determination of species exceedingly uncertain. The mature fruit and the whole plant is necessary for accuracy in identification. Almost all the common species are sufficiently matured for study about the middle of June.

The sedges are for the most part plants of marshes, although there are some notable exceptions. They form an important part of the vegetation in bogs and swales, and are of some economic importance on account of the good pasturage they afford. Those found in the uplands and meadows are fewer, rather scattered and inconspicuous. Likewise those in the woods are usually not in colonies but more or less scattered.

Among the grasses we find many introduced species of plants which thrive well in their new habitat, but among the sedges this is very rare, none being reported thus far from Iowa. The reason is very evident.—Most grasses grow under conditions very much like our cultivated plants and are easily distributed with seeds of all kinds. The sedges, on the other hand, are mostly hydrophytic, or inhabitants of woods and lowlands that are not cultivated. The xerophytic species are easily destroyed by cultivation, as nearly all the sedges are perennial by rootstocks.

Distribution of seeds is accomplished by various means, but it might be said at the outset that the plants are usually not highly specialized in this respect: Some have inflated perigynia which enable them to float, and they are thus carried by streams and by the action of waves for long distances. Other water or swamp inhabitants have no specialized structure for seed dispersal, but are doubtless carried over great distances in the mud which adheres to the feet of migratory water fowls and other animals. Some of the sedges are able to pass through the alimentary canal of herbiverous animals, being protected by their thick walled, closed achene, and are probably distributed in this way. This possibly throws some light on the reason for the scattered and sparse distribution of many of the xerophytic forms of our meadows. For this reason and the fact that they are perennial, they need no highly specialized means for seed dispersal; in fact, often the simpler the achene the better.

The collections for the studies were made mostly during June, 1908.

At this time about 150 specimens were collected, and from them 32 species identified. The specimens were compared with those of the herbarium at the State University of Iowa and the determinations confirmed, reference being also made to the herbarium at Ames.

The writer feels that this list, while it possibly includes quite as many as may be collected at any one time, is necessarily incomplete. Among the sedges many species flower only under favorable conditions. Thus a complete carex flora may not be observed in any one season.

Family-Cyperaceae J. St. Hil.

Grass like or rush like herbs. Stems (culms) triangular, solid (rarely hollow), quadrangular, terete or flattened, and rather slender. Roots fibrous and many species perennial by long rootstocks. Leaves narrow, with closed sheathes. Flowers perfect or imperfect, arranged in spikelets, one (rarely 2) in the axil of each scale, glume or bract, the spikelets solitary or clustered, 1-many-flowered. Scales two ranked or spirally imbricated, persistent or deciduous. Perianth hypogynous, composed of bristles, or inferior scales, rarely calyx-like, or entirely wanting. Stamens 1-3, rarely more. Filaments slender or filiform. Anthers two-celled. Ovule one, anatropous, erect, in the one-celled ovary. Style 2-3 cleft or rarely simple or minutely 2-toothed. Fruit a lenticular plano-convex, or trigonous achene. Endosperm mealy, embryo minute.

About 65 genera and 3,000 species of wide geographic distribution.

Genus *Carex* L. Sp. Pl. 972 (1753).

Grass like Cyperaceae, perennial by rootstocks. Culms mostly 3-angled. Leaves 3-ranked, the upper elongated, or very short (bracts) and subtending the spikes of flowers, or wanting. Flowers monoecious or dieocious, solitary in the axils of bracts (scales), Spikes either wholly pistillate, wholly staminate, or bearing both staminate or pistillate flowers (androgynous). Perianth none. Staminate flowers of three stamens, the filaments filiform. Pistillate flowers of a single pistil with a style and 2 or 3 stigmas, borne on a very short axis in the axil of a sac-like bractlet or second bract called the perigynium (utricle), which completely encloses the achene.

A vast genus of more than 1,000 widely distributed species, mostly in the temperate zone.

(The classical Latin name of obscure signification; probably derived from the Greek Keiro, to cut, on account of the sharp leaves of many of the species).

1—*Carex Asa-Grayi* Bailey, Gray's sedge.

Br. Illus. Flora, i, 293, fig. 576; Gray's Man., 6th ed, 592; Arthur, Cont. Fl. Ia. iii; Hitchcock, Pl. Ames, 524; Cratty, Ia. Sedges, 335; "Brendel, Fl, Peoriana, 63."

C. Grayi Carey, Sill. Jour., 2nd ser., iv, 22 (1847), not C. grayana Dew. (1824); Gray's Man. 7th ed., 253.

Infrequent, swamps and marshes, along Skunk river south of Mt. Pleasant. June 17, '08.

2—*Carex lupulina* Muhl., Hop sedge.

"Schk. Riedg., ii, 54 (1906);" Br. Illus. Flor, i, 294, Fig. 678; Arthur, Fl. Iowa, 34; Hitchcock, Pl. Ames, 524; MacMillan, Metas. Minn. Val., 129; Tracy, Fl. Mo., 93; Bot. Surv. Nebr., iv, 45; Fink, Iowa Acad. Sci., iv, 105; Cratty, Iowa Sedges, 336; Shimek, Ia. Geol. Surv., xvi, 169; "Brendel, Fl. Peoriana, 63.

Frequent in swampy ground. Along Skunk river and Big creek in very swampy places. June 16-18, '09.

3—*Carex comosa* Boott. Bristly sedge.

Br. Illus. Fl. i, 301, f. 698; Gray's Man. 6th ed., 596; 7th ed. 251; Arthur, Cont. Fl. Ia., v; MacMillan, Metas, Minn. Val., 126; Bot. Surv. Neb. iii, 16; Cratty, Ia., Sedges, 338.

"C. pseudo-cyperus var. comosa Boott. Bot. Cal. ii, 252 (1880). C. pseudo-cyperus var. americana Hochst., Herb. Unio. Itin. (1837).

Probably very rare. A small specimen was found with the collection some time afterward, thus its habitat is not noted. Probably along swamps and ponds in low ground. June, 1908.

4—*Carex squarrosa* L., Squarrose sedge.

L. SP. Pl. ii, 937 (1753); Br. Illus. Fl. 301, f. 700; Gray's Man. 6th ed. 597, 7th ed, 250; Arthur, Cont Fl. Ia., iii, MacMillan Metas. Minn. Val., 126; Tracy Fl. Mo., 94; Webber, App. Fl. Neb. 23; Cratty, Iowa Sedges, 338.

Frequent, in low open ground. Found in swales along creeks north of Mt. Pleasant, and along river bottoms south. June 16-18, '08.

4—*Carex typhinoides* Schwein. Cat-tail sedge.

Br. Illus. Flora. i, 302, f. 701; Gray's Man. 7th ed, 250, f. 531; Cratty, Ia. Sedges, 339; "Ann. Lyc. i, 66 (1824).

C. squarrosa Gray's Man. 6th ed., 596 (1890) in part; C. squarrosa var. typhinoides Dewey, Am. Jour. Sci., x, 316 (1826).

Rare, in a swale north of Skunk river along railway tracks. Not typical. Leaves generally less than typical (in width), bracts very short and narrow only a little longer than the culm. Spikes narrower, about 3-4 inch wide. Staminate point of spikes wanting. Many of the scales are awned, probably all.

6—*Carex aristata R. Br.*

Rich. Bot. App., 751 (1823); Br. Illus. Flora, 302, f. 703; Gray's Man. 6th ed., 598; Hitchcock, Pl. Ames 594, and Bull. Torr. Bot. Club., xvi, 70; MacMillan, Metas. Minn. Valley, 124; Tracy, Fl. Mo. 92; Cratty, Iowa Sedges, 340

C. Trichocarpa var aristata Bailey, Bot. Gaz., x 293 (1885); Gray's Man. 7th ed. 250. Quite rare, June 30, 1908.

7—*Carex Shortiana* Dewey. Short's sedge.

Dewey Am. Jour. Sci., xxx 60 (1836); Br. Illus. Flor, i, 303; Gray's Man. 6th ed., 596, 7th ed. 234; Tracy Fl. Mo., 94; Webber, Fl. Neb., 98; Cratty, Iowa Sedges, 340; Bessey, Cat. Fl. Neb., 939.

Frequent in open seepy ground. Leaves 5 inches long. Very conspicuous plants, the abundant spikes giving the vegetation a brown coloring. South of Mt. Pleasant along roadside. June 17, 1908.

8—*Carex lanuginosa* Michx. Woolly sedge.

Fl. N. A. ii, 175 (1803) ; Br. Illus. Flora, i, 305, f. 711; Gray's Man. 6th ed. 597., 7th ed. 428; Arthur, Flora Ia. 34; Hitchcock, Pl. Ames, 527; MacMillan Metas. Minn. Val., 125; Bessey, Cont. Fl. Iowa, 124; Cratty, Iowa Sedges, 341.

C. filiformis var. latifolia Boeckl. Linn., xli, 309 (1805).

C. filiformis var. lanuginosa B.S.P. Prelim. Cat. N. Y. 63 (188).

Meadows and swales, not common. June 16, 1908.

9—*Carex stricta* Lam. Tussock sedge.

Encyc. Meth., iii, 378 (1789) ; Br. Illus. Fl. i, 308, f. 719; Gray's Man. 6th ed., 599. 7th ed., 321; Arthur, Fl. Iowa, 34; Hitchcock, Pl. Ames, 524; MacMillan Metas. Minn. Val., 123; Tracy, Fl. Mo. 95; Bessey, Cont. Fl. Iowa, 123; "Wheeler Fl. Milwaukee Co. Wis., 187; Fink, Ia., Acad. Sci., iv, 105; Cratty, Iowa Sedges, 342; Shimek, Ia. Geol. Surv., xvi, 169.

Common in marshy ground. June 5, 1908.

10—*Carex Davisii* Schwein & Torr. Davis' sedge.

"Mon. Car., 326 (1825) ;" Br. Illus. Fl. i, 318, f, 751; Gray's Man. 6th ed., 605; 7th ed., 234; Arthur, Fl. Ia. 34; Hitchcock, Pl. Ames, 525; MacMillan, Metas. Minn. Val., 120; Tracy, Fl. Mo., 93; Cratty, Ia. Sedges, 343.

Abundant, in low meadows and woods. June 14, 1908.

11—*Carex grisea* Wahl. Gray sedge.

"K. Acad. Handl., xxiv, 154 (1803) ;" Br. Illus. Flora, i, 321, f. 759; Gray's Man. 6th ed., 605, 7th ed., 244; Arthur, Flora Ia., 34; Hitchcock, Pl. Ames, 525; MacMillan, Metas. Minn. Val., 120; Tracy, Flora Mo., 93; Bessey, Cont. Fl. Ia., 124; Webber Fl. Neb., 98; Cratty, Ia. Sedges, 344; Bessey, Cat. Fl. Neb., n. 924.

Low woods and thickets, not typical, probably a variety. June 14, 1908.

12—*Carex granularis* Muhl. Meadow sedge.

Willd. Sp. Pl. iv, 279 (1805) ; Br. Illus. Flora, i, 322, f, 763; Gray's Man. 6th ed., 605, 7th ed., 244; Arthur, Cont. Fl. Iowa, iv; MacMillan, Metas. Minn. Val., 120; Tracy, Fl. Mo., 93; Bot. Surv. Neb., iv, 45; Cratty, Ia. Sedges, 344.

Not quite typical. Frequent in low meadows or open damp woods. June 14-17, 1908.

13—*Carex oligocarpa* Schk. Few-fruited sedge.

"Reid. Nacht., 58 (1806);" Br. Illus. Fl. i, 325, f. 771; Gray's Man., 6th ed., 607, 7th ed., 243; Arthur, Cont. Fl. Iowa, iii; Tracy, Fl. Mo., 94; Cratty, Ia. Sedges, 254.

Frequent in dense woods. Leaves more than 1 inch wide, otherwise quite typical. June 14-16, 1908.

14—*Carex tetanica* Schk. Wood's sedge.

Br. Illus. Fl. i, 326; Bessey, Cat. Fl. Neb. Series iii, p. 23.

Rare, open woods. June 14, 1908.

15—*Carex laxiflora blanda* (Dewey) Boott. Loose-flowered sedge.

"Ill. Car. 37 (1858);" Br. Illus. Fl. i, 327; Gray's Man. 6th ed., 607, 7th ed., 242; Tracy, Fl. Mo. 93; Cratty, Ia. Sedges, 347.

C. blanda Dewey. Am. Jour. Sci. x, 45 (1826).

C. laxiflora var. striatula Carey, Gray's Man. 2d ed., 524 (1852).

Common in woods and thickets. June 14-18, 1908.

16—*Carex Albursina* Sheldon. White Bear sedge.

Bull. Torrey Bot. Club, xx, 284 (1898); Br. Illus. Fl. i, 329, f, 781; Arthur Fl. Iowa, 34; Hitchcock, Pl. Ames, 524; Tracy, Fl. Mo., 93; Cratty, Ia. Sedges, 347; Shimek, Ia. Geol. Surv. xvi, 169.

C. laxiflora var. latifolia Boott. Ill. Car. (1858) not C. latifolia Moench. Gray's Man. 6th ed., 607, 7th ed., 243.

Woods and thickets, rather rare. June 22, 1908.

17—*Carex Pennsylvanica* Lam. Pennsylvania sedge.

"Encyc. iii, 388, 1789;" Br. Illus. Fl. i. 333, f. 975; Bailey in Gray's Man., 6th ed., 616; 7th ed., 236; Arthur, Fl. Iowa, 34; MacMillan, Metas. Minn. Val., 117; Hitchcock, Pl. Ames, 525; Tracy, Fl. Mo., 94; Cratty, Ia. Sedges, 304; Shimek, Ia. Geol. Surv. xvi, 169; Bessey, Catal. Fl. Neb. Series iii, p. 23.

Abundant, open woods and hillsides. May 30, 1908.

18—*Carex pubescens* Muhl. Pubescent sedge.

Willd. Sp. Pl. iv. 281 (1805); Br. Illus. Flora, i, 336, f. 802; Gray's Man., 6th ed., 613; 7th ed., 237; Arthur, Cont. Fl. Ia., v; Hitchcock, Pl. Ames, 525; MacMillan, Metas. Minn. Val., 116; Tracy, Flora Mo., 95; Cratty, Ia. Sedges, 350.

Frequent, woods and shady places. June 14, 1908.

19—*Carex Jamesii* Schwein. James' sedge.

"Ann. Lyc. N. Y. i, 67 (1824);" Br. Illus. Fl. i, 337, f. 807; Gray's Man. 6th ed., 613; 7th ed., 335; Cratty, Ia. Sedges, 350.

C. steudellii Kunth, Enum. Pl. ii, 480 (1837).

Very rare. Grows in dense tufts in thick damp woods where other vegetation was scarce, south of Mt. Pleasant. June 18, 1908.

20—*Carex conjuncta* Boott. Soft Fox sedge.

(Boott) Ill. Car., 122 (1862); Br. Illus. Fl. i, 342., f. 822; Gray's Man., 6th ed., 614; 7th ed., 228; Arthur, Cont. Fl. Iowa, iii; Hitchcock, Pl. Ames, 525; Tracy, Fl. Mo., 93; Cratty, Iowa Sedges, 351.

Frequent, open seepy woods and meadows. Quite typical.

21—*Carex stipata* Muhl. Awl-fruited sedge.

Willd. Sp. Pl. iv, 253 (1805); Br. Illus. Flora, i, 343, f. 623; Gray's Man. 6th ed., 614; 7th ed., 228; Arthur, Fl. Ia., 33; MacMillan, Metas. Minn. Val., 115; Tracy, Fl. Mo., 94; Fink, Proc. Ia. Acad. Sci., iv, 105; Cratty, Ia. Sedges, 352; Shimek, Ia. Geol. Surv., xvi, 169; Bessey, Cont. Neb. Series iii, p. 23.

Not common, open swales in meadows. June 16, 1908.

22—*Carex vulpinoidea* Michx. Fox sedge.

Fl. No. Am., ii, 169 (1803); Br. Illus. Fl., i, 345, f. 830; Gray's Man., 6th ed., 615; 7th ed., 227; Arthur, Fl. Iowa, 33; Hitchcock, Pl. Ames, 525; MacMillan, Metas. Minn. Val., 113; Tracy, Fl. Mo., 95; Bessey, Cont. Fl. Iowa, 123; Fink, Ia. Acad. Sci., iv, 105; Cratty, Ia. Sedges, 354; Shimek, Ia. Geol. Surv., xvi, 169; Bessey, Cat. Fl. Neb., No. 940.

Abundant, low meadows and roadsides along ditches. Specimens collected quite large, ranging with the largest at the S. U. I. Herb. June 14, 1908.

23—*Carex xanthocarpa* Bicknell. Yellow-fruited sedge.

Bull. Torr. Bot. Club, xx, 22 (1896), Pl. vii; Br. Illus. Fl. i, 545, f. 831; Cratty, Ia. Sedges, 354.

C. setacea var. ambigua (Barratt) Fernald Gray's Man., 7th ed., 228.

Quite frequent along roadsides, very conspicuously yellow. Only once before reported from state. June 14, 1908.

24—*Carex rosea* Schk. Stellate sedge.

"Nacht xv. 179 (1806);" Br. Illus. Fl. i, 347., f. 835; Bailey in Gray's Man., 6th ed., 616; Gray's Man., 7th ed., 226; Arthur, Fl. Iowa, 33; MacMillan, Metas. Minn. Val. 112. Bessey, Cont. Fl. Ia., 124; Tracy Fl. Mo. 94; Webber, Fl. Neb., 98; Fink, Proc. Ia. Acad. Sci. iv, 105; Cratty, Iowa Sedges, 355; Shimek, Ia. Geol. Surv., xiv, 169; Bessey, Catl. Fl. Neb., No. 930.

Common, woods and thickets. Quite variable, sometimes with culms 3 ft. long. Along roadsides south of Mt. Pleasant, in sheltered places. June 15, 1908.

25—*Carex sparganioides* Muhl. Burreed sedge.

Willd. Sp. Pl. iv, 237 (1805); Br. Illus. Fl., i, 348, f. 839; Gray's Man., 6th ed., 616; 7th ed., 226; Arthur, Fl. Ia., 33; Hitchcock, Pl. Ames, 525; Tracy, Fl. Mo., 525; Bessey, Cont. Fl. Ia., 124; Cratty, Ia. Sedges, 356; Shimek, Ia. Geol. Surv., xvi, 169.

Quite rare, woods and thickets. June 14, 1908.

26—*Carex cephaloidea* Dewey. Thin-leaved sedge.

"Rep. Pl. Mass., 262 (1840);" Br. Illus. Flora, i, 348, f. 840; Gray's Man., 6th ed., 617; 7th ed., 237; Cratty, Ia. Sedges, 356; Bessey, Cat. Fl. Neb., No. 919.

Infrequent, dry hills and meadows. June 15, 1908.

27—*Carex cephalophora* Muhl. Oval-headed sedge.

Willd., Sp. Pl. iv, 220 (1805); Br. Illus. Flora, i, 349, f. 841; Gray's Man., 6th ed., 617; 7th ed., 226; Arthur, Fl. Iowa, 33; Hitchcock, Pl. Ames, 525; McMillan, Metas, Minn. Val., iii; Tracy, Fl. Mo., 93; Bessey, Cont. Fl. Iowa, 124; Fink, Ia. Acad. Sci., iv., 106; Cratty, Ia. Sedges, 356; Shimek, Ia. Geol. Surv., xvi, 169.

Very common, woods and meadows. June 14-19, 1908.

28—*Carex Leavenworthii* Dewey. Leavenworth's sedge.

Am. Jour. Sci. 2d Ser., ii, 246 (1846); Br. Ill. Flora, i, 349; Gray's Man., 6th ed., 617; 7th ed., 226; Cratty, Iowa Sedges, 357.

C. cephaloidea var. augustifolia Boott, Ill. Car. 123 (1862).

Rare, woods and thickets, along Skunk river. Probably somewhat larger than Britton's description calls for, but a very distinct species. June 17, 1908.

29—*Carex tribuloides* Wahl.

"K. ACAD. Handl. xxiv, 145 (1803), Pl. viii;" Britton, Illus. Flora, i, 356, f. 862; Gray's Man., 6th ed., 629; 7th ed., 217; Arthur, Fl. Iowa, 34; MacMillan, Metas. Minn. Val., 108; Bessey, Cont. Fl. Iowa, 124; Fink, Proc. Ia. Acad. Sci., iv, 106; Cratty, Iowa Sedges, 359; Shimek, Ia. Geol. Surv., xvi, 169; Bessey, Cat. Fl. Neb., Series iii, p. 23.

Very common, several varieties of this possibly being present. June 14-18, 1908.

30—*Carex scoparia* Schk. Pointed Broom sedge.

Reidgr. Nacht., 20 (1806); Br. Illus. Fl., i, 356, f. 863; Gray's Man., 6th ed., 620; 7th ed., 217; Arthur, Fl. Ia., 33; MacMillan, Metas. Minn. Val., 108; Bot. Surv. Nebr., iii, 16; Fink, Proc. Ia. Acad. Sci., iv, 106; Cratty, Ia. Sedges, 360.

Common, variable, in open swales. June 14, 1908.

31—*Carex cristatella* Britton.

Ill. Flora, i, 356 (1896); Gray's Man., 6th ed., 620; 7th ed., 219 (C. cristata Schwein); Arthur, Flora Iowa, 34; Hitchcock, Pl. Ames, 525; MacMillan, Metas. Minn. Val., 109; Tracy, Fl. Mo., 93; Cratty, Ia. Sedges, 366; Shimek, Ia. Geol. Surv., xvi, 170.

C. cristata Schwein Ann. Lyc N Y, i, 66 (1824) not Clairv. (1811); Gray's Man., 7th ed., 219.

C. straminea var. cristata Tuck. Enum. Meth., 18 (1843).

C. lagopodioides var. cristata Carey, Gray's Man., 1st ed., 545 (1848).

Abundant. June 14, 1908.

32—*Carex festucacea* Willd. Fescue sedge.

Willd., Sp. Pl., iv, 242 (1825); Br. Illus. Flora, i, 359, f. 871; Arthur, Fl. Ia., 34; MacMillan, Metas. Minn. Val., 106; Cratty, Iowa Sedges, 363; Shimek, Ia. Geol. Surv., xvi, 170.

C. festucacea Schkuhr Gray's Man. 7th ed., 220.

Common, woods and shady places throughout. June 14-18, 1908.

A PARTIAL LIST OF THE PARASITIC FUNGI OF DECATUR COUNTY, IOWA.*

BY J. P. ANDERSON.

INTRODUCTION.

During the years 1897 to 1905 the writer did considerable collecting of botanical material in Decatur County, Iowa. Parasitic fungi were included and the following list is based largely on the material collected at that time. The list is far from complete. There is still some unidentified material on hand, and no special effort was made to have the collection complete originally, as the phanerogams were the special group sought. Specimens of most of the species here enumerated are deposited in the herbarium at Iowa State College. Some of the diseases of economic plants, however, are based on notes and observations, no specimens being collected.

The thanks of the writer is due to Dr. L. H. Pammel for assistance in the identification of species. Also to Dr. Pammel and his assistants for other assistance rendered.

BACTERIACEAE.

1. Pseudomonas campestris (Pammel) E. Smith.
   On Brassica oleracea (cabbage).
2. Pseudomonas tumefaciens E. Smith & Townsend.
   On species of Amygdalus, Malus, Prunus, Pyrus, Rosa, Rubus, and Vitis. Most common on apple.
3. Bacillus amylovorus (Burr.) De Toni.
   On species of Malus and Pyrus, especially destructive on P. communis L.
4. Bacillus tracheiphilus E. Smith.
   On Cucumis sativus L. Sometimes very destructive.

*We do not have an accurate knowledge of the distribution of parasitic fungi in different parts of Iowa. Some excellent collecting has been done by Dr. Macbride of the State University, Dr. J. C. Arthur of Purdue University, E. D. Holway of Minneapolis formerly of Decorah, A. S. Hitchcock of the U. S. Dept. of Agriculture, Dr. Byron D. Halsted and Dr. C. E. Bessey formerly of Ames and members of the staff of the Dept. of Botany, Iowa State College, in recent years. The lists are, however, far from complete and should be greatly extended.—L. H. Pammel.

SYNCHYTRIACEAE.

5. Synchytrium decipiens Farl.
   On Falcata comosa (L.) Kuntze, F. pitcheri (T. & G.) Kuntze.

PERONOSPORACEAE (including Albuginaceae).

6. Cystopus candidus (Pers.) Lev.
   On Bursa bursa-pastoris (L.) Britton.
   On Cochlearia armoracia L.
   On Lepidium apetalum Willd.
   On Raphanus sativus L.
   Roripa palustris (L.) Bess. Very common.
7. Cystopus bliti (Biv.) Lev.
   On Amaranthus retroflexus L. Common.
8. Cystopus portulaceae (DC.) Lev.
   On Portulaca oleracea L. Moderately common.
9. Plasmopara viticola (B. & C.) Berl. & De Toni.
   On Vitis labrusca L. Ordinarily does but little damage but becomes destructive some seasons.
10. Plasmopara cubenis (B. & C.) Humphry.
    On leaves of Micrampelis lobata (Michx.) Greene.
11. Peronospora arthuri Farl.
    On Gaura biennis L.
12. Peronospora gonolobi Lagerh.
    On Gonolobus laevis Michx.
13. Peronospora parasitica (Pers.) De Bary.
    On Bursa bursa-pastoris (L.) Britt., Lepidium apetalum Willd., Sisymbrium officinale (L.) Scop., Sophia pinnata (Walt.) Britton.
14. Peronosposa potentillae De Bary. On Potentilla monspeliensis L.
15. Phytopthora infestans (Mont.) De Bary.
    Our Solanum tuberosum L. More or less destructive some seasons but most years gives little or no trouble.

EXOASCAEAE.

16. Exoascus deformans (Berk.) Fuckel.
    On Amygdalus persica L. Quite destructive some seasons. Different varieties differ much in susceptibility.
17. Exoascus pruni Fuckel.
    On Prunus americana Marsh and P. domestica L.

HELOTIACEAE.

18. Sclerotinia fructigena (Pers.) Schroet.
On Amygdalus persica L., Prunus americana Marsh, P. domestrica L., P. hortulana Bailey, P. triflora. Common and sometimes very destructive especially to the foreign varieties.

MOLLISIACEAE.

19. Mollisia dehnii (Rabenh.) Karst.
On Potentilla monspeliensis L.

PHACIDIACEAE.

20. Rhytisma acerinum (Pers.) Fr.
On Acer saccharinum L.

SPHAERIACEAE.

21. Guignardia bidwellii (Ell.) Viala & Ravaz.
On Vitis labrusca L.

22. Micosphaerella fragariae (Tul.) Lindau.
On Fragaria chiloensis, F. virginiana Duchesne.

23. Ventura pomi (Fr.) Wint.
On Malus ioensis (Wood) Britt., M. malus (L.) Britt., M. soulardi (Bailey) Britton.

24. Glomerella rufomaculans (Berk) Spald. & Von Sch.
On Malus malus (L.) Britton.

24½. Gonomia veneta (Sacc. & Spreg.) Kleb.
On Platanus occidentalis L.

25. Nummularia discreta Tul.
On Malus malus (L.) Britton.

HYPOCREACEAE.

26. Claviceps purpurea (Fr.) Tul.
On Elymus canadensis L.

DOTHIDIACEAE.

27. Plowrightia morbosa (Schw.) Sacc.
On Prunus americana L., P. domestica L., P. virginiana L.

28. Phyllachora graminis (Pers.) Fuckel.
On Elymus canadensis L.

29. Phyllachora lespedezae (Schw.) Sacc.
    On Lespedeza capitata Michx.
30. Phyllachora trifolii (Pers.) Fukl.
    On Trifolium repens L.
31. Ophiodothis haydeni (B. & C.) Sacc.
    On Aster diffusus Ait.

SPHAERIOIDACEAE.

32. Darluca filum (Biv.) Cast.
    On Melampsora farinosa on Salix nigra.
    On Puccinia graminis on Hordeum pratense.
    On Puccinia graminis on Poa pratensis.
33. Phyllosticta antennariae Ell. & Ev.
    On Antennaria plantaginifolia (L.) Richards.
34. Phyllosticta aesculi Ell. & Mart.
    On Aesculus glabra Willd.
35. Phyllosticta saccharini Ell & Mart.
    On Acer nigrum Michx.
36. Coniothyrium fuckelii Sacc.
    On Rubus occidentalis L.

36½. Septoria agrimonia-eupatorii Bomm. & Rouss.
    On Agrimonia mollis (T. & G.) Britton.
37. Septoria liatridis Ell. & Davis.
    On Lacinaria sp.

37½. Septoria pyricola Desm.
    On Pyrus communis L.
38. Septoria ribis Desmz.
    On Ribes missouriensis Nutt.

38½. Septoria rubi West.
    On Rubus canadensis roribaceus Bailey.
39. Septoria salliae W. R.
    On Acer saccharinum L.
40. Septoria saniculae E. & E.
    On Sanicula marylandica L.
41. Septoria silenicola Ell. & Mart.
    On Silene stellata (L.) Ait.

41½. Septoria sisymbrii Ell.
    On Dentaria laciniata Muhl.

42. Septoria viridi-tingens Curt.
    On Allium tricoccum Ait.
43. Septoria nolitangere Gerard.
    On Impatiens aurea Muhl.
44. Septoria polygonorum Desm.
    Polygonum incarnatum Ell., P. pennsylvanicum L.
45. Septoria scrophulariae Peck.
    On Scrophularia marylandica L.

MELANCONIACEAE.

46. Colletotrichum lindemuthianum (Sacc. & Magn.) Scribn.
    On Phaseolus vulgaris L., P. lunatus L.
    Sometimes quite destructive to some varieties of lima bean.
47. Gloeosporium ampelophagum Sacc.
    On Vitis labrusca L.
48. Gloeosporium venetum Speg.
    On Rubus nigrobaccus Bailey, R. occidentalis L.
    R. strigosus Michx., R. neglectus Peck. Destructive to the black raspberry but not to the others.
49. Marsonia juglandis (Lib.) Sacc.
    On Juglans cinerea L.
50. Cylindrosporium padi Karst.
    On Prunus americana Marsh, P. avium L., P. cerasus L., P. mahaleb L.

MUCEDINAE.

51. Oospora scabies Thaxter.
    On Solanum tuberosum L.
52. Ovularia obliqua (Cooke) Oud.
    On Rumex sp.
53. Cercosporella chionea (Ell. & Kellerm) Sacc.
    On Cercis Canadensis L.
54. Piricularia grisea (Cooke) Sacc.
    On Syntherisma sanguinalis (L.) Dulac.
55. Piricularia parasitica E. & E.
    On Phyllachora on Elymus canadensis.

DEMATIEAE.

56. Cladosporium carpophilum Thum.
    On Amygdalus persica L.

57. Macrosporium solani E. & M.
On Solanum tuberosum L.

58. Cercospora apii pastinacae Farl.
On Pastinaca sativa L.

58½. Cercospora angulata Wint.
On Ribes rubrum L.

59. Cercospora beticola Sacc.
On Beta vulgaris L.

60. Cercospora euonymi Ell.
On Euonymous antopurpureus Jacq.

61. Cercospora granuliformis Ell. & Holw.
On Viola papilionacea Pursh.

62. Cercospora monoica Ell. & Holw.
On Falcata Sp.

63. Cercospora rhoina C. & E.
On Rhus glabra L.

64. Cercospora venturioides Peck.
On Asclepias syriaca L.

65. Cercospora vernonieae E. & K.
On Vernonia fasciculata Michx.

66. Cercospora avicularis Wint.
On Poloygonum aviculare L.

ERYSIPHACEAE.

67. Sphaerotheca humuli (DC.) Burrill.
On Rosa Arkansana Porter. This species is not very common.

68. Sphaerotheca humuli fuliginea (Schlecht), Salmon.
On Bidens frondosa L., B. involucrata (Nutt.) Britton, Erichitites hieracifolia (L.) Raf., Leptandra virginica (L.) Nutt., Taraxacum taraxacum (L.) Karst. This species is very common but confined to weeds.

69. Sphaerotheca pannosa (Wallr.) Lev.
On Rosa multiflora—especially on the hybrid variety known as Crimson Rambler. Does some damage.

70. Sphaerotheca mors-uvae (Schwein.) Berk & Curt.
On Ribes spp. Does considerable damage to cultivated gooseberries some years.

71. Podosphaera oxyacanthae (DC.) De Bary.
On Prunus americana Marsh, P. avium L., P. besseyi Bailey, P. cerasus L. Often does some damage to the cherry. Is quite common.

72. Podosphaera leucotricha (Ell. & Ever.) Salmon.
On Malus malus (L.) Britton. This species injures young trees and sprouts, etc.

73. Erysiphe polygoni D C.
On Astragalus carolinianus L., Brassica nigra (L.) Koch, Clematis virginiana L., Falcata pitcheri (T. & G.) Kunze, Pisum sativum L.; Polygonum aviculare L., P. erectum L., Ranunculus abortivus L., Thalictrum purpurascens L. This species often proves very destructive on the pea.

74. Erysiphe cichoracearum D C.
On Ambrosia artemisiaefolia L., A trifida L., A trifida integrifolia (Muhl.) T. & G., Aster laevis L., Carduus discolor (Muhl.) Nutt., Galium circaezans Michx., Helenium autumnale L., Helianthus grosse-serratus Martens, H. tuberosus L., Phlox divaricata L., Plantago major L., P. rugelii Dec., Verbena hastata L., V. stricta Vent., V. urticifolia L., Verbesina alternifolia (L.) Britt. This is a very abundant species but as most of the hosts attacked are weeds it cannot be considered as causing damage.

75. Erysiphe graminis D C.
On Poa pratensis L. Quite common.

76. Erysiphe taurica Lev.
On Heliopsis scabra Dunal. Common.

77. Microsphaera alni (Wallr.) Wint.
On Corylus americana L., Lonicera sullivantii A. Gray, Ostrya virginica (Mill.) Willd., Quercus rubra L., Syringia vulgaris L. Very common, especially on the lilac.

78. Microsphaera alni vaccinii (Schwein.) Salmon.
On Catalpa speciosa Wardr. Destructive but not very common.

79. Microsphaere alni extensa (Cooke & Peck) Salmon.
On Quercus prinoides Willd. Not very destructive.

80. Microsphaera diffusa Cooke and Peck.
On Meibomia canadensis (L.) Kuntze, and Symphoricarpos vulgaris Michx. Common.

81. Microsphaera russellii Clinton.
    On Oxalis stricta L. Not conspicuous enough to be often noticed.

82. Microsphaera euphorbiae (Peck) Berk. & Curt.
    On Euphorbia carollata L. Common.

83. Uncinula necator (Schwein.) Burrill.
    On Parthenocissus quinquefolia (L.) Planch., and Vitis labrusca L. This species appears to be more common and destructive on the former than on the latter host.

84. Uncinula circinata Cooke and Peck.
    On Acer saccharinum L.

85. Uncinula macrospora Peck.
    On Ulums americana L. and U. racemosa Thomas. Quite common. In some cases it is conspicuous and in other cases not.

86. Uncinula geniculata Gerard.
    On Morus rubra L. Inconspicuous and not often found.

87. Phyllactinia corylea (Pers.) Karst.
    On Ostrya virginiana (Mill.) Willd., Ulmus racemosa Thomas. This species probably occurs on many other hosts but the writer has collected only on the two mentioned.

UREDINEAE.

88. Uromyces appendiculatus (Pers.) Lev.
    On Phaseolus vulgaris L. Sometimes destructive.

89. Uromyces caladii Farl.
    On Arisaema triphyllum (L.) Schott. A dracontium (L.) Torr.

90. Uromyces erythronii (DC.) Passer.
    On Allium canadense L.

91. Uromyces euphorbiae Cooke & Peck.
    On Euphorbia maculata L. Common.

92. Uromyces fabae (Pers.) DeBy.
    On Apios tuberosa Moench.

93. Uromyces geranii (DC.) Warton.
    On Geranium maculatum L.

94. Uromyces howei Peck.
    On Asclepias syriaca L. Common and somewhat destructive.

95. Uromyces junci (Desm.) Tul.
    On Juncus tenuis Willd. Common.

96. Uromyces terebinthii (DC.) Wint.
On Rhus toxicodendron L.

97. Uromyces trifolii (Hedw.) Lev.
On Trifolium pratense L.

97½. Uropyxis amorphae (Curt.) Schroet.
On Amorpha canescens Pursh.

98. Puccinia asparagi D C.
On Asparagus officinalis L. Very destructive.

99. Puccinia coronata Corda.
On Rhamnus lanceolatus Pursh, Avena sativa L.

100. Puccinia circaeae Pers.
On Circaea lutetiana L.

101. Puccinia caricis (Schum.) Reb.
On Carex spp.

102. Puccinia convolvuli (Pers.) Karst.
On Convolvulus sepium L.

103. Puccinia galii (Pers.) Schwein.
On Galium trifidum L.

104. Puccinia graminis Pers.
On Avena sativa L., Berberis vulgaris L., Agrostis alba L., Hordeum pratense L., Hordeum jubatum, Triticum vulgare L. Very common and destructive.

105. Puccinia helianthi Schwein.
On Helianthus annuus L., H. tuberosus L.

106. Puccinia heliopsidis Schwein.
On Veronia fasciculata Michx., V. noveboracensis (L.) Willd.

107. Puccinia hieracii (Shum.) Mart.
On Taraxacum taraxacum (L.) Karst.

108. Puccinia hydrophylli Peck & Clint.
On Macrocalyx nyctelea (L.) Kuntze.

109. Puccinia menthae Pers.
On Monarda fistulosa L.
Koellia virginiana (L.) Mc.M.

109½. Puccinia phlei-pratense Eriks & Henn.
On Phleum pratense L.

110. Puccinia phragmites (Schum.) Korn.
On Spartina cynosuroides (L.) Willd.

111. Puccinia polysora Underw.
On Tripsacum dactyloides L.

112. Puccinia podophylli Schwein.
    On Podophyllum peltatum L.
113. Puccinia polygoni Pers.
    On Polygonum scandens L., Polygonum sp.
114. Puccinia pruni-spinosa Pers.
    On Prunus hortulana Bailey.
115. Puccinia rubigo-vera (DC.) Winter.
    On Elymus canadensis L.
116. Puccinia silphii Schwein.
    On Silphium integrifolium Michx.
117. Puccinia sorghi Schwein.
    On Oxalis stricta L., Zea mays.
118. Puccinia solida Schwein.
    On Anemone virginiana L.
119. Puccinia xanthii Schwein.
    On Xanthium Canadense Mill.
120. Gymnosporangium macropus Lk.
    On Malus ioensis (Wood) Britton, M. malus (L.) Britton, Juniperus virginiana L. Only of moderate frequency on cultivated apple but at times destructive to the wild crab and disfiguring the red cedar.
121. Gymnosporangium clavariaeforme (Jacq.) Rees.
    On Crataegus tomentosa L.
122. Gymnoconia peckiana (Howe) Franz.
    On Rubus nigrobaccus Bailey. Very common on the wild forms but the leading cultivated varieties seem somewhat resistant.

122½. Phragmidium potentillae (Pers.) Karst.
    On Potentilla canadensis L.
123. Phragimidium subcorticum (Schrank) Wint.
    On Rosa hemisphaerica Herrm.
124. Phragmidium speciosuum Fr.
    On Rosa arkansana Porter.
125. Coleosporium solidagineis (Schwein.) Thum.
    On Solidago canadensis L., S. ulmifolia Muhl.
126. Coleosporium vernoniae B. & C.
    On Vernonia noveboracensis (L.) Willd.
127. Coleosporium sonchi (Pers.) Lev. On Aster diffusus Ait.

128. Melampsora populina (Jacq.) Lev.
On Populus deltoides Marsh, P. balsamifera L.

129. Melampsora farinosa (Pers.) Schroet.
On Salix nigra Marsh, S. interior Rowlee.

130. Uredo agrimoniae (DC.) Schroet.
On Agrimonia mollis (T. & G.) Britton.

131. Uredo polypodii (Pers.) D C.
On Filix fragilis (L.) Underw.

132. Aecidium asterum Schwein.
On Aster saggitifolius Willd., Solidago canadensis L., S. ulmifolia Muhl., Aster laevis L.

133. Aecidium abundans Pec. On Symphoricrpos vulgaris Michx.

134. Aecidium compositarium Mart.
On Aster laevis L., A cordifolius L., Helianthus tuberosus L., Lactuca canadensis L., Silphium integrifolium Michx., S. laciniatum L., Solidago serotina Ait.

135. Aecidium convallariae Schum.
Salomonia commutata (R. & S.) Britt.

136. Aecidium erigeronatum Schwein.
On Erigeron annuus (L.) Pers., Leptilon canadense (L.) Britton, Erigeron philadelphicus L.

137. Aecidium fraxini Schwein.
On Fraxinus lanceolata Borck, F. Americana L.

138. Aecidium grossulariae Schum.
On Ribes missouriensis Nutt., Ribes sp. (Cult.)

139. Aecidium impatientis Schwein.
On Impatiens aurea Muhl.

140. Aecidium lysamichiae (Schlect) Wallr.
On Stieronema ciliatum (L.) Raf.

141. Aecidium peckii De Toni.
On Onagra biennis (L.) Scop.

142. Aecidium plantaginis Ces.
On Plantago aristata Michx., P. major L.

143. Aecidium polemonii Curt.
On Polemonium reptans L., Phlox pilosa L.

144. Aecidium pustulatum Curt.
On Comandra umbellata (L.) Nutt.

145. Aecidium thalactri-flavi (DC.) Wint.
On Syndesmon thalactroides (L.) Hoffng.

146. Aecidium verbenae Speg.
 On Verbena stricta Vent.
147. Aecidium compositarium silphii Burr.
 On Silphium laciniatum L.
148. Aecidium jamesianum Peck.
 On Ascelpias syriaca L.
149. Aecidium Ranunculi Schwein.
 On Ranunculus abortivus L.

USTILAGINACEAE.

150. Ustilago maydis (DC.) Corda.
 On Zea Mays.
151. Ustilago tritici (Pers.) Jensen.
 On Triticum vulgare L.
152. Ustilago avenae (Pers.) Jensen.
 On Avena sativa L.
153. Ustilago urticulosa (Nees.) Tul.
 On Polygonum pennsylvanicum L., P. incarnatum Ell.
154. Ustilago neglecta Niessl.
 On Chaetochloa glauca (L.) Scribn.
155. Ustilago rabenhorstiana Kuehn.
 On Panicum proliferum Lam. Syntherisma sanguinalis (L.) Dulac.
156. Ustilago reiliana Kuehn.
 On Zea mays.
157. Entyloma physalidis (Kalchbr. & Cooke) Wint.
 On Physalis pubescens L.

HOST INDEX.

THE GRASSES OF THE UINTAH MOUNTAINS AND ADJACENT REGIONS.

BY L. H. PAMMEL.

This paper contains an account of the grasses found in the Uintah Mountains and the adjacent Wasatch Mountains in Utah. Most of the region has an elevation of over 5,000 feet. The Uintah range contains a large number of snow capped peaks; the highest about 13,700 feet high. Tributary to the range are two arid basins, the Green River Basin to the north and to the south the Uintah Basin. The region has been visited by Parry, Jones, Watson, Aven Nelson and some other botanists. Dr. Sereno Watson did some extensive work in the region as a member of the exploring party of the Fortieth Parallel. I gave an account of the physiography of the region in another connection—"Some Ecological Notes on the Vegetation of the Uintah Mountains."* In an earlier paper** I gave an account of the grasses of the Eastern Rockies which was somewhat extended later in a paper giving the forage resources between Jefferson, Iowa, and Denver, Colorado,*** and subsequently a paper "Notes on Grasses of Nebraska, South Dakota and Wyoming."****

The grasses of the region are largely boreal, such genera as *Poa, Calamagrostis, Agrostis,* are well represented. Genera derived from the south of the adjacent arid plains are represented by *Stipa,* of which there are seven species, one the *Stipa comata* reaches northwestern Iowa. The *S. viridula* rather widely distributed in the west is another common species. The *S. Lettermanii* and *S. Tweedyi* are alpine and subalpine.

The *Hordeum jubatum* and its close ally *H. caespitosum* are common in alkali spots at lower altitudes while the *H. nodosum* is common at higher altitudes. The Giant Lyme Grass (*Elymus condensatus*) is common along alkali streams or borders of old lake beds from 5,000-7,500 feet. The marshy parks contain such willows as *Salix stricta, S. lutea, S. chlorophylla* and *Geum triflorum, Erigeron glabellus, Poa epilis,* and *P. Wolfii.* These parks frequently become dry later in the season.

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**Proc. Soc. Prom. Agrl. Sci. 17:94. Joint paper with F. Lamson-Scribner.
***Bull. Div. of Agrost., U. S. Dept. Agr. 9:1-47, *f. 1-12.*
****Proc. Davenport Acal. Sci. 7:229-258, *pl. 10-16*

I have listed something over 100 species of grasses collected. These collections were made mostly on four trips made in this region. Some collecting was done in 1898 and 1899. For verification of the identification of species I am indebted to various members of the former Division of Agrostology. Owing to the many changes in nomenclature, the names are not the same always as now recognized. The collections were made between the years 1898, 1899, 1900, 1901, 1902, 1908.

The Uintah Mountains are important sources for the water supply of the irrigated districts of Utah. Such streams as the Weber, Provo, Bear, Black's Fork, the Duchesne and the several branches of the Lake Fork have their sources in the high, snow capped peaks of the Uintah Mountains. Such rugged peaks as La Motte, Wilson, Gilbert, Watson, Emmons, Bald, and Mt. Agassiz are snow capped for much of the year. Black's Fork, Henry's Creek, Sheep Creek, Burnt Fork, Weber, Smith's Fork, and Bear River come from the north side of the range, while the Duchesne with its branches, Lake Fork, Uintah River, Brush Creek, come from the south side of the range. There are numerous lakes, but all are small. Kamas is situated on what is commonly called a prairie, an ancient fresh water lake of considerable size. Evanston, Lower Black's Fork, Myer's Ranch, Burnt Fork, are in Wyoming, the remaining localities in Utah. In the list more numbers are recorded from the north side of the range because it represents the work of four seasons of collecting.

The collectors will be referred to by letters*, the altitude by the number preceding the collector's letter.

PHALARIDEAE.

Hierochloe odorata (L.) Wahlenb.

This boreal grass is distributed across the United States and in the mountain regions of the Rockies, also Europe; common in northern Iowa. Sometimes forms a considerable part of the herbage in meadows. Associated with such plants as *Pedicularis groenlandica*, *Erigeron* and *Pentstemon*.

193, mouth of Provo River, 7400, (P. & S.), *192*, East Provo Canon, 9200 (P. & S.), *847*, Black's Fork, 9200 (P. J. L. B.).

*P. and S.=L. H. Pammel and E. M. Stanton (1900).
P. J. L. B.=L. H. Pammel, C. P. Johnson, G. M. Lummis, and R. E. Buchanan (1901).
P. and B.=L. H. Pammel and R. E. Blackwood (1902).
P. B. L. R.=L. H. Pammel, R. L. Barrett, C. V. Lee, F. Raney (1908).
L. and S.=E. E. Little and E. M. Stanton, Elk. Mt., Wyo. (1899).
P.=L. H. Pammel.
P. B. H. P. V. P.=Pammel, Blackwood, Harold Pammel and Violet Pammel (1902).

Phalaris arundinacea L.

This grass occurs from the Atlantic to the Pacific, also in Europe; grows in wet places.

116, bank of streams, Black's Fork, 6500 (P. J. B. L.), *4079*, Myer's Ranch, Bear River, S. of Evanston, Wyo., 7400 (P. & B.), *3922*, Peterson Canon, Utah, moist places, 8000 (P. & B.), *21*, Logan, Utah, swale (P. B. L. & R.).

Aristida purpurea Nutt.

179, Salt Lake City, dry soil, abundant near Garfield Beach (P.), *33*, Lagoon, Farmington Canon, Salt Lake City, Utah (P. B. L. R.).

AGROSTIDEAE.

Stipa comata Trin. & Rupr.

73, Placerville, Col., dry open places, 7300 (P. B. L. R.), *188*, Salt Lake City; dry banks hills (P.); *1542*, Mud Creek, Black's Fork, Uintah Mts., Utah, 6800 (P. J. B. L.); *3905*, Peterson, 6500 (P. & B.); *13*, Bear Lake, Utah, abundant with sage brush (P. B. L. R.).

Stipa lettermanii, Vasey.

921, Smith's Fork, Uintah Mts., 10,000 (P. J. L. B.); Junction East and Middle Black's Fork, Uintah Mts., 9500, open places (P. J. L. & B.).

Stipa Scribneri Vasey.

914, Smith's Fork, 10500, ridge dry soil (P. J. B. L.); *913*, Fuller's Ranch, Black's Fork (P. J. B. L.); *221*, Hayden's Fork of Bear River (P. & S.); *218*, Duchesne River, 7200 (P. & S.); 219, Soapstone Creek (P. & S.); *269*, Junction of East and West branch Provo River, 7400 (P. & S.); *211*, W. Bear River, 9500 (P. & S.); *216*, East Provo Canon, 8500 (P. & S.); *267*, West Duchesne River, 7200 (P. & S.); *265*, East Fork of Weber, 9000 (P. & S.).

Stipa Nelsoni Scribner.

208, East Provo Canon, 8000 (P. & S.); *212*, W. Bear River, 9500 (P. & S.); *213*, W. Bear River; dry places (P. & S.).

Stipa Tweedyi Vasey.

918, *920*, Echo, 6800 (P. J. B. L.), dry places; *919*, in meadow, Black's Fork, Utah, 9000 (P. J. B. L.); *214*, W. Lake Fork, 8500 (P. & S.); *216*, Hayden's Branch, Bear River, 9500, dry places (P. & S.).

Stipa Vaseyi Scribner.

916, Mud Creek of Black's Fork, 8000 (P.); *917*, Fuller's ranch, Black's Fork, 8000 (P.).

Stipa viridula Trin.

220, Kamas, Utah, 6850 (P. & S.).

Eriocoma cuspidata Nutt.

3566, Ensign Mt., Salt Lake City, 5000 (P. & B.) dry hills; *182*, E. Duchesne River, 8500 (P. & S.); *181*, W. Duchesne River, 7200 (P. & S.); *4064*, Myer's Ranch, S. of Evanston, Wyo., 7500 (P. & B.), dry limestone.

Muhlenbergia comata Benth.

187, East Lake Fork, Uintah Mts., 8500 (P. & S.); *184*, Duchesne River, 8500, marsh (P. & S.).

Muhlenbergia racemosa (Michx.) B. S. P.

183 a, W. Duchesne River, 8500 (P. & S.); *188*, E. Duchesne River 8500 (P. & S.).

Phleum alpinum L.

1687, Junction East Middle Black's Fork, 9500 (P. J. L. B.); *52*, Elk Mt., Wyoming (S. & L.); *879*, Black's Fork, 8500 (P.); *881*, La Motte Peak, 11200 (P. J. B. L.); in low meadows; *879*, *880*, Black's Fork, 9200 (P. J. L. B.); *135*, Junction E. & W. Fork of Provo River, 7400 (P. & S.); *136*, Ashley Creek, 9800 (P. & S.); *140*, Carter Creek, 9200 (P. & S.); *142*, Brush Creek (P. & S.); *143*, East Provo Conon, 8000, in meadows (P. & S.); *144*, East Fork of the Weber, 9500 (P. & S.) in meadows.

Phleum pratense L.

877, Piedmont, Wyo., 6500 (P. J. B. L.) in meadows; *137*, White Rock Agency, 7000 (P. & S.); *138*, West Duchesne River, 7200 (P. & S.); *141*, E. Lake Fork, 8500 (P. & S.); *139*, E. Duchesne River, 8500 (P. & S.), along roads; *52*, *53*, Elk Mt., Wyo., (S. & L.); *3653*, Farmington Canon, Salt Lake City, (P. & B.).

Alopecuras fulvus Smith.

884, Echo, Muddy shores of Weber River, 6500 (P. J. B. L.); *297*, East Duchesne River, 8500 (P. & S.); *3930*, Peterson Canon, 6500 (P. & B.); *296*, East Lake Fork (P. & S.).

Sporobolus airoides, Torr.

A coarse stout grass.

294, Lone Tree and West Henry's Fork, Uintah Mts.; *292,* Vernal (P. & S.); *1569,* (J. B. L.); *3596,* sand dunes, Saltair Beach, Salt Lake City, 4250 (J. & B.); *1621,* Fuller's Ranch, Black's Fork, Ut., 7500 (P. J. L. B.); *1569,* Saltair Beach, (J. B. L.).

Sporobolus aspericaulis Trin.

186, Duchesne River, 8500 (P. & S.); *185,* East Lake Fork, 8500 (P. & S.); *480,* (P. B. L. R.).

Sporobolus asperifolius (Nees and Mey) Thurb.

A slender leafy perennial, occurring in dry places.

291, White Rock Agency, Ut., 7000 (P. & S.); *50,* Salt Lake, Garfield Beach (P.).

Sporobolus depauperatus (Torr.) Scrib.

277, Junction E. & W. Fk. Provo River, 7400 (P. & S.); *295,* East Provo Canon, dry places (P. & S.)

Sporobolus gracillimus (Thurb.) Vasey.

290, Uintah Canon, 7800 (P. & S.).

Sporobolus Richardsoni (Trin.) Merrill.

3915, Peterson Canon, 8000 (P. & B.); *1627,* Junction East and Middle Black's Fork, Ut., 9500, abundant dry meadows, benches (P. J. L. B.); *480,* Bear Lake, 6500, alkali meadow (P. B. L. R.).

Polypogon monspeliensis (L.) Desf.

50, Vernal, Ut., 5000 (P. & S.); *222,* Salt Lake City, (P. & S.); *3545,* Sulphur Springs, Salt Lake City, irrigation ditches (P. B. L. R.); *268,* Salt Lake ditches; *912,* Echo (P. J. B. L.).

Agrostis sp.

Stillwater Canon, Bear River, 10000 (P. & B.).

Agrostis alba L.

An abundant grass at lower altitudes throughout the region. Introduced.

869, in meadows under irrigation, Lagoon, Salt Lake City, 5000 (P. J. B. L.); *868,* Salt Lake City, 5000 (P. J. B. L.); *103,* Burnt Fork, irrigated meadow (P. & S.); *102,* Vernal, 5500 (P. & S.); *105,* Kamas, 6850 (P. & S.); *107,* White Rock Agency, 6500 (P. & S.); *3642,* Farmington Canon, Salt Lake City, 550 (P. & B.).

Agrostis asperifolia Trin.

In moist places, meadows.

133, East Provo Canon, 8000 (P. & S.) ; *145*, East Fork of Weber, meadows, 9500 (P. & S.) ; *3928*, Peterson, 6500 (P. & B.) ; *183*, Provo River, 8000 (P. & S.).

Agrostis hiemalis (Walt.) B. S. P.

1603, East Middle Black's Fork, gravel beds (P. J. B. L.) ; *866*, gravel beds, streams, 10000 (P. J. B. L. O.) ; *861*, *865*, *900*, Black's Fork, 9500, low grounds (P. J. L. B.) ; *864*, East Middle Black's Fork, 10000 (P. J. B. L.) ; *863*, La Motte Peak, 10500 (P. J. B. L.) ; *870*, West Black's Fork (P. J. B. L.) ; *112*, East Provo Canon, 9500 (P. & S.) ; *101*, Hayden's Fork Bear River (P. & S.) ; *104*, East Lake Fork, 8500 (P. & S.) ; *108*, East Provo Canyon, 8000 (P. & S.) ; *115*, Burnt Creek, 9500 (P. & S.) ; *115*, Brush Creek, 9500 (P. & S.).

Agrostis rubra L.

86, Wilson's Peak, 10000 (P. & S.).

Agrostis verticillata Thuil.

3701, Salt Lake City, 5200, saline soil (P. & B.).

Calamagrostis canadensis (Michx.) Beauv.

3950, Peterson Canon, Peterson, 8000 (P. & B.), in low, moist, boggy places; *4244*, Stillwater Canon, Bear River, 10000, boggy places (P. & B.) ; *201*, Brush Creek, 9500 (P. & S.).

Calamagrostis canadensis, Beauv. var. *acuminata* Vasey.

203, Junction of Provo River, East and West Fork, 7400 (P. & S.) ; *204*, East Provo Canon, 9500 (P. & S.).

Calamagrostis montaniensis Scrib.

50, Elk Mt., Wyo., (L. & S.).

Calamagrostis hyperborea Lange var. *Americana* (Vasey) Kearney.

196, Carter Creek, Wyo., Uintah Mts., (P. & S.) ; *197*, Kamas, meadows, 6850 (P. & S.) ; *4017*, Bear River, 7500 (P. & B.) ; *202*, Burnt Fork, Uintah Mts., (P. & S.) ; *199*, Duchesne River, 7250 (P. & S.) ; *898*, Fuller's Ranch, Black's Fork, Uintah Mts., 7500 (P. J. L. B.) ; *198*, East Lake Fork, Uintah Mts., 8500 (P. & S.) ; *195*, White Rock Agency, 7500 (P. & S.).

Holcus lanatus L.

209, Farmington, Ut., 4500 (P. B. L. R.).

Sphenopholis palustris (Michx.) Scribner.

3707, Ogden Canon, 5000 (P. & B.).

Koeleria cristata (L.) Pers.

1590, Black's Fork, 9000, meadows (P. J. B. & L.); *891*, *1547*, *1689*, Fuller's Ranch, Black's Fork, 7800 (P. J. B. L.); *81*, West Branch Bear River, 9500 (P. & S.); *97*, East and West Fork, Provo River, 7400 (P. & S.); Myer's Ranch, Evanston, Bear River, 7500 (P. B. V. P. H. P.); *4112*, Bear River, 7000 (P. & B.); *96*, West Branch, Bear River, 8800 (P. & S.); *445*, Bear Lake (P. B. L. R.); *674*, Mt. Logan, 8500 (P. B. L. R.); *231*, Placerville, Colorado (P. B. L. R.).

Deschampsia caespitosa L., Beauv.

1587 & *1574*, East Middle Black's Fork, 10000 (P. J. B. L.); *1620* & *1625*, La Motte Peak, 13000 (P. J. L. B.); *857*, open meadows, La Motte Peak, 11500 (P. J. L. B.); *858*, *854*, *853*, La Motte Peak, 12000 (P. J. L. B.); *851*, Fuller's Ranch (P. J. L. B.); *848*, *852*, Black's Fork, 9200 (P. J. L. B.); *854*, West Black's Fork, 9200 (P.); *858*, East Black's Fork, 8500 (P. J. L. B.); *116*, Duchesne River, 8500 (P. & S.); *117*, Bear River, 9500 (P. & S.); *111*, East Provo Canon, 8000 (P. & S.); *109*, Junction of the East and West Provo, 7400 (P. & S.); Bear River (P. B., H. P., V. P.).

Deschampsia caespitosa L. var. *alpina.*

Ashley Creek, 10500 (P. & S.), *146*, *147*; Carter's Creek, 9200.

Deschampsia elongata. (Hook) Munro.

83, Junction East and West Provo, 7400 (P. & S.); *85*, Wilson's Peak, 9800 (P. & S.); *82*, East Provo Canon, 8000 (P. & S.).

Deschampsia flexuosa (L.) Trin.

446, *686*, Bear Lake, Ut., 6500 (P. B. L. R.).

Trisetum montanum Vasey.

91, East Fork Weber, 10000 (P. & S.).

Trisetum muticum (Bol.) Scrib.

119, *148*, Junction East Fork Provo, 7400 (P. & S.); *118*, East Provo Canon, 9500 (P. & S.); *79*, Provo Canon, 7000, (P. & S.); *4292*, Stillwater Canon, 10000 (P. & B.).

Trisetum subspicatum (L.) Beauv.

4294, Stillwater Canon, 10000 (P. & B.); *92*, West Branch Bear River, 9000 (P. & S.); *90*, Brush Creek, 9500 (P. & S.); *98*, Carter's

Creek, 9200 (P. & S.); *907*, Divide Smith's and Black's Fork, 10000 (P. J. L. & B.); *907*, La Motte Peak (P. J. B. L.); *905*, *906*, East Middle Black's Fork, 10000 (P. J. B. L.); *206*, Mill Creek, 8200, (P. & S.).

Trisetum subspicatum var.

95, Junction East and West Provo River, 7400 (P. & S.). This may be *T. interruptum.*

Avena mortoniana Scrib.

Wilson's Peak, 12000 (P. & S.).

Avena sativa L.

Cultivated, Fuller's Ranch (P.).

Danthonia intermedia Vasey.

1616, La Motte Peak, 11500 (P. J. B. L.); *856*, between Middle and East Black's Fork in meadow, 12000 (P. J. B. L.); *1617*, *1624*, Junction East and Middle Black's Fork (P. J. B. L.); *134*, East Provo Canon, 8000 (P. & S.).

CHLORIDEAE.

Spartina gracilis Trin.

1554, Fuller's Ranch, 8000 (P. J. B. L.); alkali flats, *3580*, Salt Lake City, Saltair Beach, 4250, alkali flats and meadows, (P. & B.).

Beckmannia erucaeformis (L.) Host.

1548, Fuller's Ranch, Black's Fork (P. J. B. L.).

FESTUCEAE.

Phragmites communis Trin.

298, Duchesne River, in swamps, 8500 (P. & S.).

Eragrostis major Host.

Salt Lake City.

Catabrosa aquatica (L.) Beauv.

904, *1599*, Fuller's Ranch, 7500 (P. J. L. B.), in running streams, springs, and seepage soil, irrigation ditches; 1601, Echo (P. J. L. B.); *293*, Logan Canon, 6000 (P. B. L. & R.).

Melica sp.

Ogden (P.); *443*, Bear Lake (P. B. L. R.).

Melica bulbosa Geyer.

615, Bear Lake, 8000, red loamy soil (P. B. L. R.); *131*, Bear River, Hayden's Fork, 9500 (P. & S.), Rhodes Canon, 8000 (P. & S.); *130*, Junction East and West Provo River, 7400 (P. & S.); *128*, West Bear River, 9500 (P. & S.); *900*, between Smith's Fork and Black's Fork, 10000 (P. J. B. L.); *16*, *20*, *59*, Ogden (P.).

Distichlis spicata (L.) Greene.

267, Salt Lake, 4500 (P. B. L. R.); *3593*, alkali flats, Saltair Beach (P. & B.); *288*, Duchesne River, 8500, (P. & S.); *1596*, Fuller's Ranch, Black's Fork (P. J. B. L.); *3553*, Sulphur Springs, Utah, 4400 (P. & B.); *35*, Lagoon Farmington, Utah, 4500 (P. B. L. & R.); *160*, Garfield Beach, salt marsh (P.).

Dactylis glomerata L.

317, Logan (P. B. L. R.); *258*, Farmington (P. B. L. R.).

Poa.

88, Hayden's Fork, 9500 (P. & S.).

Poa.

289, Carter's Creek, 9200 (P. & S.).

Poa.

924, *925*, *932*, *933*, La Motte Peak, 10000 (P. J. L. B.); *161*, Wilson's Peak, 1000 (P. & S.).

Poa.

Peterson Canon, Utah, 8000 (P. & B.).

Poa.

1700, La Motte Peak, 12000 (P. J. L. B.).

Poa.

1706, Black's Fork, old river bed, 9500 (P. J. L. B.).

Poa.

1712, *1713*, Junction East and Middle Black's Fork, 9500 (P.).

Poa.

1711, Echo, Utah, 6000, alkali flats (P. J. B. L.).

Poa.

1710, La Motte Peak, between Bear River and Middle Black's Fork, 11500 (P. J. L. B.); *1684*, *1632*, *1692*, *1691*, *1714*, *1704*, *1702*, *1701*, open places and in meadows (P. J. L. B.).

Poa.

1631, 1690, 1693, 1703, Fuller's Ranch, Black's Fork, 7500 (P. J. L. B.).

Poa.

1688, Junction East and Middle Black's Fork, 9500 (P. J. L. B.).

Poa.

1686, near springs (P. J. B. L.).

Poa.

1589, Black's Fork, 9200 (P. J. B. L.).

Poa.

926, Echo, 6000, alkali flats, labelled *P. pratense* (P. J. B. & L.).

Poa.

1705, Piedmont & Mud Creek, Wyo. (P. J. L. B.).

Poa.

3585, Saltair Beach, saline soil, 4250 (P. & B.)

Poa.

536, Dry Creek Basin near Logan, Ut., near spring, 8500 (P. B. L. R.).

Poa.

580, Mt. Logan, 9500 (P. B. L. R.); *573,* Mt. Logan (P. B. L. R.).

Poa.

511, shore of Bear Lake, 6000, meadows (P. B. L. R.)

Poa.

510, Bear Lake (P. B. L. R.).

Poa.

3644, Farmington, Utah, 4300 (P. & B.).

Poa.

639, Bear Lake, 7000, moist places near springs (P. B. L. R.).

Poa.

3855, Peterson Canon (P. & B.).

Poa annua L.

928, Mud Creek, Uintah Mountain foot hills, near spring (P. J. B.); *46,* Ogden, near spring, in moist places (P.).

Poa alpina L.

947, 948, 956, 1100; *905,* 1300; *952,* 12000; *958,* 11000; La Motte Peak, in meadows; *1607, 1608,* East Middle Black's Fork, 1000 (P. J. B. L.).

Poa arida Vasey.

1531, Fuller's Ranch, Black's Fork, 7500 (P. J. B. L.).

Poa Buckleyana Nash.

67, Ogden, 7000 (P.) ; *4016,* Bear River near Evanston, 7500 (P. B. VP. HP.) ; *888,* Junction East and Middle Black's Fork (B. & L.) ; *959, 1610,* Fuller's Ranch, Black's Fork (P. J. B. L.).

Poa epilis Scrib.

890, La Motte Peak, 1100 (P. J. L. B.) ; *176,* East Provo Canon, 10500 (P. & S.).

Poa flava L.

4078, Bear River, Myer's Ranch, low grounds, 7500 (P. B. VP. HP.).

Poa laevigata Scrib.

Kamas, 6850, meadow (P. & S.) ; *162,* Bear River, 9500 (P. & S.) ; *163,* salt marsh, Garfield, Beach, Salt Lake (P.).

Poa leptocoma Trin.

169, Moffatt Creek, Uintah Mts., 9500 (P. & S.) ; *170, 171,* East Fork Weber, Holiday Park, 9000 (P. & S.) ; *938, 939,* East Middle Black's Fork, 10000 (P. J. L. B.) ; *168,* East Provo Canon, 8000.

Poa longiligula, Scribner & Will.

3839, Peterson Canon, 8000, open woods (P. B. VP. HP.) ; *89,* Junction East and West Fork Provo River, 7400 (P. & S.) ; *45, 59, 68,* Ogden.

Poa lucida Vasey.

889, La Motte Peak, 11000 (P. J. B. L.) ; *164,* West Bear River (P. & S.).

Poa nemoralis L.

152, Smith's Fork, 8000 (P. & S.) ; *153,* Hayden's Branch, Bear River, 9500 (P. & S.) ; *154,* Junction East and West Fork Provo River, 7400 (P. & S.) ; *941, 944, 945,* Black's Fork, 9200 (P. J. L. B.) ; *943,* Fuller's Ranch, Black's Fork, 7000, in dry meadows (P. J. B. L.) ; *946,* Divide between Smith's and Black's Fork (P. J. B. L.) ; *155,* Burnt Fork, foothills (P. & S.) ; *180,* East Fork of the Weber, 9500 (P. & S.) ; *1694,* second beach, pine woods, Black's Fork, 7000 (P. J. B. L.).

Poa Pammelii Scribner.

Snake River, Uintah Co., (Aven Nelson) 6462.

Poa reflexa Vasey and Scribner.

936, East Middle Black's Fork, 10000 (P. J. B. L.); *935,* La Motte Peak, timber line (P. J. B. L.)

Poa saxatilis S. & W.

150, Wilson's Peak, 98000 (P. & S.).

Poa Sheldoni Vasey.

179, Head of Provo, 10000 (P. & S.).

Poa subaristata orendensis Williams.

940, East Middle Black's Fork, 10000 (P. J. L. B.).

Poa pratensis L.

156, Mill Creek, Uintah Mt. foothills, 8200 (P. & S.); *157,* Rhodes Canon, 8000 (P. & S.); *158,* Wilson's Peak, 9800 (P. & S.); *159,* Bear River, 9500 (P. & S.); *160,* East Fork of the Weber, 9000 (P. & S.); *166,* Junction East and West Fork of the Provo, 7400 (P. & S.); *937, 1681,* Fuller's Ranch, Black's Fork, 7000 (P. J. B. L.); *927,* La Motte Peak, 10500, meadows (P. J. B. L.); *922, 934,* Black's Fork, 9500, meadows (P. J. B. L.); *931,* Salt Lake City, Ft. Douglass, irrigation ditch (P. J. B. & L.); *429,* Bear River (P. & B.).

Poa pratensis var.

165, Junction East and West Fork Provo, 7400 (P. & S.).

Poa tenuifolia Buckl.

56, Odgen (P.)=P. Buckleyana Nash.

Poa Tracyi Vasey.

167, Rhodes Canon, 8000 (P. & S.); *83,* Ogden (P.).

Poa Wheeleri Vasey.

174, East Provo Canon, 8000 (P. & S.); *175,* Soapstone Creek, 10000 (P. & S.).

Poa Wheeleri Vaseyana (Scribner) Will.

172, 173, East Provo Canon, 10000 (P. & S.).

Poa Wolfii Scribn.

923, 930, La Motte Peak, 11000 (P. J. B. L.).

Glyceria nervata (Willd.) Trin.

3634, Farmington Canon, Salt Lake, 4500 (P. & B.); *3965,* Peterson Canon, 8000 (P. & B.), Black's Fork (P. J. B. L.).

Glyceria grandis Wats.

910, Fuller's Ranch, 7500 (P. J. B. L.)—*Panicularia Americana.*

Puccinellia airoides (Nutt.) Wats. & Coult.

4026, Myer's Ranch, Bear River, near Evanston, in alkaline soil, 7500 (P. & B.)

Festuca brevifolia R. Brown.

149, Wilson's Peak, 9800 (P. & S.).

Festuca elatior L. var *pratensis.*

3883, Peterson Canon (P. & B.); Bear Lake, meadows (P. B. L. & R.); *3633,* Farmington Canon, 4500 (P. & B.); *262,* Farmington Canon (P. B. L. R.).

Festuca Kingii (Sereno Watson) Scribner.

Bear River, Hayden's Fork (P. & S.); *44,* Ogden, Utah (P.).

Festuca octoflora Walt.

1606, Junction East and Middle Black's Fork, 9500 (P. J. L. B.); *886, 1605,* La Motte Peak, 11500 (P. J. B. L.); *885,* Black's Fork, 9200 (P. J. L. B.).

Festuca ovina L.

4250, Stillwater Canon, Bear River, 9000, in gravel bed of stream (P. & B.).

Festuca ovina var.

1602, 1619, East and Middle Black's Fork, dry places, 10000 (P. J. L. B.); *1604,* Junction East and Middle Black's Fork (P. & S.).

Festuca rubra L.

76, West Bear River, 9500 (P. & S.); *84,* Hayden's Fork, Bear River, 9500 (P. & S.).

Festuca rubra L. var *grandiflora* Hack.

86 A, Mill Creek, 8200 (P. & S.).

Festuca Thurberi Vasey.

1696, Black's Fork, 7500 (P. J. L. B.).

Bromus

318, 575, Logan Canon, 460 (P. B. L. R.); *263,* East Fork of Weber, 9000 (P. & S.).

Bromus

1629, Moss Creek, 8500 (P. J. B.); *3732,* Ogden Canon, 5000 (P. & B.).

Bromus arvensis L.

34, Farmington Canon, 4500 roadsides (P. B. L. R.).

Bromus brizaeformis Fisch & Mey.

3738, Ogden, 4900, a common weed (P. & B.).

Bromus marginatus Nees.

275, East Provo Canon, 8500 (P. & S.).

Bromus pallidus (Hook.) Shear.

267, 277, Duchesne River, 8500 (P. & S.) ; *273,* East Lake Fork, 8500 (P. & S.).

Bromus polyanthus Scrib.

264, East Provo Canon, 8000 (P. & S.) ; *266,* West Bear River (P. & S.), 9500; *268,* Moffatt Creek, 9500 (P. & S.) ; *4253,* Stillwater Canon (B.) ; *266 A,* in meadows, West Bear River, 9500 (P. & S.) ; *274,* Kamas, 6850 (P. & S.) ; *968,* Middle Muddy Creek (P.) ; *574,* Mt. Logan (P. B. L. & R.) ; *512,* Bear Lake, 6000 (P. B. L. & R.).

Bromus Porteri (Coulter) Nash.

4002, Peterson, Weber River, 6500, river bottom (P. & B.) ; *271,* West Duchesne, 7200 (P. & S.) ; *270,* Rhodes Canon, 8000 (P. & S.) ; *265,* Junction East and West Provo River, 7400 (P. & S.).

Bromus Richardsoni Link.

964, Black's Fork, 9500 (P. J. B. L.) ; *267,* Wilson's Peak (P. & S.) ; *960, 961,* Black's Fork, 9500 (P. J. L. B.) ; *967, 576,* La Motte Peak, 10500, in meadows (P. J. B. L.) ; *962,* Fuller's Ranch, 8000 (P. J. B. L.).

Bromus secalinus L.

3635, Farmington Canon, 4500 (P. & B.).

Bromus tectorum L.

3636, Farmington Canon, 4300, in grain fields (P. & B.) ; *4245,* Logan Canon, 4700 (P. B. L. & R.) ; abundant; *7215,* Evanston (Aven Nelson).

HORDEAE.

Agropyron

263, Taylor Mt. (P. & S.) ; *261,* West Branch Bear River (P. & S.) ; *243,* Burnt Fork (P. & S.) ; Junction East and West Fork of Provo River (P. & S.) ; *263,* East Duchesne River (P. & S.) ; *276,* East Provo Canon (P. & S.) ; *1636,* Junction East and Middle Black's Fork, 9500 (P. J. L. B.) ; *3728,* Ogden (P. & B.) ; *1698, 1682, 1552, 1558,* Fuller's Ranch, Black's Fork; *911, 1685, 1639,* Echo (P. J. B. L.).

Agropyron caninum (L.) Beauv.

3533, Emigrant Canon, Salt Lake (P. & B.).

Agropyron dasytachyum (Hook.) Scrib.

Peterson Canon (P. & B.); *253,* Taylor Mountain (P. & S.); Black's Fork (P. J. B. L.); *904,* Junction East and West Black's Fork (P. J. L. B.); *3989, 4004,* Peterson Canon, dry soil (P. & B.); *1580,* Evanston (P.), Evanston (Aven Nelson); *1574,* Echo (P. J. B. L.); *1583,* Fuller's Ranch, Black's Fork (P. J. L. B.); *106, 115,* Salt Lake City, City Creek, 4700 (P. B. L. R.); *256,* West Bear River, 9500 (P. & S.); *259,* East Provo Canon (P. & S.); *257,* Junction East and West Provo (P. & S.).

Agropyron lanceolatum.

229, West Bear River, 9500 (P. & S.).

Agropyron pseudorepens, Scrib. & Smith.

1633, East Middle Black's Fork, 10000 (P. J. L. B.); *1634,* Evanston, Wyo., Bear River, 7000 (P.); *969, 1635,* Junction East and West Black's Fork, 10000 (P. J. L. B.); *1553,* Black's Fork, 8000 (P. J. L. B.); *255,* Bear River, 9500 (P. & S.); *226,* Sumner, Utah, 7468 (P. & S.); *249,* Junction East and West Fork Provo River, 7400 (P. & S.); *250,* West Black's Fork, 8500 (P. & S.); *87,* Bear River, Hayden's Fork (P. & S.); *1539,* Echo (P. J. B. L.); *4022,* Bear River (P. & B.); *4293,* Stillwater Canon (P. & B.).

Agropyron Smithii Rydb.

Piedmont, Wyo., (P.); Echo (P. J. B. & L.); *1683,* Salt Lake City, Saltair Beach (P. J. B. L.); *72,* Placerville, Col.; *7330* (P. B. L. R.); *251,* White Rock Agency (P. & S.); Burnt Fork (P. & S.); *248,* Vernal (P. & S.); Echo (P. J. B. L.); *1680,* Junction and East and Middle Black's Fork (P. J. L. B.).

Agropyron spicatum (Pursh.) Rydb.

232, Kamas (P. & S.).

Agropyron Richardsonii Schrad.

231, Kamas, 6850 (P. & S.); *244,* Burnt Fork, Wyo., (P. & S.); *241, 242,* Duchesne River, 8500 (P. & S.); *258,* East Provo Canon, 8000 (P. & S.); *260,* East Lake Fork, 8500 (P. & S.); *254,* West Bear River (P. & S.), 9500.

Agropyron riparium S. & S.

237, Kamas, 6850 (P. & S.).

Agropyron tenerum Vasey.

Black's Fork, 800 (P. J. B. L.) ; *246, 247, 252*, Burnt Fork (P. & S.) ; *227*, Salt Lake City (P. & S.) ; *240*, Duchesne River, 8500 (P. & S.) ; *238*, West Duchesne River, 7200 (P. & S.) ; *228*, White Rock Agency ; *1581*, Black's Fork, 10000 (P. J. B. L.) ; *1582*, Echo (P. J. B. L.) ; *1578*, Black's Fork, 9200 (P. J. B. L.) ; *4279*, Myer's Ranch, Evanston (P. & B.).

Agropyron violaceum (Hornem.) Lange.

234, Soapstone Creek, 9500 (P. & S.) ; *970, 1595*, Black's Fork, 9200 (P. J. B. L.) ; *1592*, East Middle Black's Fork (P. J. B. L.) ; *239*, East Lake Fork, 8500 (P. & S.) ; *236*, West Duchesne, 7200 (P. & S.).

Hordeum aegiceras Royle=(*H. trifurcatum*).

Cultivated San Miguel Mountains, Col., 8000.

Hordeum caespitosum Scribner.

Long slender spikes, awns shorter than *H. jubatum.* This species is abundant in the region, also abundant in Wyoming, east of range to Evanston. Ogden.

203, 204, Salt Lake, in alkaline seepage soils.

Hordeum jubatum L.

This grass is abundant in the region west of the Rockies, frequently associated with the preceding.

1559, Echo (P. J. B. L.) ; *4068*, Bear River, 7000 (P. & B.) ; *3552*, Sulphur Springs, Salt Lake (P. & B.).

Hordeum murinum L.

A common weed in Utah. Especially foothills.

3554, Salt Lake City (P. & B.) ; *24*, Ogden.

Hordeum nodosum L.

This grass is abundant in mountain meadows.

4019, Bear River, 7000 (P. & B.) ; *902*, East Black's Fork, abundant in meadows with willows and blue grass 10000 (P. J. B. L.) ; *1557*, Ridge between Smith's and Black's Fork, 10000 (P. J. B. L.) ; *1558*, Fuller's Ranch, Black's Fork (P. J. B. L.).

Secale cereale L.

514, Garden City, Bear Lake, Utah, 6000 (P. B. R. L.).

Triticum vulgare L.

1564, Saltair Beach, Salt Lake City, Utah (P. J. B. L.).

Elymus canadensis L.

124, Duchesne River, 8500 (P. & S.); Ogden (S. M. Tracy); *3739*, Ogden Canon, along ditches (P. & B.).

Elymus condensatus Presl.

West Duchesne, 7200 (P. & S.); *120*, Burnt Fork, Wyo., (P. & S.); *122*, Helper, 9500 (P. & S.); *239*, Logan Canon, 5000 (P. B. L. R.); *207*, Salt Lake, Utah, (P.); *1596*, Echo (P. J. B. L.); *405*, Peterson, Weber River, Utah (P. B. VP. HP.); 6500, Wasatch (P.); *312* Wasatch, 6824 (P.); *211* Weber Canon (P.).

Elymus glaucus Buckl.

1127, Junction East and West Fork of Provo River, 7400 (P. & S.); *126*, East Provo Canon, 8000 (P. & S.).

Elymus robustus, Scrib. & Smith.

3631, Farmington (P. & B.).

Elymus simplex, Scrib.

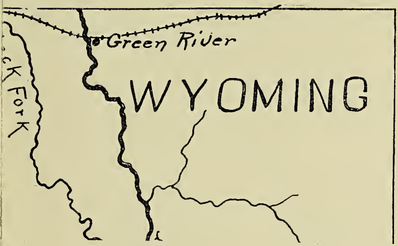
237, Duchesne River (P. & S.).

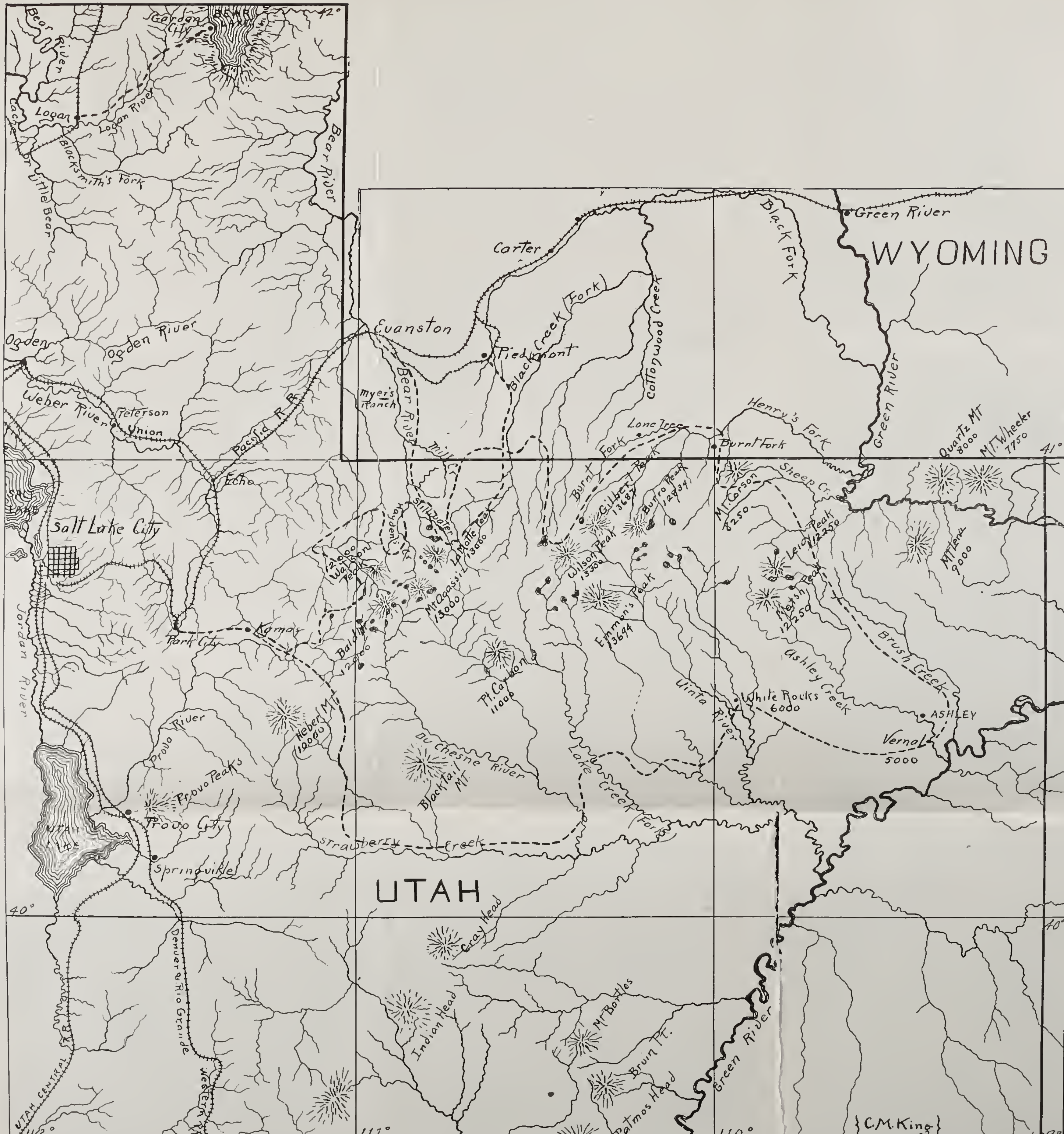
Elymus triticoides Buckl.

860, Echo, 6000 (P. J. B. L.); *4007*, Peterson Canon, Weber River, 8000 (P. & B.).

Sitanion brevifolium J. G. S.

1612, Junction East and Middle Black's Fork, 9500 (P. L. B.); *161*, Black's Fork (P. J. B. L.); *1614*, Muddy Creek, Uintah Mts. (P. J. B.); *1613*, Ridge Black and Smith Forks (P. J. B. L.); *189*, Lake Fork, dry scil, 8500 (P. & S.).


Green River
WYOMING


WYOMING
UTAH
Green River
Black Fork
Carter
Evanston
Piedmont
Black Creek (Fork)
Cottonwood Creek
Henry's Fork
Lone Tree
Burnt Fork
Bear River
Logan
Logan River
Blacksmith's Fork
Little Bear
Ogden
Ogden River
Weber River
Peterson
Union
Pacific R.R.
Echo
Salt Lake City
Park City
Kamas
Jordan River
Provo River
Provo Peaks
Provo City
Springville
Utah Lake
Strawberry Creek
Du Chesne River
Blacktail Mt.
Heber Mt. 10060
Lake Creek (Fork)
Uinta River
White Rocks 6000
Ashley Creek
Brush Creek
Ashley
Vernal 5000
Mt. Agassiz 13000
Wilson Peak 13300
Gilbert Peak 13687
Burro Peak 12934
Emmon's Peak 13694
Mt. Carson 8250
Leidy Peak 12250
Marsh Peak 12250
Sheep Cr.
Quartz Mt 8000
Mt. Wheeler 7750
Mt. Lena 9000
Pt. Carbon 11000
Bald Mt. 12000
Gray Head
Indian Head
Mt. Bartles
Bruin Pt.
Patmos Head
Denver & Rio Grande Western
Utah Central R.R.
40°
41°
42°
109°
110°
111°
112°
C.M. King

THE DICLINOUS FLOWERS OF *IVA GANTHIIFOLIA*, NUTT.

BY CLIFFORD H. FARR.

Relatively few of the Compositae have been studied throughout their whole life history. Most investigations have dealt with the varied expressions of a single structure, such as vascular anatomy, style, etc., in various genera of this family. However valuable such research it cannot replace the more intensive study of a single species. Only by this latter method can the different morphological structures be satisfactorily interpreted and relationships established.

Probably no group of Angiosperms displays a wider range of dicliny. In some species all the flowers are perfect; in a few there are pistillate and staminate individuals; while the remaining forms display almost all possible intermediate conditions. Uexkull-Gyllenband (14) and others have called attention to the fact that several forms of dicliny may occur within a single species.

This study was undertaken in the hope of throwing some light upon the organography of the capitulum of the Compositae. *Iva xanthiifolia,* Nutt was selected since it possesses both pistillate and staminate flowers in the same head. The former are always marginal and the latter are always central thus displaying a very stable condition with respect to the differentiation of sex.

The material was collected during the summer of 1911 in the vicinity of the Macbride Lakeside Laboratory on West Okoboji Lake in Iowa. The writer is indebted to Professor R. B. Wylie for many helpful suggestions and for his kindness in directing the work.

INFLORESCENCE.

The flowers of *Iva xanthiifolia,* Nutt. are arranged in the capitulum in concentric cycles of five flowers each (fig. 1), the members of successive whorls alternating. The outer cycle consists of five pistillate flowers, each in the axil of a large involucral bract. The staminate flowers, numbering 11 to 23 in each head, make up the remaining whorls. Development is in acropetal succession, often leaving the youngest inner cycle incomplete. Britton (1) places the number of staminate flowers at 10 to 15, which is too low for the material examined in this study. Danforth (3) and others have shown that certain of the Compositae have their flowers arranged in spirals. It is possible that in *Iva* the cyclic arrangement of flowers may have been derived from the spiral. The cyclic arrangement of the parts of the angiosperm flower has long been considered as derived from an ancestral spiral arrangement through the shortening of the floral axis. It appears that in the Compositae a similar transition has occurred with respect to the arrangements of flowers in the head, the cyclic being derived from the spiral through the shortening of the spike to form the capitulum.

A floral bract subtends each flower in the head, except the outer whorl of staminate flowers. The slender bracts of all other central flowers are short and stand erect in the interstices between the flowers. The bracts of the marginal pistillate flowers, on the contrary, are very large, taper to a point and conform to the inner surface of the subtending involucral bracts. Britton (1) suggests that these constitute an inner whorl of involucral bracts. This study shows that they are intimately associated with the pistillate flowers (figs. 7, 8, 9, and 10) during their development and are morphologically similar to the floral bracts of the staminate flowers. Furthermore, if Warming's (15) theory of the spicate origin of the capitulum is accepted, it would seem that these structures, subtending the pistillate flowers, should be considered floral bracts.

The abortion of the floral bracts of the outer whorl of staminate flowers is probably due to their peculiar position. It is evident that the excessive lateral development of both the involucral bracts and the bracts of the pistillate flowers would result in crowding and excessive protection in this region. Knupp (7) believes that the development of the sepals of *Myriophyllum* was arrested through excessive protection. Warming (15) attributes the formation of pappus from the typical calyx to the pressure and crowding of flowers in the head. It is possible that these factors may have resulted in *Iva* in the complete abortion of the bracts of the outer whorl of staminate flowers.

A study of the vascular anatomy of the head shows that the marginal flowers are most closely connected with the bundles of the stem. Each of the five strands entering the head proceeds directly to an involucral bract. The pistillate flower is supplied by a branch from this bundle. Normally the flowers of each succeeding cycle receive their vascular supply through branches from the bundles of the next outer cycle. Whatever the determining factors in the arrangement of this system, the significant fact in the present consideration is that the more nearly central the flower, the farther it is removed from the main vascular supply.

THE STAMINATE FLOWER.

The four microsporangia of each stamens are about equal in size at an early stage, but later the outer become somewhat larger. This may be a mechanical adaptation, since the space available for growth is restricted by the tubular coralla. The stamens enlarge until they touch and the walls of adjacent stamens unite by the fusion of contiguous cutinized layers (fig. 6). It is possible by considerable pressure to separate the anthers of *Iva*. However the fused layers were in no case found to separate, although the cutinized layers sometimes broke loose from the epidermis. Tschirch (12) holds that the anthers of the Compositae remain permanently grown together, "dauernd verwacksen bleibt," since he was unable to separate them either mechanically or by treatment with chemical reagents. Britton (1) has taken the *Ambrosia* tribe out of the Compositae on the ground that their anthers are "not truly syngenesious." It seems that typical Compositae are not alike in this respect, as is shown by Stadler's (12) study of Cnicus in which the walls of adjacent inner microsporangia never fuse. It therefore seems probable that Gray (6) is fully warranted in including *Iva* among the Compositae.

The first sugestion of dehiscence is found in the breaking of the walls between the inner and outer microsporangia. Schneider (11) has suggested that this may be due to a growth of the pollen. In *Iva* the pollen grains do enlarge just before maturity and this probably contributes to the rupturing of the walls.

The lateral pollen sacs of adjacent stamens break together, through the dissolution of the central portion of the lateral wall of each stamen. In this way five large pollen chambers are formed, in the flower, each enveloped by an intact wall and containing the pollen grains of four microsporangia,—the lateral pair of each of the two contiguous stamens (fig. 5).

Five very small structures, having the appearance of nectaries, stand about the base of the pistil and alternate with the filaments (fig. 4). Martin (8) interprets similar structures in *Aster* and *Solidago* as "imperfectly formed stamens." Goebel (5) has presented evidence that certain nectaries arise by the transformation of various morphological structures. Merrell (8) suggests that, "It is much more reasonable to regard the nectary as an organ of independent origin." Of course it is quite possible that nectaries may arise in either way, but unless evidence to the contrary is shown, it seems better to consider them derived structures. These small structures in Iva may therefore be considered vestiges of an inner whorl of stamens.

The development of the pistil of the staminate flower is very different from that of the fertile flower. No ovarian cavity is formed, but quite early a notch appears in the center of the upper surface of the papilla (fig. 3). This notch is later obliterated by the growth of large hairs which form a broad capitate disc at the apex of the mature style. Although Chamberlain (2) contends that this style "is undivided," it is seen to be somewhat cleft during its development, an indication or derivation from the typical bifid form.

The abortive pistil doubtless aids in the dehiscence of the anthers. As the style elongates it pushes against the hook-like tips ("Anhangseln" 4) of the stamens, which arch over its capitate disc, and in this way probably tears open the pollen chambers. The capitate structure seems to serve a further purpose during pollination in preventing the microspores from being shed *en masse*. Wernham (16) believes that in the Compositae the style "forces its way through the anther tube, sweeping the pollen before it." That this is not the case in *Iva* is shown by the position of the style prior to dehiscence (fig. 4), the brush hairs being above most of the pollen mass.

That this structure in the center of the staminate flowers of *Iva xanthiifolia*, Nutt. is a rudimentary pistil can scarcely be doubted. The position, the tardy appearance, the notch, the brush hairs and the stylar thrust all point to this interpretation.

THE PISTILLATE FLOWER.

The development of the pistillate flower presents only a few peculiarities. The coralla is abortive, never becoming lobed, and does not normally develop to more than one-fifth the length of the mature style (fig. 10). In contrast with Silphium (9) the abortive stamens of the pistillate flower of *Iva* appear after the carpels. Furthermore these rudimentary stamens are not distinct but form a continuous collar-like structure about the base of the style. That this collar is the vestige of a whorl of stamens is further indicated by an abnormal flower which was found in the material examined.

ABNORMAL FLOWERS.

In one of these abnormal pistillate flowers the only irregularity consisted in the lengthening of the abortive coralla, which was better developed on the inner than on the outer side. In another marginal flower (fig. 11) the parts on the outer side were developed like those of the normal pistillate flower. On the inner side, however, they took the form of the staminate flower, the coralla and stamens being fully formed. This modification even extended to the style which bore brush hairs on the inner (staminate) side. On the lateral side of the flower there was a gradual transition between the two conditions (fig. 12), two stamens aborting at the mother-cell stage. On the other lateral side an abrupt change from the pistillate to the staminate form occurred. At this point there was present an opening in the ovarian wall between the coralla and the base of the style. The abnormal flowers suggest that the normal pistillate flower possesses both abortive stamens and an abortive coralla, and that the staminate flower possesses an abortive pistil, which indicates the derivation of both forms from the perfect flower.

DISCUSSION AND SUMMARY.

The study of floral development in Iva xanthiifolia, Nutt. reveals strong evidence that the capitulum is, as Warning (15) held, phylogenetically a contracted spike. The meristematic region in the center of the head is suggestive of apical growth. The existence of floral bracts within the head points to the previous arrangement of flowers in the axils of subtending leaves. And the vascular system, in so far as it is dependent upon recapitulation for its form, is likewise indicative of axial organization.

Considerable difference of opinion has arisen as to whether the ancestral form of the Compositae possessed perfect or diclinous flowers. Lecoq, Delpino, Dammers and Müller contended that hermaphrodite flowers were derived from the unisexual forms. Spruce, Bentham, Darwin, Hildebrand, Warming and Uexkull-Gyllenband held that perfect flowers represent the primitive condition and that monosporangiate flowers have arisen by the abortion of stamens or pistils. In Iva the abortive pistil which still functions in opening the anthers, indicates the derivation of the staminate flower from the hermaphrodite. In like manner the abortive stamens, which occasionally develop into pollen-bearing members, suggest a similar origin for the pistillate flower. So that the evidence presented in this study favors the view that the unisexual condition is derived.

Assuming, then, that the pistillate and staminate flowers have arisen from the perfect, one seeks an explanation of this differentiation. The conditions surrounding the staminate flowers are in several ways unlike those of the pistillate. The opening of the involucral bracts exposes the central flowers first and the marginal last. Furthermore, while the involucral bracts are open they shield the marginal flowers almost completely from the direct rays of the sun and from drying currents of air (fig. 2). At the same time the central flowers are subjected to the drying effect of both wind and sun. The marginal flowers are, in addition, protected by their large floral bracts, while with the central flowers these structures are either wanting or else rudimentary. The convexity of the receptacle results in the elevation of the central flowers and hence increases their exposure. The central flowers, moreover, appear last and therefore have a shorter time in which to develop before the buds opens. Nissen (10) found that the vascular bundles which enter the staminate flowers of the Compositae are composed of smaller elements than those entering the pistillate. The water supply of the central flowers is further reduced in *Iva* by their being farther removed from the main vascular supply. In fact, the whole organization of the head is such that the marginal flowers receive a maximum of protection, while the central flowers are subjected to a maximum of exposure. May not the difference in the surroundings of these two kinds of flowers have given rise to the difference in structure?

It is apparent that the androecium of a flower is better adapted, both in structure and function to endure dessication than is the gynoecium. The stamens are relatively short lived and both dehiscence and pollination are facilitated by dryness. With the shedding of pollen the work of the stamen is completed, while the development of the pistil has only fairly begun. The pistil, at maturity, must expose a delicate stigma, and, after fertilization, the growing embryo must be nourished and the seed developed. So that it seems quite probable that the exposure of the central flowers may have resulted in the abortion of their pistils.

The abortion of the stamens in the marginal flowers, is, however, doubtless due to other causes. In an epigynous flower the stamens are necessarily elevated. In the flowers under consideration such a position would bring them into contact with the enlarged ends of the corallas of adjacent staminate flowers on the one hand, and with the apices of convex floral and involucral bracts on the other. It therefore seems that this crowding of the stamens may have prevented their growth.

While decliny has probably become hereditary, the original cause for such differentiation seems to lie in the difference in the conditions surrounding the two kinds of flowers. The existence of a capitulum of this kind necessitates the greater exposure of some flowers and the marked protection of others. Whether this interpretation will hold for other species can only be told after careful investigation of their heads. But it now seems that dessication will adequately explain the origin of the staminate flower and excessive protection the origin of the pistillate.

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EXPLANATION OF PLATES.

All drawings were made with Spencer camera lucida, except figures 1, 2, 5 and 12. The plates are reduced one-half in reproduction. Figures 3, 4, 7, 8, 9 and 10 were made with Spencer 16 mm. objective and 4 ocular. Figure 6 was made with Bausch and Lomb $^{1}/_{12}$ immersion objective and 4 ocular. The original magnifications in diameters were approximately as follows: figure 1, 35; figure 2, 105; figures 3, 4, 7, 8, 9, 10, 11 and 12, 210.

The abbreviations employed in describing figures are as follows: i, involucral bract; f, floral bract; p, pistillate flower; s, staminate flower; c, coralla; l, carpels; y, style; m, stamens; r, abortive stamens; e, epidermis.

Fig. 1. Diagram of capitulum.
Fig. 2. Longitudinal section of one-half of capitulum.
Fig. 3. Young staminate flower in longitudinal section.
Fig. 4. Nearly mature staminate flower in longitudinal section.
Fig. 5. Floral diagram of staminate flower at maturity.
Fig. 6. Fused walls of two adjacent stamens in cross section.
Fig. 7. Young pistillate flower showing appearance of corolla.
Fig. 8. Young pistillate flower showing appearance of carpels.
Fig. 9. Immature pistillate flower showing beginnings of rudimentary stamens.
Fig. 10. Nearly mature pistillate flower in longitudinal section.
Fig. 11. Abnormal flower in longitudinal section.
Fig. 12. Floral diagram of abnormal flower.

Since this paper was presented to the Academy there has appeared in the Transactions and Proceedings of the Botanical Society of Edinburgh for 1913, a paper by Dr. K. von Goebel on "The Inflorescences of the Ambrosiaceae." In this no mention is made of *Iva*, but there is reference to an article on the same subject by S. Rostowzew in Bibliotheca botanica Heft 20. The latter paper is primarily a study of the systematic position of the members of this group, and presents certain of the facts noted above. The author attempts however no interpretation of the rudiments, etc., nor does he discuss the origin of the inflorescence of this form.

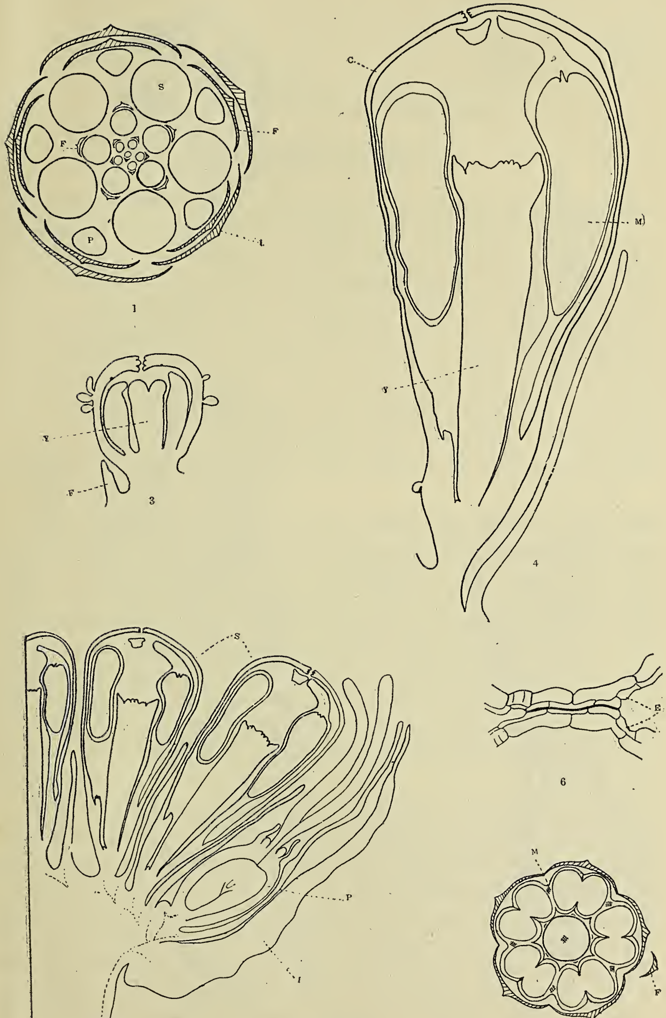

Plate 1.

Plate 2.

PHYLOGENY OF THE ARACEAE.

By James Ellis Gow.

The study of the Morphology of the Aroids has been almost completely neglected by botanists. This is unfortunate, since the group is, in a sense, pivotal. Its anatomical characteristics indicate a relationship with the *Naiadaceae* and their allies; together with a more distant connection, on the one hand with the Screw-pines and Palms, and on the other with the grasses. Points of relationship to the *Liliaceae* are not lacking, and there are some indications of affinity with the more primitive members of the *Dicotyledons*. At the same time, the group is by no means a doubtful assemblage, but has a distinctive character of its own. In view of these facts, its Morphology and Phylogeny should prove most interesting, and should throw some light on the more general problems of descent and relationship.

In the past but little work has been done along this line. In 1892 Mottier published an account of the embryo-sac in *Arisaema triphyllum*. Duggar, in 1900, described the development of the pollen grain in *Symplocarpus* and *Peltandra*. Between 1900 and 1905 Campbell published a series of articles on the Morphology of *Lysichiton kamschatcense*, *Anthurium violaceum*, *Nephthytis liberica*, *Dieffenbachia seguine*, and *Aglaonema commutatum*. Practically no other work has been done along this line up to the time when the present investigation was undertaken. The few scattering references to Aroids contained in occasional papers on closely related subjects embrace nothing of value in the present discussion.

In 1906 the writer undertook the investigation of the embryo-sac of a number of species of Aroids, with the intent of ascertaining whether the members of this family follow the typical eight-celled plan of embryo-sac formation, or vary from it. As the investigation proceeded its scope broadened. It was found possible, in the case of many species, to secure good sections showing phases of megaspore and microspore development, and in all such cases, this was included in the scope of the investigation. The development of the endosperm and embryo in a number of species was also studied somewhat in detail, and some definite conclusions reached; and a few cases of abnormal development suggested new morphological interpretations.

In all, eighteen members of the family *Araceae* have been studied in the laboratory. In some cases the history has been worked out with substantial completeness. In others, it was impossible to obtain material in all stages of development, and a study has been made of certain isolated phases in the life history of the plant. In all cases the results are of some morphological significance. Aside from the difficulty of obtaining material in all stages of development, serious difficulties were encountered in handling the plants in the laboratory. Most members of this family contain a more or less tenacious gum or mucilage. These substances vary in the different species. Some of the gums are soluble in water (as in the case of *Arisaema* and *Richardia*), some are insoluble in water but soluble in alcohol (as in *Philodendron Wendlandii*) and some are quite insoluble in either liquid. In most cases the gum absorbs water readily and when placed in an aqueous fixing medium swells into a thin tenaceous jelly, distorting the tissues and ruining the preparation. *Acorus calamus* proved especially troublesome in this respect. A saturated solution of corrosive sublimate in absolute alcohol dissolved the gum in most species, but is a poor fixing agent on account of the distortion of the tissues. *Acorus* proved refractory even to this reagent, and the results, in the case of that species, were poor. The mucilage of *Homalomena argentea* dissolves in one per cent acetic acid, but better yet in acetic alcohol. Other species show varying reactions indicating individual differences in the nature of the mucilaginous substance. In spite of these and other difficulties, good results, of definite significance, have been obtained and, in part, published in the Botanical Gazette for the years 1907, 1908, and 1913.

While engaged in the morphological work above described, the writer became interested in the Phylogeny of the primitive *Monocotyledons*—including, of course, the *Araceae*—and for his own satisfaction began attempting to work out a rational genetic classification, based in part upon our existing knowledge of the Anatomy of the *Arales* and his own study of Aroid Morphology. The latter thus was built into, and became a part of, a larger and more extensive scheme. Although in the present state of Botanical knowledge we cannot speak with dogmatic assurance regarding the descent and affinities of this or any other family; nevertheless the evidence of Anatomy and Morphology is now sufficiently complete that some more or less definite conclusions can be drawn therefrom. The writer has been led to question some existing theories regarding the affinities of the *Monocotyledons,* and will here present some conclusions of his own as the Phylogeny of the group, together with the evidence on which the conclusions rest.

1. Spiral character of the Aroids: It is the commonly accepted theory that the spiral arrangement is older than the cyclic. This seems reasonable, since the cycles of floral parts may be conceived of as a reduced spiral, and the position of the organs in such cases bears out this interpretation. The fact that the outer organs may become cyclic while the inner remain spiral also fits in with the theory, and when in addition to this one reflects that in the Dicotyledons spirality appears only in the Archiclamydeae, while the younger and more highly specialized Sympetalae shows no sign of it, the weight of evidence seems quite conclusive. The theory is well expressed by Coulter & Chamberlain as follows:

Among the most primitive flowers the floral axis tends to elongate, and the members appear in indefinite numbers along a low spiral. In more highly developed flowers the growth of the axis in length is checked at a very early period, so that the spiral along which the members successively appear becomes lower and lower, until it has only a theoretical existence, passing into successive cycles, which eventually become limited in number. With the appearance of definite cycles, the number of members appearing in each one becomes limited, the limit in Monocotyledons being prevailingly three, and in Dicotyledons five or four. It is to be noted that the cyclic arrangement is not attained simultaneously by all parts of the flower. For example, in many species of *Ranunculus* the sepals and petals are cyclic, or approximately so, while the stamens and carpels are distinctly spiral. This tendency is so well marked that Engler has used it as a basis for dividing Monocotyledons into two great series, the "spiral series" comprising all those families that show the spiral tendency in any of the floral sets, and the "cyclic series" comprising all those whose flowers are completely cyclic, the former series including all the more primitive families. There is no reason why this same distinction cannot be applied also in a general way in the Archichlamydeae. This gradual transition of flowers from the spiral to the cyclic condition is one of the best marked tendencies in their evolution, and has the advantage of being represented by innumerable intermediate stages. All of those families which are now recognized as being of the highest rank have completely cyclic flowers, with members appearing in definite and low numbers, notably illustrated by the whole group Sympetalae.—(Morphology of Angiosperms, p. 11.)

It should be borne in mind that these words refer in no way to the arrangement of the blossoms on the stalk, but simply and solely to the arrangement of the sepals, petals, stamens, and carpels, in the individual blossom. So far as the arrangement of floral parts is concerned, the course of evolution appears to have been in the direction of progressive reduction of the axis, resulting in a shorter and shorter spiral, and culminating in a completely cyclic condition.

When we come to consider the arrangement of the flowers on the stalk, we find a corresponding tendency. The blossoms are at first scattered spirally over an extremely elongated axis. (Many of the Sympetalae have chosen to preserve this arrangement, but show a compensatingly high development of the corolla, thus adapting themselves to entomophily by modification of the individual flower, rather than by grouping of the flowers.) The shortening of the axis may result (*a*) in a corresponding broadening and flattening, as in the Composites. In this case, the spiral origin is usually evident in the arrangement of the blossoms on the flattened axis, but a sufficient reduction of the number of blossoms would lead to a perfectly cyclic arrangement; and often the outer ray flowers are cyclically arranged. (*b*) The axis may be greatly shortened without being broadened or flattened, the individual peduncles being reduced but not eliminated, and the leaves in whose axes they stand may persist as subtending bracts. This gives rise to all the varying sorts of heads, spikes, and catkins. (*c*) The flower stalks and subtending bracts may be completely eliminated, and the flowers may become densely crowded on a greatly shortened axis—the spadix. This results in the closest possible grouping of blossoms, the only thing comparable to it in this respect being found in the Compositae. A single bract—the basal one—persists, and often becomes petaloid. (*d*) Whorled leaves, in whose axes blossoms may be borne, and floral whorls (ex: umbels) must be regarded as examples of extreme reduction of the axis, and are of course cyclic. The general tendency, therefore, in the grouping of flowers, seems to be (1) to pass from a loose to a dense spiral, and (2) from the spiral to the cyclic habit, or to something approaching it. But it is to be noted that, whereas the organs making up the flower have attained in most cases a perfectly cyclic arrangement, the arrangement of blossoms on the stalk is usually completely or partially spiral, and seldom shows more than a faint approach to cyclicism. Apparently therefore the tendency to axis reduction and cyclicism as applied to the position of individual flowers on the stalk must be very recent as compared with the same tendency in the arrangement of the parts of the flower.

Presumably, at some point in the ancestry of the present Spermatophytes, the individual sporophylls which now compose the flower were spirally arranged along an elongated axis. The very evident advantages to be obtained by closer grouping sufficiently explain the progressive reduction of the axis. The closer grouping would make possible a reduction in number, and when the floral whorls consist each of a limited number of members standing in the same plane, the climax of cyclicism has been attained. (This applies of course to floral leaves as to sporophylls. Their relation will be discussed later.)

If this theory be correct, the change from the spiral to the cyclic habit in the arrangement of floral parts must have occurred at a very early period, for in the Mesozoic *Bennettitales* we find the spirally arranged carpels surrounded by cyclically arranged stamens. Nevertheless most plants that can be recognized as primitive show the spiral rather than the cyclic arrangement. Spirality among Angiosperms must be regarded as a more or less vestigial characteristic, and the genera exhibiting it must be regarded as representatives of the more primitive phyla. No such characteristics are known in the family *Araceae*. Incomplete flowers consisting of a single carpel, or a pair of stamens, are common, and it is of course impossible to definitely classify such imperfect representatives of floral structure, but when a complete flower occurs it is invariably cyclic. Therefore, all other things being equal, the *Araceae* are to be regarded as less primitive than are those families whose flowers show distinctly spiral arrangement of parts. An acquaintance with the Aroid structure makes it evident (1) that the process of axis reduction, and reduction of floral parts has here reached its climax, in the formation of a perfectly cyclic flower and (2) that the process of stalk reduction and crowding of blossoms has been carried to its climax, *without corresponding reduction in number*, so that the group of flowers remains completely spiral, no trace of an approach to cyclicism being discernible. The *Araceae* are not therefore as primitive a group as might at first appear. While they are perhaps one of the more primitive groups of the Monocotyledonous alliance, they are by no means the most primitive, and they certainly are far less primitive than are those Dicotyledons the parts of whose blossoms are spirally arranged, if floral structure is to be taken as any criterion.*

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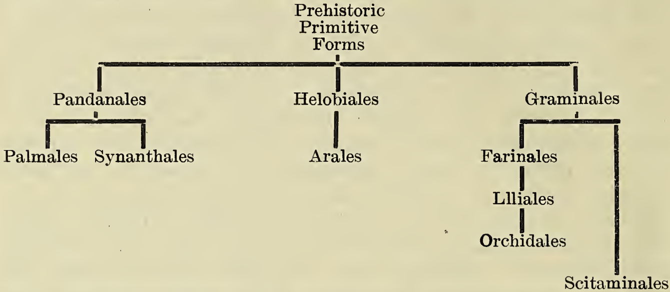
*A sharp distinction should be drawn between spirality of parts of the flower, and spirality of flowers on the stalk. The spirality of the Aroids is not to be compared, for instance, with that of the *Ranunculaceae*. In the latter case the sporophylls are spirally arranged in the blossom, while in the former the cyclic blossoms are spirally arranged on the stalk. The difference is indicated by the fact that the stamens are above in the Aroids and below in the *Ranunculaceae*. In the flower, the staminate sporophylls occur below the pistillate, but on the axis of a monoecious plant the staminate flowers usually occur above the pistillate. (Doubtless this is a vestige of primitive anemophily.)

The writer must protest against such confusion as appears in the following statements:

According to Engler, the general tendency among Monocotyledons is to advance from naked flowers with *parts* spirally arranged and indefinite in number to pentacyclic trimerous flowers. * * * Engler has subdivided the monocotyledous into ten great alliances. The first six constitute the more primitive Spiral series, * * * the spiral arrangement and indefinite numbers occurring in one or more sets.—Coulter and Chamberlin. Morphology of Angosperms, p. 228.

Among the first six orders of Engler occur the *Arales*, but surely nobody can pretend that this order has "naked flowers with parts spirally arranged." The spirality lies entirely in the arrangement of the flowers on the spadix, and not at all in the arrangement of the parts of the flower. If we are to group families with reference to spirality, we should have two groups, one based on spirality of floral parts, the other on spirality of flowers on stalk.

2. Place of the *Araceae* in the natural system: In their "Morphology of the Angiosperms" Coulter and Chamberlain suggest a scheme of relationship for the various orders of Monocotyledons, which, when expressed diagrammatically, may be represented as follows:

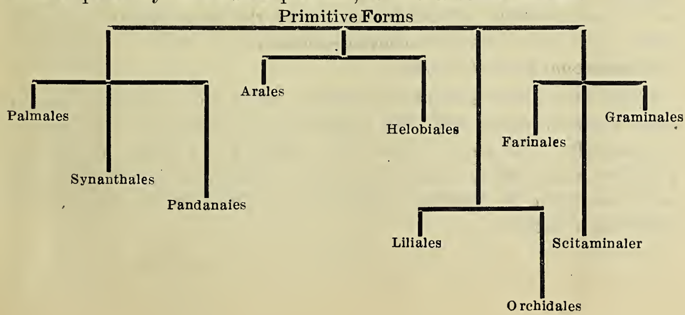


In this scheme of descent, the Aroids are placed next to the *Helobiales,* which they strongly resemble in many ways, with the suggestion that the latter are probably the more primitive and that the Aroids may be derived from them. In venation, *Acorus* and *Gymnostachys* strongly remind one of the *Potomagetons* and in their general habit of growth, branching, venation, inconspicuous spathe, and deficient endosperm, *Pothos* and *Pothoidium* remind one of the same genus. In fact, the general impression left on one's mind after such a comparison is that the Aroid is a Pondweed that has taken to the land. Possibly the aquatic habit is more primitive than the terrestrial, and doubtless also the anemophilous habit is more primitive than the entomophilous; and from that standpoint it is perhaps reasonable to regard the Aroid as developed from some ancestral Naiad. On the other hand, it may not be impossible for terrestrial entomophilous plants to become aquatic and hydrophilous or anemophilous, and the poorly developed perianth of the Naiad may be an example of reduction from some better-developed form. It is safer merely to say that the two orders undoubtedly stand very close to each other, and represent together a common line of descent which has, in comparatively recent times, diverged in two directions. Beyond this cautious statement we can hardly go.

The relationship existing between the *Arales* and *Pandanales* is also a close one. The monoecious spadix of *Typha,* subtended by a spathe in the form of a bract, the spiral crowding of the blossoms, the extremely reduced cyclic perianth, and the anatropous ovule with its abundant endosperm, all point to the existence of such a relationship. The hair-like perianth of the *Pandanales* can only be regarded as an example of reduction. It cannot be regarded as a protective organ, nor could it ever, in its present condition, have been of use in entomophily. We are forced to the conclusion either that it is rudimentary, or that it is a nascent organ awaiting some change in the economy of the plant to make it of use; and the latter of course is ridiculous. A form like *Typha,* with rudimentary perianth and spathe is reduced rather than primitive. If it is to be classed with the Palms it should follow rather than precede.

The formation of a spathe and spadix links the *Arales* with the *Palmales.* The latter show true spiral characteristics in the individual blossom, the arrangement of the stamens being spiral while that of the carpels is cyclic. The well developed perianth has led to its being regarded as one of the higher orders, but in view of the floral spirality it would seem that it ought to be regarded as a more primitive group. This merely bears out the writer's view that the *Pandanales* are a reduced type with rudimentary perianth and in the *Palmales* we find a type which has not suffered reduction.

While the *Graminales* are a comparatively primitive group, they stand farther from the *Arales* than do any of the other distinctly primitive groups, and the connection between the two must be very remote. Reduction of parts has proceeded farther among the *Graminales,* yet they have retained the primitive anemophilous habit. The *Farinales* come somewhat closer to the *Arales* than do the *Graminales.* The well developed perianth would indicate this. But the *Farinales, Liliales, Orchidales,* and *Scitaminales* all represent a comparatively advanced stage of development, as indicated by the cyclic flowers, and the absence of spiral grouping of blossoms on the stalk. All consist for the most part of terrestrial, entomophilous plants which, in some cases, show decided tendencies in the direction of syncarpy, perigyny, and sympetaly. Were the writer to suggest a grouping which would put the Aroid order in what is probably its natural position, it would be as follows:



3. Reduction of parts: Rudimentary stamens, or staminodia, are present in most of the *Philodendroideae* (*Philodendron, Peltandra, Homalomena, Typhonodorum,* and occasionally perhaps *Richardia*), and in a few of the *Aroideae* (*Gorgonidium, Spathantheum, Spathicarpa*), also in the *Staurostigmoideae,* and in *Dieffenbachia* of the *Aglaonemoideae.* In the staminate blossoms, rudimentary carpels are occasionally present (*Peltandra, Apatemone*). Engler notes that all forms having both a perianth and petaloid spathe have very inconspicuous sepals, and in many cases the latter must be regarded as rudimentary. Aroids having a bract-like spathe have comparatively conspicuous perianths. The perianth of *Symplocarpus* is plainly protective in its function. Possibly that of *Acorus* is also protective; if not, it must be regarded as rudimentary, as it evidently is not in its present condition adapted to entomophily. *Anthurium* possesses a rudimentary perianth, as does also *Spathiphyllum.* The other genera studied lack the perianth.

The frequent presence of staminodia indicate that the perfect flower is, in the case of the Aroids, more primitive than the imperfect, and that the monoecious and dioecious species have suffered reduction of the floral parts. This is further suggested by the occasional presence of perfect flowers in *Richardia.* The rudimentary character of the perianth in many genera indicates reduction along that line also, and suggests that the sepaloid forms are the more primitive. The crowding of the blossoms on the stalk would naturally lead to a gradual elimination of the floral envelopes, and as they tend to disappear in the course of evolution, their place is taken by a more or less brightly colored and petaloid spathe. Such a form as *Arisaema* cannot but be regarded as quite highly developed, since it is dioecious (sometimes slightly monoecious) and has naked blossoms crowded on the spadix, and a highly developed spathe. *Symplocarpus* is more primitive, having perfect, sepaloid flowers, though the spathe here also is well developed and of use in entomophily. *Richardia* is one of the more highly specialized forms, but shows vestigial characteristics in the form of staminodia, and occasional perfect flowers.

If the theory here advanced is correct, the Aroids must trace back to some ancestral form that was sepaloid and adapted to the habit of entomophily. Far back of that, very likely, lies a group of yet more primitive anemophilous plants, but their existence is purely inferential, and rests upon no positive evidence to be found in the Aroids as we know them today.

THE EFFECT OF SMOKE AND GASES UPON VEGETATION.

BY A. L. BAKKE.

INTRODUCTION.

The history of an industrial community marks itself into three divisions: (1) the movement from the country into the city, (2) the building up of enterprises or commercial concerns, (3) the conservation of waste products. The movement of the people from the country to the city carries with it a number of problems. Many of these would not be met with in the country. The earlier stages, with reference to this development, are not concerned with problems for the community as a whole. The pavement of streets, the erection of public buildings, other than school houses are not a part of the general program. Then as industries, under competition, endeavor to utilize a narrower selling margin, there is a general movement, and in many cases instigated by the people at large, for a conservation of products that are a nuisance, or regarded as being detrimental to the health of the people, as well as the animals and plants of that community. Such considerations have lead to a condensation of the sulphur dioxide and arsenic trioxide in our smelters; such considerations are responsible for the condensing of the cement dust* in our cement plants: such considerations have led the manufacturers of Germany to utilize profitably as many of the waste products as they do, rather than to have them emptied into the atmosphere as is ordinarily done under the first two periods.

The smoke problem is a question that centers about the third state. In Germany and elsewhere on the Continent, the issues have long been presented. A great deal of careful investigation is now being done in the city of Pittsburgh, Penn. Smoke has been considered a necessary evil. But experimental evidence is entirely against this conception. When it is understood that in burning of coal, incomplete combustion with its emission of toxic materials is a wasteful process to the manufacturer, and an obstacle to normal existence of animals and plants, the problem of smoke prevention will be successfully dealt with. This calls our attention to a consideration of another phase of the conservation move-

*Plant World 13: 283-288.

ment, whereby the vegetation in and about an industrial center, may be saved from a gradual elimination process, not by an added expense to the community, but by conditions that conserve the waste products for the manufacturer, and also conserve the health to say nothing of the beauty of the town itself for the inhabitants. It will then be the purpose of this paper to show the application of these issues to a restricted area in an industrial center of the city of Chicago, Ill., and also to cite some general features in connection with a survey made of the city of Des Moines, Iowa.

HISTORICAL.

As early as in 1845, records show that smoke emitted from the smoke stacks of manufacturing concerns had an injurious effect upon vegetation. Rettstadt (1) pointed out that forest trees in the vicinity of a silver smelter were injured. Stöckhardt (2) a few years later confirmed this report. Girardin (3) found that illuminating gas had an injurious effect upon street trees. Schroeder & Reuss (4) employing sulphur dioxide and hydrochloride gases upon *Carpinus, Alnus, Picea,* and *Acer,* noted a destruction of the chlorphyll and a retardation of the photosynthetic processes. In a later experiment these same authors using SO_2 recorded a premature falling of leaves, along with a greater SO_3 content. These same results were again verified by Stockhardt (2). Sorauer (5) using asphalt vapors, in contact with the rose and horse chestnut, has shown that brown discolorations along with an increased tannin content are produced. Kny (6) demonstrated the injurious effect of coal gas upon the maple and linden. In 1903, Hasselhoff and Lindau (7) brought out in a book form a number of important statements as to nature and means by which the injury could take place. They concluded: 1, that the action does not take place through the soil but is centered in the conditions of the atmosphere and the leaf itself; 2, that the plants vary with reference to their sensitiveness; 3, that plants allowed to remain for a considerable length of time in an atmosphere containing small amounts of SO_2 will in time show the effects; 4, that the stomata play no role in the absorption of sulphurous acids; 5, that there is a derangement in the water circulation by an increased loss of water; 6, that the interior of the cells show plasmolysis and a decrease in starch manufacture and finally a decomposition; 7, that a chemical analysis gives an index to injury. Molisch (8) has recently studied the effect of tobacco smoke upon various seedlings and found that they behaved as if they had been exposed to traces of illuminating gas. He thinks that carbon monoxide is the toxic agent. He is of the opinion that tobacco smoke has a marked effect upon micro organisms. Gaten (9) in his long paper on the effect of tarred roads upon vegetation calls attention to two central ideas; (1), that injury may be due to various gases; (2), that injury may be due to the action of the dust. The vapors of the various gases emitted from tar have been determined to be at least twenty-seven in number. A large number of these products are known to be toxic. In the case of the dusts, the vapors may be more directly applied. The effects produced may according to Gaten be summarized accordingly: (1), there is a decrease in leaf area due to a dropping of the leaves, and also to a diminution of local leaf areas; (2), there are no noticeable anatomical differences; (3), there is a difference in the form, size, and arrangement of the cells; (4), there is in a great many instances an accumulation of cork; (5), there is not a sufficient amount of storage food in the tissues; (6), there is a reduction in the width of the annual rings; (7), there are certain species that are more susceptible than others. P. Brizi (15) has made a very extensive study of the effect of gases and fumes upon cultivated plants. The fumes came from gas works, chemical establishments, smelters and foundries. Although SO_2 is considered for the most part, yet, the fumes from HCl, and other substances, such as zinc and arsenic are discussed. The general effect produced upon the cells themselves is plasmolysis, and later disorganization. Richards & McDougal (16) have shown that carbon monoxide although not as effective as illuminating gas yet is considered as being very toxic to plants.

Crowthers & Ruston (9) have carried on a number of interesting experiments in and about the city of Leeds, England. They established throughout this industrial center a number of stations and then compared records. The results arrived at, show that there is considerable difference in the amount of suspended matter, in the amount of free acids, in the amount of sulphur dioxide of rains at Station I, situated in the heart of the city than at Station II, situated in the residential portion. These various products were proven to have a direct injurious effect upon vegetation in the main by causing a reduction of the intensity of the sunlight and by causing a decrease in assimilation of CO_2. The following figures taken from their experiments performed according to the method used by Brown & Escomb* in their classical experiments upon the CO_2 intake, show a marked difference.

*Phil. Trans. 193: 298. 1900.

Assimilation of CO_2 by Laurel Leaves.

Exp. No.	Source of Leaves	Area of Leaves	Intensity of Light	Hourly Mean Temperature	Total CO_2 Assimilated	CO_2 Assimil at'd per 10 sq. in. per 10 hrs.
	Station*	Sq. in.	Cc. N-10 Iodine	C	Milligrams	Milligrams
1	9	36.21	1.22	10.8	21.56	5.95
2	9	23.5	3.40	17.6	40.48	17.20
3	9	23.52	1.0	13.7	36.08	11.51
7	9	28.64	2.8	17.6	47.21	13.52
	----	16.42	2.8	17.6	2.64	1.56

*Sa. 9—Residential Centers.
Sta. 4—Industrial Center.

These authors carried on additional experiments to ascertain whether the soil played any role. To secure data upon this particular phase of the question, they grew timothy plants and watered them with rain water taken from the various stations. In the industrial centers they found that chemical analysis revealed a smaller protein content and a greater amount of crude fiber. In addition they also ascertained that an indirect effect was produced by a decreased bacterial acitity in the soil.

Cohen & Ruston (10) in their recent book "Smoke—A Study of Town Air" have here made a more exhaustive study of conditions at Leeds. The essential results derived at are practically the same.

In the United States the contributions upon this subject are not as extensive as in Europe. Buckhout (11) in 1900, published an account on the effect of gases and smokes upon vegetation. His results are similar to those recorded in the earlier work of Schroeder and Reuss.

Widtsoe (13) studied the effect of smelter smokes upon vegetation in the vicinity of the Highland Bay Smelter at Murray, Utah, belonging to the Utah Consolidated Mining Company. He found that the white pine was killed for a distance of seven miles as a direct result from the emission of SO_2. In an analysis of fifty different soils in the smelter region, the amount of sulphuric acid present was not different, from the acid content in normal soils.

By far the most extensive work in America has been done by H. K. Haywood (17) of the U. S. Department of Agriculture, Bureau of Chemistry. His results as ascertained from his first study show that the vegetation about a smelter is killed for a considerable distance. He attributes the cause to sulphur dioxide. Even if this gas is in small quantities, yet in time the effect is noticed and there is in addition an increased sulphur trioxide content of the leaves when put to a chemical test. In his later study he has pointed out that the extent of injury cannot be shown definitely by a chemical analysis, since the difference in sulphur trioxide content is within the limits of experimental error. He states further that the injury to forest trees may extend to a distance from fifteen to twenty miles; also that the injury takes place directly through the leaves and that the roots are not a medium of conduction.

Ebaugh (18) thinks that undue emphasis has been placed upon the sulphur dioxide given forth and that sufficient attention is not given to the solid emanations. Harkness & Swain (19) have pointed out that high stacks of large condensing flues serve the purpose of disseminating the sulphur dioxide over a wider area.

Stone (20) finds that in the case of illuminating gas, that small leaks cause local injury to trees. Crocker & Knight (21) have put forth conclusive evidence to show that traces of illuminating gas and ethylene prevent the normal opening of the flowers of the sweet pea. Wilcox (22) also notes that illuminating gas has an injurious effect upon greenhouse plants.

NATURE OF SMOKE.

Smoke is not a necessary evil, and under no condition can it be considered as a question of economy. It is tied up with the question of combustion. Gebhardt (25) points out that smoke is produced by the following methods: "(1) An insufficient amount of air for the perfect combustion of the volatile gases. (2) An imperfect mixture of air and combustible. (3) A temperature too low to permit complete oxidation of the volatile combustible. Breckenridge (21) cites the following: "The problem of smoke prevention is the problem of perfect combustion. In the complete combustion of carbon the product of combustion is CO_2. If sufficient oxygen is not provided it will happen that each carbon atom will combine with one oxygen atom, thus forming carbon monoxide, CO. As a result of this incomplete combustion the heat developed is only 4400 British Thermal units (B. t. u.). The carbon monoxide may itself combine according to the formula $CO+O=CO_2$ and the heat developed will be the difference, $14500-4400=10100$ B. T. U. per pound of carbon in the carbon monoxide." This citation brings out the economic importance. He also states that in order to insure complete combustion in practice, an excess of air must be furnished. Furthermore, carbon and oxygen atoms will not unite unless a certain temperature is reached. Breckenridge further adds, "The products of combustion, carbon dioxide, steam, and sulphur dioxide, are colorless gases. If nothing but these gases escaped, there would be no smoke problem. Visible smoke is due to the visible hydrocarbons, which all bituminous coal contains to a greater or less extent, and which are driven off, when the coal is heated. When coal is heated in a furnace, the volatile content consisting largely of methane and ethylene is driven oc. If the volatile gases should not enter into a region of high temperature they would simply pass out of the chimney with the products of combustion.''

The relationship existing between the temperature and gaseous products evolved is summarized in tabulated form by Porter and Ovitz (24).

TOTAL GAS YIELD AND COMPOSITION AT DIFFERENT TEMPERATURES.

(From 10 grams air-dried coal.)

COAL NO. I. ZEIGLER, ILL.

Temperature of furnace c	500	600	700	800	900	1000	1100
Highest temperature reached in coal. C	390	480	585	685	811	920	1026
Gas at 25 C—cubic centimeters	137	535	980	1550	2335	2700	3120
Composition of Gas—							
Illuminants	6.5	5.0	4.1	3.3	3.2	3.7	4.0
CO_2	23.8	7.6	6.4	3.9	2.5	2.7	1.8
CO	16.5	16.1	21.1	16.9	15.2	15.1	16.1
$CH_4C_2H_6$ etc.	49.5	55.0	41.5	34.4	27.8	23.1	19.4
H	3.7	16.3	26.9	41.5	51.3	55.4	58.7
Value of N. in Cn H2n 2	1.42	1.29	1.21	1.16	1.22	1.18	1.23

In this analysis no determination of tar and water were made.

In the same publication Table 4, an analysis of coal tested, is brought forth.

Laboratory No.	1	3	10	11	16	18	23	25	46
Bulk sample (100 lbs.)									
Air-drying loss	1.63	0.10	0.69	14.63	0.81	2.30	5.21	0.56	1.64
Analysis of air dried sample	{7.67	1.10	.87	11.45	.35	2.64	1.96	2.30	2.17
Moisture[a]	{7.40	1.09	.98	10.83	.39	3.48	------	------	------
Volatile matter	30.38	30.67	32.46	[b]35.74	20.93	42.23	32.05	40.24	34.01
Fixed carbon	54.32	60.35	61.66	47.74	75.51	50.65	56.75	51.38	58.37
Ash	7.63	7.88	5.01	5.07	3.21	4.48	9.24	6.08	5.45
Computed to "as received" basis	9.19	1.18	1.55	24.40	1.16	4.88	7.07	2.85	3.74
Moisture[a]	------	------	------	21.96	------	------	------	------	------
Volatile matter	29.89	30.64	32.22	30.52	20.76	41.25	30.37	40.04	33.46
Fixed carbon	53.41	60.31	61.26	40.75	74.90	49.49	53.80	51.06	57.44
Ash	7.51	7.87	4.97	4.33	3.18	4.38	8.76	6.05	5.36
Sulphur	------	------	------	.38	.61	.41	1.48	.42	.91
Nitrogen	------	------	------	1.15	1.07	.97	1.27	1.16	------

[a]Second determinations given were made on samples twelve to eighteen months later.
[b]Determined by modified method: Somermlies, E. E., Journal Amer. Chem. Soc., Vol. 28, 1906, p. 1002.

As far as our study is concerned, the two tables above show essentially two categories, first, the gaseous products such as CO, C_2H_6 etc.; second, such products as sulphur. The gaseous products as a result of dry distillation which are given off under incomplete combustion and the sulphur as sulphur dioxide as a result of complete combustion furnish us with at least two important considerations of our problem.

Another important feature of the smoke problem derived from incomplete combustion lies in the nature of soot. According to Cohen and Ruston, soot consists of carbon, tar, and ash (mineral matter) together with small quantities of sulphur, arsenic and nitrogen compounds which frequently possess an acid character. This acid character is responsible for the corrosion features imparted to masonry structures and leaves of trees, shrubs and herbs. Furthermore, the corrosion assists in making the tarry material, which is ejected, adhere. This tar compound will play the same role upon the vegetation when it comes in immediate contact with it as the material from tarred roads.

GENERAL OBSERVATIONS.

Even to the casual observer, there is considerable difference in the vegetation as found in the heart of an industrial center and the suburbs or residential portions. The prevailing slowness of growth, and the early leaf fall of trees is noticed by almost everyone. This condition of affairs is well shown in traveling out from the center of Chicago to the neighboring suburbs. But an additional feature also comes in. Here and there on the outskirts of the city proper, large manufacturing concerns or mills are found. The immediate territory is ideal for a smoke survey. This is well illustrated in the case of the territory immediately surrounding the Illinois Steel and Wisconsin Steel Companies.

The city of Des Moines, Iowa, has most of its manufacturing concerns, in the heart of the city itself. To the person going to the Iowa capitol for the first time, the amount of smoke is of considerable annoyance. He probably is so concerned as to his own personal welfare that he does not stop to consider the trees that are conspicuously absent. This state of affairs is to some extent perhaps natural in that Des Moines is situated in a valley. But even if it is the fact, yet they can be remedied as the further discussion will show.

In Germany most of the observations have been made upon the conifers. On account of their deeply sunken stomata, they are much more susceptible than the majority of our deciduous forms. In many of the parks of the city of Chicago, such as Humbolt, Washington, the so called Norway-pine (*Pinus resinosa* Ait.) the most common evergreen, is a small scrawny tree with distorted branches, which carry in many instances only a single tuft of needles. Parks situated in closer proximinity to the industrial center do not have any conifers whatsoever. There is a contrast in the pines of Jackson and Washington Parks, those of the former being more abundantly supplied with needles than the latter. This is accounted for in the fact that the lake breeze is more of a factor, in Jackson Park than at Washington Park. In all surveys, and in accounts given, the prevailing winds serve to concentrate or disseminate the smoke and its effects in one general direction. Grant Park, made famous through the Aviation Meet, offers conditions that are met with, when establishing parks in the center of large cities. The elms show the general effect of injury, by smoke. The same is true of the elms, on the north edge of the park as well as those near the 12th St. station of the Illinois Central Railway. The trees are stunted in growth, have few leaves and even in the early part of August, a large portion of them had already fallen. The elms and oaks near the 59th St. suburban station of the Illinois Central show the effects to which they are subjected. The stopping and starting of the locomotives of this line cause a great deal of smoke to come forth. Combustion is necessarily incomplete and as a result the soot includes a number of toxic substances. The oaks are partially dead, and the number of leaves present, are few in number, the elms, however, do not show as many dead branches, but the leaf surface is insufficient for normal photosynthetic purposes. As the elms and the oaks, a block away, show an entirely different color and tone, the conclusion is that the injury is due to the smoke emitted.

In Des Moines the same general conditions are found to be present. It is rather an unusual thing to find along the railway tracks in the city limits, a tree like the locust, or the oak, with a full foliage. Near the pumping station of the city of Des Moines an interesting feature is met with. Around the stations there is a small park with the elm as the principal tree. These trees have the same general appearance as the elms referred to in Grant Park, Chicago. The superintendent informed the writer that the elms were twenty-five years old, but the size to which they had attained would under natural conditions, make one assume that they were less than one-half the age. The superintendent said that he had spent hundreds of dollars for shrubbery and trees. He remarked, "We can't grow anything here."

At Stony Island, Chicago, in passing from Stony Island Ave., on 93d St., toward South Chicago, no one can but be impressed by the large number of oak trees that are in a pathological condition. When the observation was first noted (May, 1912) it was thought probably that other factors might enter in to influence the growth development;

but the opinion that the injury was due to smoke was substantiated when the trees were examined in August. At that time they were covered with dust and soot particles. The branches are rather short, distorted and the bark appears unusually thick. As there are a large number of outcropping rocks, one would naturally expect that here, lichens would have a great foothold. But none are found; the rocks are entirely free from them. The smoke* was again the critical factor. A similar situation is met with in a survey of the metropolis of Iowa.

In proceeding on 93d St., toward the Illinois Steel Co.'s works, the number of tree species falls; the red oaks, the burr oaks, the elms, the cottonwoods, the willows, drop out in succession. This is not true of the territory near the Illinois Steel Co. alone, but a similar situation is met with in the territory in the vicinity of the Wisconsin Steel Co., and the Indland Steel Co.'s Works at Indiana Harbor. The trees that are planted have a hard struggle for existence. The Baldwin Locomotive Works, the Pullman Car Works, all show similar conditions; near the American Brake Shoe and Foundry Co., the cockle burs in close proximity were covered with a hard tarry substance, which could be pared off with a knife. A good sized silver poplar (*Populus alba* L.) was found in the same locality as the cockle burs, and it apparently was not affected by the smoke even if there was sufficient material of tarry, greasy nature to leave a permanent impression on the back of the hand where the under surface of the leaf was pressed against it. At Whiting in the vicinity of the oil refineries of the Standard Oil Co., the vegetation is almost normal. The only outstanding feature was that the cat tails were dried further back, at that time of the year than is usual. This point would lead one to conclude that smoke generated from crude oil is not as harmful as smoke from coal. No doubt this is closely correlated with complete combustion.

The chemical works near Hegewisch show the results of a continued application of smoke from the coal consumed as well as the fumes from the chemicals manufactured. At this place the gases emitted have caused the tops of the oaks and willows to become dead. The trees in the direction of the prevailing winds are alone affected. Those on the opposite side are practically intact. At Gary, Indiana, the center of the U. S. Steel Co., the conditions are not well marked. The leaves of a basswood tree near the office had leaves that were of a dark brown color as early as in June.

*First noted by Dr. Henry C. Cowles of the University of Chicago. This information was given in a verbal statement.

These general observations then show that vegetation in the vicinity of manufacturing concerns shows the effects of the fumes and smoke emitted. It also appears that some species are more susceptible than others.

SURVEY AREAS—FLORAL DEMARKATIONS.

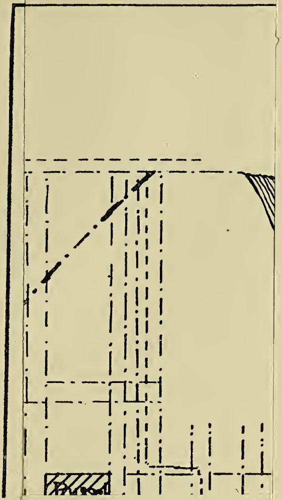
When general observations were made in the early part of June of last year, certain demarkation features, imparted by the flora itself, were present. The absence of a certain form in one portion and the presence of a form in another area, providing the same ecological features, immediately led one to conclude that the absence or pathological presence is brought about by the gaseous emanations from mills or other manufacturing concerns. In order to ascertain this feature more definitely, two restricted areas were chosen, one in the vicinity of the Illinois Steel Co., and the other in the vicinity of the Wisconsin Steel Co.

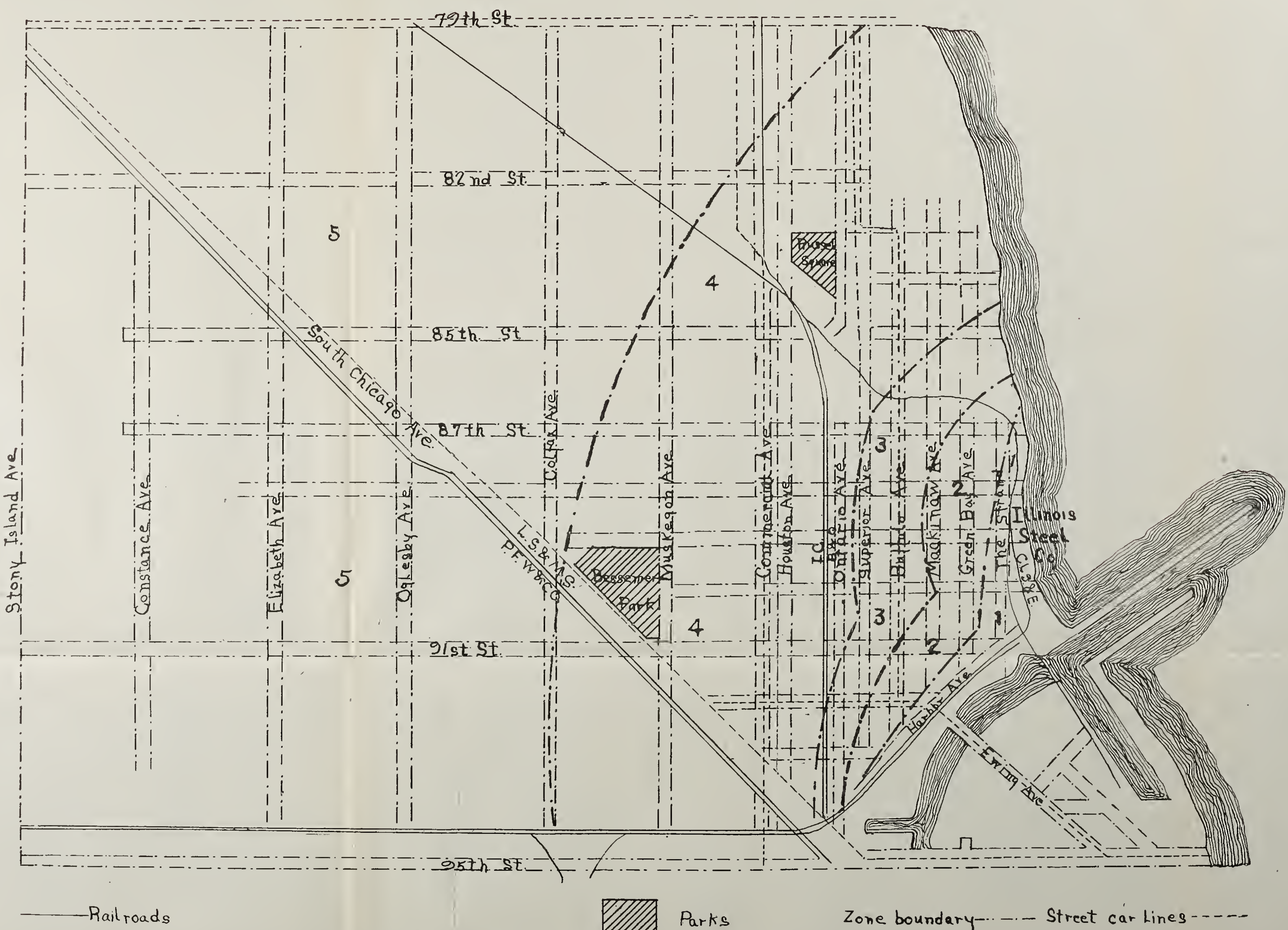
For the purpose of reference as well as convenience, it was thought advisable to have a number of belts or zones and each belt to be represented by a numeral as well as by the outstanding floral representative or representatives. These belts are as follows: (1) Restricted annuals, (2) Numerous annuals, (3) Willows, (4) Cottonwoods, (5) Burr Oaks, (6) Other deciduous trees, (7) Conifers, (8) Pleurococcus.

The first belt* known as belt (1) is the result of a gradual elimination stage in the general process. The zone is not very extensive in area and the species are not large in number. Four outstanding species were present. Prostrate pigweed (*Amaranthus blitoides* Wats.), fescue grass (*Festuca ovina* L.), milk purslane (*Euphorbia maculata* L.), old witch grass (*Panicum capillare* L.). Even these forms are stunted in size, and often are in such shape as to be extremely hard of identification.

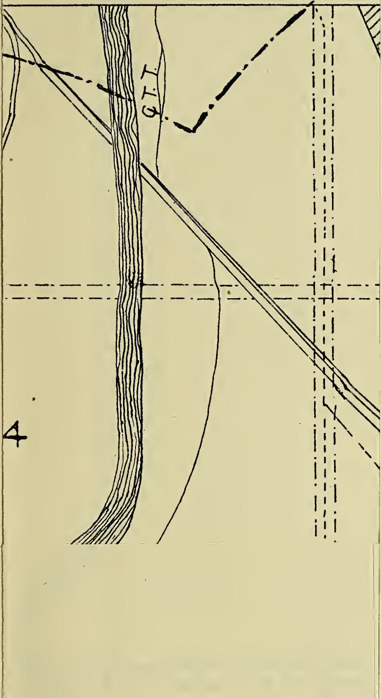
The next belt includes the forms of the previous one but they are much more vigorous and considerably truer to type. In addition, the following are conspicuous: cockle bur (*xanthium canadense* Mill), ragweed (*Ambrosia artemesiifolia* L.), yellow fox tail (*Setaria glauca* (L.) Beauv.), green fox tail (*Setaria verdis* (L.) Beauv.), hedge mustard (*Sisymbrium altissimum* L.), rough pig-weed (*Amaranthus retroflexus* L.), barnyard grass (*Echinochloa crusgalli* (L.) Beauv.), begar's ticks (*Bidens frondosa* L.), squirrel tail grass (*Hordeum jubatum* L.), Russian thistle (*Salsola Kali* var *tenuifolia* G. F. W. Mey.). This belt has an area extending approximately from Harbor Ave. and The Strand to Mackinaw Ave. In the instance of the Wisconsin Steel

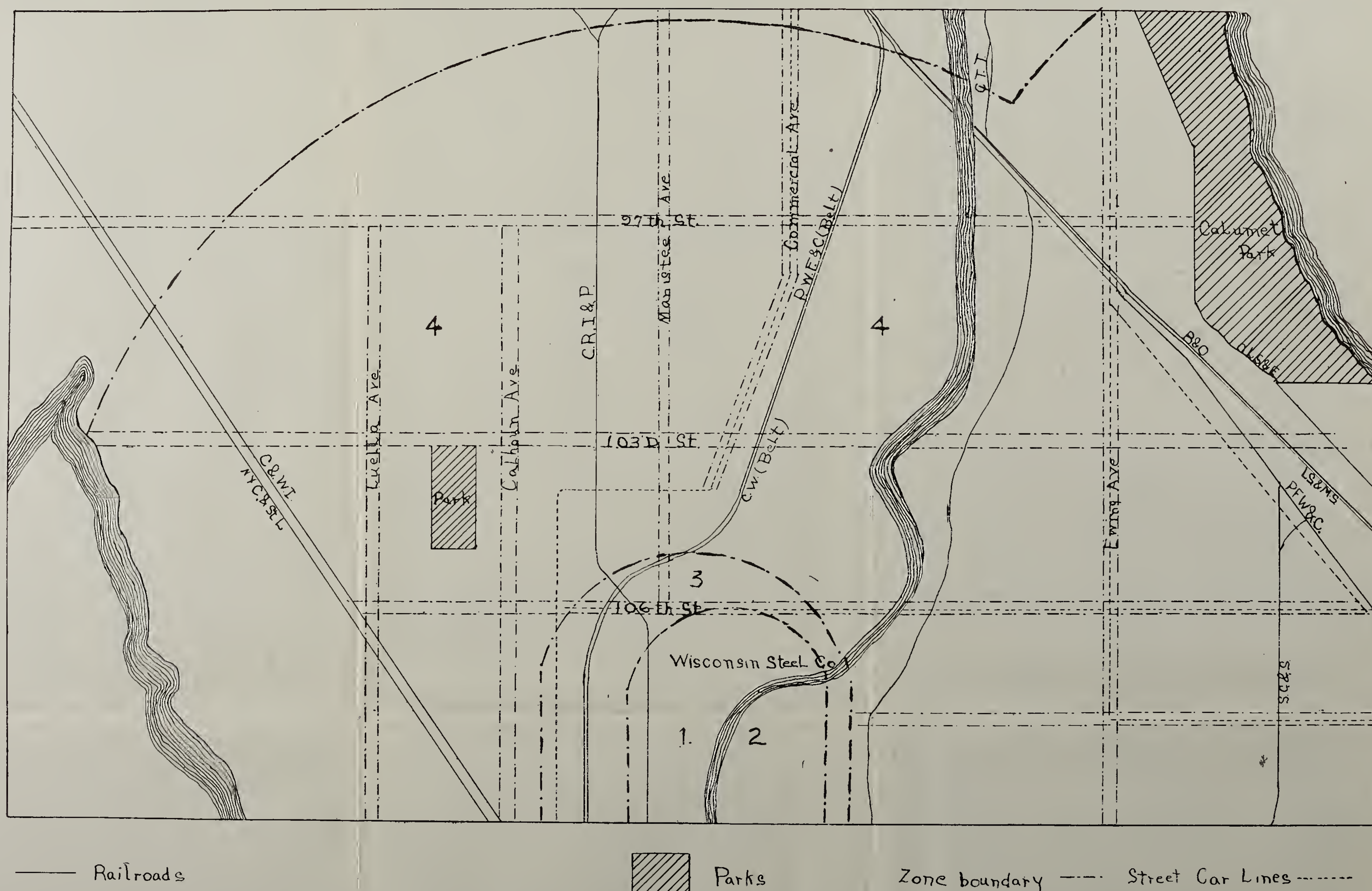
*These zones are marked out in the accompanying map. By using the general standard of eight blocks to the mile a good idea of the distance is obtained.





Zone map of area where Illinois Steel Co is the dominating or most important concern.


4



Zone map of area where the Wisconsin Steel Co is the dominating or most important concern st

Co. and the Iroquois Iron Co., there is an overlapping of the two above mentioned zones, so that separation is not as easily made.

Belt (2) includes a number of new species of annuals and other herbs such as the following: goosefoot or lamb's quarter (*Chenopodium album* L.), pepper grass (*Lepidium apetalum* Willd.), *Lepidium virginicum L.,* blue vervain (*Verbena hastata* L.), horse weed (*Erigeron canadensis* L.), evening primrose (*Oenthera biennis* L.), five finger (*Potentilla canadensis* L.), dandelion (*Taraxacum officinale* Weber), *Aster* sp., yarrow (*Achillea Millefolium* L.), sour dock (*Rumex crispus* L.), crab grass (*Digitaria sanguinalis* L.) Scop. wild lettuce (*Lactuca scariola* L.), Solidago sp., blue grass (*Poa pratensis* L.), *Eragrostis megastachya* (Koeler) Link. The willow (*Salix alba* var. *caerules* (*Sm*) *Koch*) is the first tree to come in. In a large number of instances, these trees are killed showing that they are present to as great an extent as is allowed by external factors.

The next belt (belt 4) will include a territory extending from Lake Michigan beginning with 83d St. and reaching westward to Marquette Ave. Thus Russel Square and Bessemer Park are included in this tract. This belt does not show marked difference as to annuals, but such perennials, as trees, add a few characters that were not present in the former zone. The willow becomes a conspicuous representative, not partially killed but in a good thriving condition. In addition, the cottonwood (*Populus deltoides*) (Marsh) forms another representative of this region, followed by the elm (*Ulmus Americana* L.), the ash (*Fraximus americana* L.), and sycamore (*Platanus occidentalis* L.) The trees named after the cottonwood were characterized by a foliage that was very scant. Many show a spotting of the few leaves that are present, as well as curling. These conditions serve the purpose of cutting down the leaf area. The annuals found in belt (4) have much more foliage and furthermore will have better tone and quality, if such a thing can be said of a weed. In addition the following species will be noted: reed grass (*Phragmites communis* Trin) *Bidens,* Indian rice (*Zizania palustris* L.), *Steironema quadriflorum* (*Sims*) *Hitch*), loosestrife, (*Lythrum alatum Push*), *Gerardia paupercula* (Gray) Britton.

The willow is the outstanding tree. At Calumet Park this tree is the most common and is in a vigorous condition. The cottonwoods are next in line. As shrubbery in such a locality as is being studied, is in the majority of cases planted in a park and as trees serve as a protective agent by obstructing the action of smoke and gases, the effeet upon shrubs is not easily diagnosed. In the park near 103d St. and Yates Ave., the privet (*Ligustrum vulgare* L.) is seriously affected. But in another park at 79th St., it is noticed that the stag horn sumac (*Rhus typhina* L.) and *nine bark* (*Physocarpus opulifolius* (L) Maxim are at least able to withstand a small amount of smoke.

Belt (5) occupies a greater area in the restricted survey than any of the previous ones. The Stony Island region is the conspicuous outstanding example. In this particular region another species is added, namely the burr oak (*Quercus macrocarpa* Michx). In addition any of the species represented in the preceding zones may be present. As the oak association is the climax forest as far as this region is concerned, an interesting situation presents itself. This area allows the presence of the burr oak, but it is present only in a pathological condition. An examination of the growth and a comparison with rings noted from sections made of normal trees of the same species show a surprising difference. Even a small tree possesses a large number of growth rings. In many instances these rings are so narrow as to be extremely hard to separate out when counting. The trees also possess peculiarly twisted branches. The bark is also noted as being extremely thick. In the vicinity of the Wisconsin Steel Co., a similar situation is met with. A further study of the situation at Des Moines, where again the climax forest is of the oak type, shows a similar result. These observations would immediately lead one to conclude, that where the oak type of forest is the climax, that the burr oak forms a good "indicator" of a smoke region.

The next area (belt 6) is in the smoke zone, yet the injury does not extend to the point where the common deciduous trees are affected. At times there may be noticeable effects, but from a practical point of view conditions are not looked upon as being serious even if conifers are not able to thrive.

Belt (7) represents a step in advance of the former in that it permits conifers such as the pines, to have a normal development.

Since the Des Moines survey another belt in advance of the previous one has been marked out. This zone is conveniently designated as the Pleurococcus belt. The idea of using *Pleurococcus* as a possible index to smoke injury was brought to my attention by Dr. William Crocker of the University of Chicago. He noted that trees in the vicinity of the University and in Jackson and Washington Parks did not have any *Pleurococcus* upon their trunks. Even trees possessing a sufficient amount of shade and having more than sufficient moisture were without the green material upon the north side. The territory studied at Chicago did not offer conditions which would permit of a mapping out of a *Pleurococcus* belt. That it too is an index for a small amount of smoke injury was noted in the Des Moines survey. On account of great amount of rainfall in the fall this was readily done. For instance, when the residence portion of Des Moines on the west side begins at 12th St. the pines or the 6th zone will be marked out from 18th St. to 32d St. At this point *Pleurococcus* is noted for the first time. Similar conditions are noted on the east, north and south sides of the city. It may be well to point that the Lichens are even more susceptible to smokes and gases than *Pleurococcus.*

The results of the restricted survey show: that smoke and gases present in industrial cities have a detrimental effect upon the vegetation in the vicinity; that different belts represented by outstanding types are of special interest in a survey; that certain forms are very susceptible to smoke and in this way act as "indicators."

LABORATORY EXPERIMENTS.

As has been pointed out in the earlier part of this discussion *Pleurococcus* offers a means by which this plant may be used as an "indicator," for smoke where lichens are not normally found. It was then thought advisable to obtain *Pleurococcus* and grow it upon the bark or upon Knop's solution and then treat it with various quantities of common gases, in order to ascertain the exact physiological actions encountered. A culture of the green alga was subjected to acetylene gas (2-6750) for four days. At that time the cells showed a marked plasmolysis. In a culture exposed for a longer period cellular disintegration took place. Where acetylene (2-7750) for four days a similar effect was shown. Illuminating gas in like proportions showed an action similar to the acetylene. At a longer exposure cells became dark and examination revealed a complete disintegration.

In connection with the Des Moines Survey SO_2 was generated from CS_2 by burning with alcohol as was done by Haywood*. In comparing this with acetylene, it was found that SO_2 was slightly more toxic than the acetylene. Another experiment consisting in taking an amount of SO_2 and acetylene together and making the two gases, equal in volume to where one gas is used.

This experiment was run in connection with one having acetylene alone, and another with SO_2 alone. Where there was a mixture even

*Bull. 89 Bur. of Chem. U. S. D. of Agr.

if the proportion of the two gases was same as the one gas or even slightly less, the mixture revealed a greater toxic action. *Pleurococcus* after having been in the two gases for four days had lost practically all its color, while in the jars with SO_2 and acetylene a brownish color was present. On further examination microscopically, the mixture presented considerably more plasmolysis, when precipitated with ferric chloride. This injury was further identified with the amount of tannin present in the interior of the cells, when precipitated with ferric chloride.

The next series of experiments made in the laboratory utilized the pine (*Pinus resinosa*) taken from Washington Park. As the stomata of the pines are deeply sunken they are easily made the resort places for the tarry compounds emitted in smoke. For instance it was found that ten needles from *Pinus resinosa* had material that was removed by washing in ether equal to .0185 grams. In using a small limb six feet long taken from a tree in Washington would have 2.96 grams. At this rate it would not be long before an amount equal to a pound is reached. By taking the same number of the pine needles of the same species having the same area from *Pinus resinosa* at Ames, Ia., during the month of November a much smaller amount of tarry material was found present. If the time element was the same in both cases the result would doubtless be more marked.

It has been noted that certain trees are more resistant than others. The cottonwood and willow have been shown to be less susceptible from injury by smokes than others. This is due to the hard cutinized layer that these species possess along with their compact texture. On account of the tomentose character of the under surface of the leaf of the white poplar (*Populus alba* L.) and its cutinized upper surface, the tree is very resistant.

The results of the laboratory experiments then call attention to the need of perfect combustion in the burning of coal, for it is shown that when there is a mixture of two gases that the action is more toxic than where one gas alone is given out. The experiments also show that there is a direct relation between the amount of injury and the amount of tannin present; that the tarry material emitted in smoke is of sufficient amount to at least partially clog the stomata and at the same time interfere with the assimilatory processes; that the resistance of the cottonwood and the silver poplar is due to the anatomical structure of the epidermal cells.

PHYSIOLOGICAL FACTORS.

In noting the various physiological conditions, the first outstanding one is that of the light intensity. An atmosphere laden with smoke does not offer as good conditions for photosynthesis as one that does not contain any impurities.

When a leaf is coated with a tarry compound, there is an interference with the assimilation process. Many of the investigators on the subject have claimed that the stomata do not enter in. In case of the stomata of the conifers this opinion will not hold. In cross sections made of conifers of a smoke region, the stomata were found to be at least partially filled with a tarry compound. Cohen and Ruston have also emphasized this point in their study of the silver fir at Leeds. Such a deposit will interfere with the assimilation of CO_2 and O_2, and with the transpiration stream.

Another means by which assimilation is diminished, is: by cutting down of the leaf area. This is accomplished (1) by a loss of leaflets when a plant with a compound leaf is in question, (2) by curling or by taking on abnormal shapes, (3) by the formation of spots or lesions.

The loss of the leaflets has been frequently observed by the writer for the honey locust (*Gleditsia triacanthos* L.) and the common locust (*Robinia Pseudo-Acacia* L.) at Bessemer Park at South Chicago. The common locust at Des Moines in the smoke district, also shows a decrease in leaf surface by this method.

Trees in a district where the fumes of SO_2 are prevalent often have their tips browned or curved. As a result there is naturally a decrease in the leaf area. In addition a portion of the leaf will be twisted from its normal position and in this way the leaf area that under normay conditions is exposed to the light will be cut down. This feature is well marked out among some sycamores that have been planted along the cinder path, on the way to the city of Ames, from the College. The trees near the heating plant, with its low smoke stack, are either in a state as mentioned above or have lost their leaves entirely.

Where there is a quantity of SO_2 present, in the smoke and where the injury is intermittent, brown localized spots or lesions are produced. When there is an accumulation of these spots a considerable reduction in leaf area takes place.

The effect upon cells themselves is well noticed in the cells of *Pleurococcus* of which an account has been given. There is a resulting plasmolysis and associated with the extent of the plasmolysis is the amount of tannin in the cells. Gaten has emphasized the accumulation of considerable cork deposit in the leaf petiole.

The whole question as to the injury encountered is intimately connected with the subject of assimilation. The diminished illumination, the cutting off of the CO_2 and O_2 supply, the interference with the transpiration stream, the cutting down of the leaf surface through a loss of leaflets, change in position or by the formation of spotted areas all show that normal photosynthesis does not occur. As the process is responsible for the storage food manufactured, the natural conclusion to be arrived at, is that insufficient food is manufactured. As food is stored from the base of the trunk upward, there is not always sufficient time to complete the storage up to the tips, when the laboratories are run with less than their normal supply of raw material. This point was emphasized in connection with the cross sections made of pine needles collected at Washington Park, Chicago. Where a leaf was entirely covered with the tarry mixture a considerable smaller quantity of stored starch was found than in a leaf which had not been exposed sufficiently to be coated. In making an examination of the growth rings it is noted that those of the smoke region are much smaller. This whole question then concentrates itself into one of food supply, and growth development. When there is not a sufficient amount of food manufactured, growth becomes less. The result of the insufficient amount of food causes a slow starvation. As a final result death occurs.

PROPOSED SUGGESTIONS FOR REMEDY.

It is not the purpose of this paper to give an account of extensive plans, that might aid in the cutting down of the smoke nuisance but a few suggestions might be appropriate. Concerns like the Illinois Steel Co., and Wisconsin Steel Co. will have to concern themselves with gaseous emanations from two sources; first, those coming as a by product from the ore, second, those coming from the stacks. Both are questions of economy. Some plan whereby the waste products as gases are condensed appears to be the only method for solution for the first. The other can to a large extent be solved by following out the laws necessary for complete combustion. Mechanical stokers to a large extent have helped to solve this part of it.

For commercial or industrial centers like Des Moines, Iowa, the plan is to put in every plant of any considerable size mechanical stokers or devices that will give a complete combustion for the coal whereby CO_2 and SO_2 alone, are produced. As Des Moines is situated in a low area or valley, the SO_2 will do more harm even if the city was located on a plain or elevation. To overcome this feature, it is proposed to erect tall smoke stacks, which will dilute the SO_2 to a concentration sufficiently low, so that it will not be effective in killing the leaves of trees and shrubs. Of course, on foggy days the SO_2 will concentrate itself in the valley, but the number of foggy days are not numerous in a year, and so for that reason, this solution is reached as being the most practical under present conditions.

In the report of the smoke inspector of the city of Chicago, considerable emphasis is placed upon the smoke as emitted from locomotives. He states that co-operation of the railroad and smoke inspector is one of the best means of lessening the amount. Breckenridge admits in his report that he is not able to suggest methods whereby Illinois coal can be burned without smoke, but that careful firing is the most effective method of smoke reduction. However in a thickly populated area, the only solution is electrification. Recently at Pittsburgh* the railroads have agreed to equip all locomotives entering Pittsburgh with locomotive stokers.

Another partial assistance in the solution of the problem is to plant only such forms as are able to withstand at least traces of SO_2. The survey of the restricted area at Chicago has shown that there is a difference in the resistance power of different species. The cottonwood, the willow and the white poplar have been shown to be the least susceptible to injury from smokes and gases. By a reference to the species listed for the various zones, an idea can easily be obtained with reference to the forms best suited to meet the conditions at hand.

SUMMARY AND CONCLUSION.

As a direct result of the above study, the following conclusions are reached:

1. Gases and smoke have a detrimental effect upon vegetation.

2. The presence of vegetation in the vicinity of a manufacturing concern depends to a large degree upon its proximity to the plant in question. The territory reaching out from an industrial center is marked out into various belts. Each belt has a certain characteristic flora that marks it out from the others.

3. An industrial city shows conditions that are similar to those of a single large manufacturing concern.

*Industrial World, Feb. 3, 1913.

4. The effect of smokes and gases upon the leaves of plants concerns itself mainly with the assimilation process.

5. Certain species on account of their anatomical structure are more resistant than others.

6. As a means of prevention for an industrial city like that of Des Moines, Iowa, it is proposed to put in smokeless furnaces with tall smoke stacks, which will dilute the SO_2 to such an extent as to be harmless to the vegetation in general. Where gaseous emanations are peculiar to the product manufactured, special condensing flues must be provided.

7. The smoke from locomotives is largely prevented by careful firing. The real solution lies in electrification.

As a final conclusion I wish to express my thanks to Dr. William Crocker and Mr. Lee I. Knight of the University of Chicago, who first suggested the problem to me and who have given me assistance in all phases of the work. I am also indebted to Mrs. Mary Fairfield for assistance in the translation of the French, and to Miss Harriette S. Kellogg for the translation of the Italian. I am also grateful to Mr. Harry McNutt of the Public Safety Department of the city of Des Moines, who has given me every possible assistance in carrying on my survey in that city; to Dr. J. M. Greenman, formerly of the University of Chicago, but now of the Missouri Botanical Garden and Mr. E. E. Sherff, of the Curtis High School, Chicago, for their determination and verification of species of plants listed for the various zones; to Dr. George T. Moore, Director of the Missouri Botanical Garden, for the loan of reference works on the subject.

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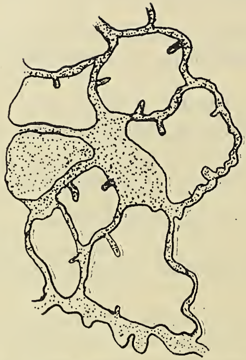


Fig. 1.—Cross section, through portion entirely coated.

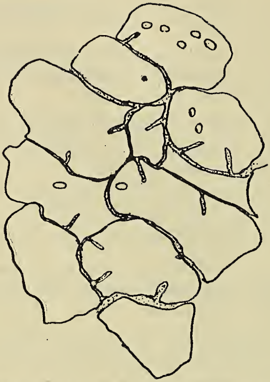


Fig. 2.—Cross section, through portion partially coated.

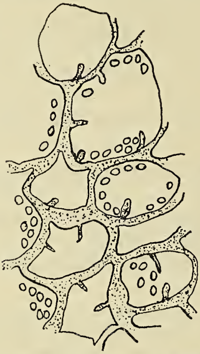


Fig. 3.—Cross section, through needle near base where no perceptible amount of tarry material was present.

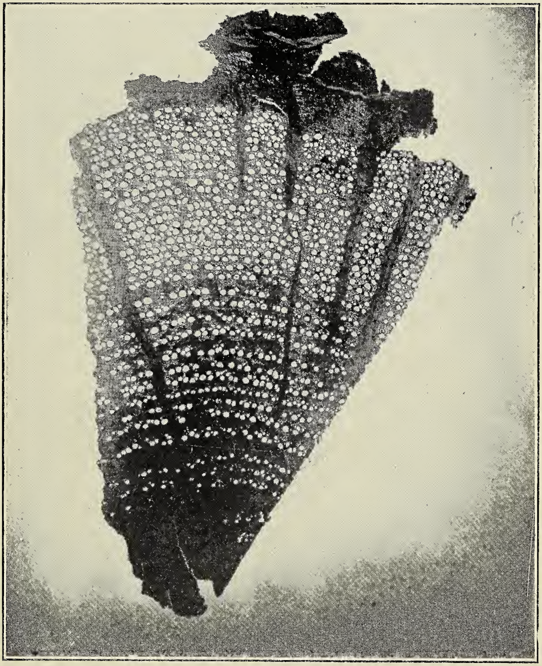
Fig. 4.—Normal.

Fig. 5—Acetylene (1-6750) 4 days.

Fig. 6.—Acetylene (1-6750) 4 days.

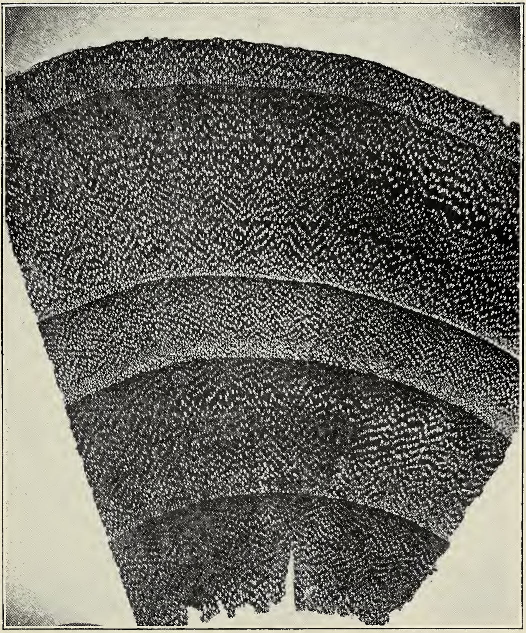
Fig. 7.—Acetylene (2-7750) 4 days.

Figs. 1-3.—Cross sections of a Pine needle taken from Washington Park, Chicago.
Figs. 4-7.—Pleurococens vulgaris.



(Photomicrograph by Buchanan and writer)

Fig. 8—Cross section of Burr Oak from smoke region.



(Photomicrograph by Buchanan and writer)

Fig. 9.—Cross section of Burr Oak from a non-smoke region.

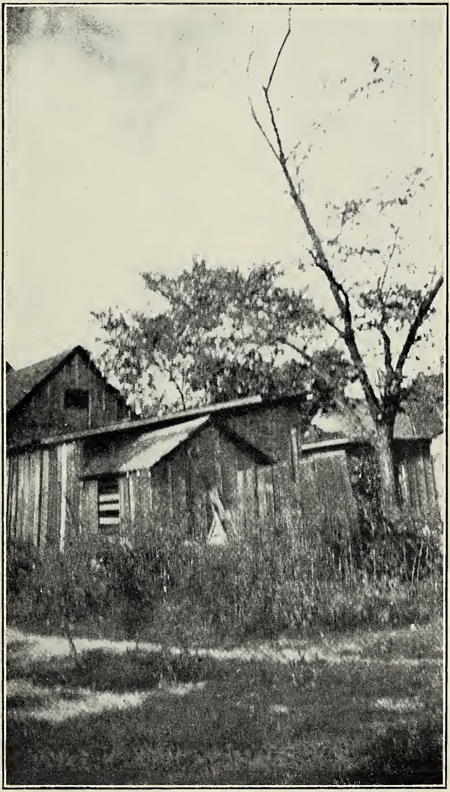


Fig. 10.—Shows the intimate relation of the smoke and upper branches. Note that the smaller tree is intact.

Figs. 10-17.—Photographs of the general appearance of vegetation in the vicinity of concerns that make the smoke areas of Des Moines, Iowa. (Photographs by McNutt and writer.)

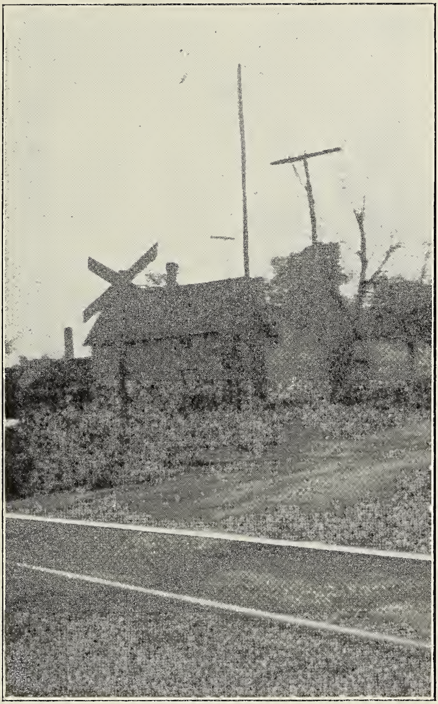


Fig. 11.—Shows the general appearance of a street as far as its trees are concerned.

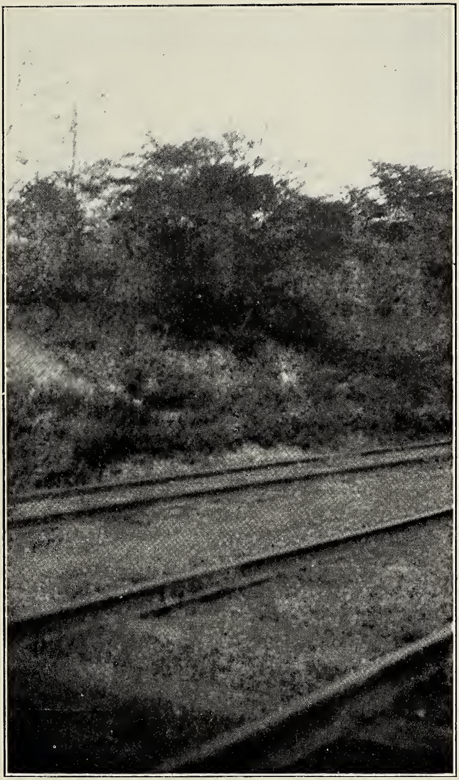


Fig. 12.—The appearance of trees along railroad tracks in yards where switching is done.

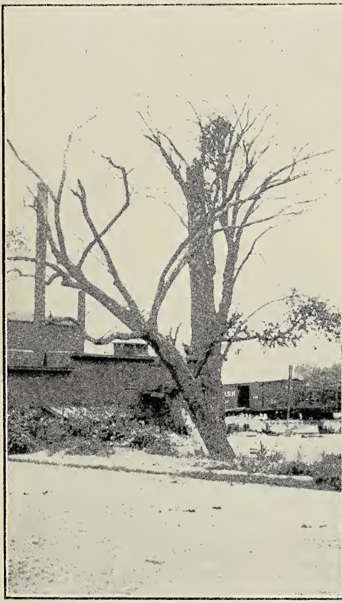


Fig. 13.—The appearance shows the effects of tar vapors on nearby trees. This plant manufactured asphalt for paving.

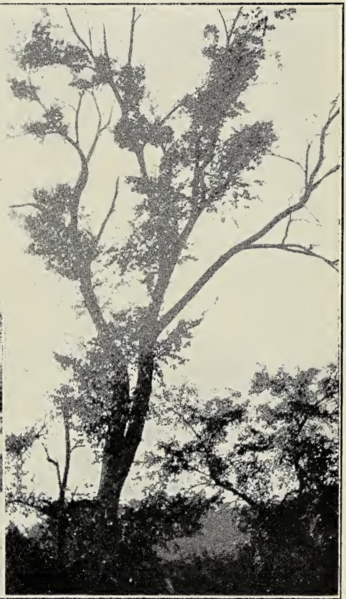


Fig. 14.—General appearance of a Cottonwood tree in the smoke region.

Fig. 15.—General view of trees in the vicinity of Iowa Brick Co.

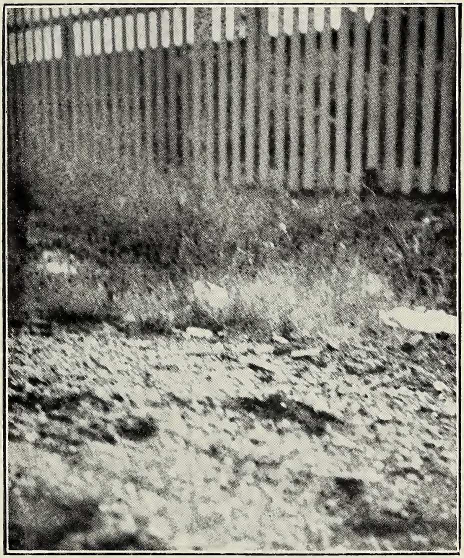


Fig. 16.—A good illustration of what is met with in Zone 1.

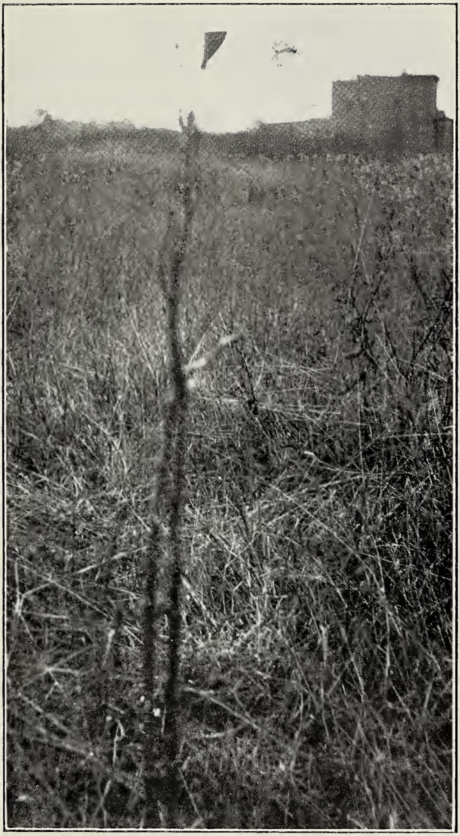


Fig. 17.—Shows the general defoliation taking place even among herbs such as the Common Milkweed.

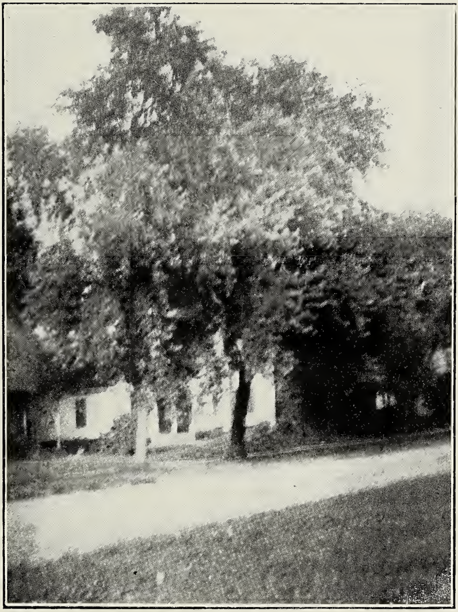


Fig. 18.—General appearance noted in the case of two Red Oaks that were just out

NITROGEN IN RAIN AND SNOW.

Second Paper.

By Nicholas Knight.

In the proceedings of the Iowa Academy of Science for 1911, we described a series of experiments to show the amount of nitrogen in rain and snow, which we carried on during the year 1910. The work described in this paper has to do with a series of experiments in the same line during some months of 1911-12. During this period we collected twenty-seven samples altogether, fourteen of which were snow, and thirteen were rain or rain and snow. There were sixty-nine inches of snow and about five inches of rain.

We collected the samples in two enameled pans, each about twenty inches in diameter. The samples were contained in glass stoppered bottles until the determinations were made, and kept as free as possible from contamination. There was not always a sufficient amount of the sample available to make the chlorine test. Our method for the chlorine was to evaporate 500 c.c. of the sample to dryness on the water bath, then to dissolve the residue in 50 c.c. distilled water, and titrate with tenth normal silver nitrate solution, using neutral potassium chromate solution as the indicator.

The oceans are doubtless the source of the chlorine. The salt spray from the waves as they beat upon the shore is caught by the winds and borne to the interior of the continent. We found chlorine in each sample examined for it.

In the experiments described in our previous paper, we determined the nitrates by reducing to ammonia with aluminum foil in alkaline solution. The nitrate determinations of the present paper were made by the phenolsulphonic method, which seems to give lower results than the reduction with nascent hydrogen.

TABLE I.

Date	Nitrite N in in 1,000,000 pts. of the water	Nitrate N in 1,000,000 pts. of the water	Free Ammonia in 1,000,000 pts. of the water	Albuminoid ammonia in 1,000,000 pts. of the water	Chlorine parts per million	Precipitation
December 20	0.23	0.40	0.82	0.51	----------	1/3 in. rain and snow
December 25	0.06	0.22	0.29	0.15	----------	3 in. snow
December 26	0.08	0.14	0.058	0.29	----------	4 in. snow
December 30	0.015	0.14	0.216	0.16	0.284	4 in. snow
January 9	0.08	0.32	0.11	0.16	7.1	3 in. snow
January 13	0.075	0.28	0.23	0.30	3.55	4 in. snow
February 1	0.03	0.48	0.33	0.11	0.71	2 in. snow
February 13	0.09	0.34	0.36	0.43	3.55	4 in. snow
February 24	0.06	0.04	0.56	0.21	----------	1-10 in. rain and snow
February 25	Trace	0.56	1.64	0.33	2.13	8 in. snow
March 2	Trace	0.72	0.29	0.29	2.485	6 in. snow
March 11	0.01	0.40	0.41	0.30	2.13	4 in. snow
March 14—I	0.07	0.84	0.47	0.36	4.61	3 in. snow
March 14—II	0.08	0.76	0.47	0.36	2.13	4 in. snow
March 20	0.01	0.44	0.44	0.23	1.8	10 in. snow
April 13	Trace	0.12	0.56	0.23	1.8	1/2 in. rain
April 17—I	0.01	0.18	0.47	0.33	4.26	1 in. rain
April 17—II	0.02	0.34	0.52	0.36	2.84	6 in. snow
April 21	Trace	0.48	0.41	0.50	----------	1/8 in. rain
April 25	0.01	1.00	0.58	0.70	----------	1/8 in. rain
April 28	0.36	0.88	0.70	0.66	5.68	1/2 in. rain
May 2	Trace	0.22	0.67	----------	----------	3/4 in. rain

D	Nitrite N in 1,000,000 parts of the water	Nitrate N in 1,000,000 pts. water	Free Ammonia in 1,000,000 parts of the water	Albuminoid Ammonia in 1,000,000 parts of the water	Chlorine parts in a million	Precipitation
May 10	0.25	0.30	0.81	0.51	----------	1/4 in. rain
May 11—I	Trace	0.32	0.79	0.68	----------	3/4 in. rain
May 11—II	0.052	0.22	0.84	0.78	----------	1/4 in. rain
May 14	0.38	0.30	0.85	0.70	----------	1/6 in. rain
May 20	0.40	0.60	0.91	0.78	----------	1/8 in. rain
May 21	0.01	0.44	0.85	0.80	----------	1/8 in. rain

TABLE II.

POUNDS PER ACRE.

Date	N in Nitrites	N in Nitrates	N in Free Ammonia	N in Albuminoid Ammonia	Total
1912					
December 20	0.0174	0.0303	0.0620	0.0386	0.1483
December 25	0.0042	0.0154	0.0203	0.0105	0.0504
December 26	0.0073	0.0091	0.0053	0.0264	0.0481
December 30	0.0014	0.0127	0.0197	0.0528	0.0866
1913					
January 9	0.0054	0.0216	0.0075	0.0108	0.0453
January 13	0.0068	0.0253	0.0208	0.0272	0.0801
February 1	0.0014	0.0224	0.0154	0.0051	0.0443
February 13	0.0082	0.0309	0.0328	0.0390	0.1109
February 24	0.0014	0.0008	0.0130	0.0049	0.0201
February 25	Trace	0.1016	0.2977	0.0599	0.4598
March 2	Trace	0.0980	0.0325	0.0325	0.1630
March 11	0.0010	0.0363	0.0347	0.0254	0.0974
March 14—I	0.0070	0.0571	0.0270	0.0210	0.1151
March 14—II	0.0070	0.0690	0.0290	0.0230	0.1280
March 20	0.0020	0.0998	0.0822	0.0420	0.2260
April 13	Trace	0.0136	0.0934	0.0384	0.1454
April 17—I	0.0020	0.0408	0.1066	0.0749	0.2243
April 17—II	0.0027	0.0463	0.0583	0.0403	0.1476
April 21	Trace	0.0136	0.0096	0.0117	0.0349
April 25	0.0002	0.0283	0.0135	0.0163	0.0583
April 28	0.0408	0.0998	0.0654	0.0693	0.2753
May 2	Trace	0.0330	0.0875	0.0862	0.2067
	0.1162	0.9067	1.1342	0.7562	2.9133
May 10	0.0142	0.0170	0.0361	0.0230	0.0903
May 11—I	Trace	0.0545	0.1107	0.0953	0.2605
May 12—II	0.0029	0.0125	0.0392	0.0362	0.0908
May 14	0.0646	0.0510	0.1200	0.0981	0.3337
May 20	0.0113	0.1200	0.0214	0.0182	0.1709
May 21	0.0028	0.0125	0.0199	0.0187	0.0539
	0.2120	1.1742	1.4815	1.0457	3.9134

We desire to express our hearty thanks to W. E. Morling and John W. Liddle for conducting the experiments described in the foregoing.

THE ROCK FROM SOLOMON'S QUARRIES.

By Nicholas Knight.

A specimen of the rock from Solomon's quarry was lately received by us for analysis. It is the material that served in the construction of Solomon's Temple, a building characterized by Dr. Lyman Abbott as an *architectural splendor*. The rock is of snowy whiteness, soft when first removed from the quarry, but it soon hardens on exposure to the air. The natives call the rock from this portion of the quarry "The Royal." The quarries extend underneath the city. The rock is soft and quite porous. There is a variety in another portion of the quarry, on a higher level which is locally called "The Hard Jewish." The analysis was made by G. H. Wiesner, in the Cornell chemical laboratory, as follows:

Ca CO_3	99.32%
Mg CO_3	0.67%
	99.99%

There is not a trace of silica iron or alumina. It is almost a perfect specimen of calcium carbonate, with only a small quantity of magnesium carbonate. It is purer limestone than *Carara marble, and the query arises whether there is another limestone formation as extensive as this anywhere, of equal purity. It would be an ideal rock for Portland cement and calcium carbide on account of the low magnesia content. The specimen was sent us by Herbert E. Clark, Jaffa Gate, Jerusalem, for which we desire to record our hearty thanks. He suggested as the formation lies under the city, and being porous, that drainage may have affected the nature of the rock, but the analysis does not seem to indicate any disturbing influence.

On account of the porosity, we did not get a satisfactory result in determining the specific gravity. By one method we obtained 2.25, and by another process 2.48. The latter would seem to be more nearly the correct value.

*School Science and Mathematics, February, 1911, page 175.

SEGREGATION OF FAT FACTORS IN MILK PRODUCTION.

BY F. B. HILLS AND E. N. BOLAND.

The need of an investigation into the problem of inheritance of fat in milk, has long been recognized by the practical milk producer and the physiologist. For the former, a solution of the problem would simplify, very markedly, his breeding operations, as well as increase the certainty of his results. For the latter, a knowledge of the fat producing possibilities of the animal genetically would give an index to the physiological limits of fat formation, and its relation to metabolism.

The title of this paper might indicate that the problem has been solved, but in this sense, the title is a misnomer, for the paper can merely throw a little light, perhaps, on some of the work to be done. It records the principal discoveries made in the pursuance of a Master's degree thesis in the breeding laboratory of the Animal Husbandry Department of this college.

With the exception of the data collected from the microscopical examination of many samples of milk in the laboratory, the source of the data studied is the Advanced Registry Official records of the Holstein-Friesian Association. The number of animals listed is large and the field little exploited, although worthy of systematic consideration, since the records have been kept for a sufficient length of time to include the performance of many generations.

The commonly accepted theory of milk secretion, is that first proposed by Langer and since slightly modified by Steinhaus, Brouha and others. Dr. Marshall, in his "Physiology of Reproduction," has outlined this theory somewhat as follows: Some of the cells of the gland lengthen out so that their ends project freely into the lumina of the alveoli, and probably undergo cell division. The projecting portions then disintegrate, before or after becoming detached, and the cell substance passes into solution to form the albuminous and carbohydrate constituents of the milk. The fat droplets, which collect in the disintegrating part of the cell, give rise to the milk fat. The basal portions of the cells remain in position, without being detached, and subsequently develop fresh processes, which in turn are disintegrated. It is believed, however, that some cells, possibly the largest number, simply discharge their fat droplets and other contents into the lumina, while otherwise remaining intact. To support the first mentioned idea, Steinhaus and Szabo report actual evidence of mitotic cell division in the actively secreting glands, the daughter nuclei taking part in the general disintegration.

The precise method of the formation of fat in milk is not known. It occurs in the milk in the form of innumerable globules, covered with a thin layer of casein. These vary in diameter from .001 to .005 mm. and give color to the emulsion by the reflection of light. The relative numbers of larger and smaller globules in milk is somewhat affected by the breed to which the producing animal belongs. It is commonly recognized that there is a higher percentage of large globules in Jersey and Guernsey milk than in Ayrshire and Holstein milk, since the emulsive power of the former is less than that of the latter, permitting the cream to rise more rapidly. This fact might suggest a factor in inheritance similar to the intensity factors found in color inheritance.

In a microscopical examination of a large number of samples of milk of various composition, it was found convenient for comparison to divide the globules into three classes, as regards size. All under .0016 mm. in diameter were in the first class, those ranging from .0016 to .0032 mm. in diameter fell into the second group, and all over .0032 mm. were placed in the third class.

Numerous counts of the globules were made in samples of milk of the following fat content: 2.8%, 3.2%, 4.2%, 5.2%, 6.2%, and 7.2%. There was found to be a positive correlation between the percentage fat composition of the milk and the number of fat globules of different sizes, the co-efficient being .19. From an inspection of the counts, the relation is evident,—for instance in the sample of 2.8% fat content, 66% of the number of globules were in the first division, 28% in the second and 6% in the third division. In the 7.2% milk there were only 47% of the total number of fat globules in the first division, while there were 40% in the second and 16% in the third,—showing at a glance the large increase in the proportion of large globules, with the increased fat composition of the milk.

The grouping of the globules according to the system mentioned, was purely arbitrary. Under a different grouping the correlation might be even more evident. But the results were positive enough to warrant the conclusions drawn. Continued investigation along this line should reveal some facts of great value to the practical producer.

For a study of inheritance of fat production, as shown by the relation of the production of dams to that of their offspring, 3,700 pairs of variates were taken from the 1910-1911 Official Year book of the Advanced Registry of the Holstein-Friesian Association. The mean fat production of the offspring was 16.952±.039, while that of the dams was 15.971±.034. The standard deviation and co-efficient of variability of the offspring were also greater than those of the dams, showing the tendency of the individuals of the F_1 generation to reach the extremes of the parental generations. The correlation coefficient of .29 would, according to the statistical method of study of Biparental Inheritance, show evidence of prepotency on the part of the dams as opposed to the sires. This fact may indicate a sex-linkage of the factors controlling inheritance of fat production.

A rearrangement of the data, used in the work just discussed, in classes representing three generations, shows the following coefficients of variability,—parental generation, 21.686, F_1 generation 18.737, and F_2 generation 21.824. This is typically Mendelian, although the fact that there is an artilcial selection which leaves the poorer producers out of the Advanced Registry and also out of the breeding herd, lowers the coefficient. With as large numbers as are under consideration here the effect is probably equal in each generation.

Any attempt to distinguish the unit of inheritance is somewhat futile, when one depends entirely on written records. An attempt was made to find such a unit however, and a dividing point, that separated into two classes was readily recognized. The breeding records of the granddams, classified into different groups with the pound as the unit, were tabulated and compared. For example the granddams producing 12 lbs., (the lowest production allowed in Advanced Registry for a mature animal) were grouped together, their daughters forming the relative class, and their granddaughters the subject class. All the granddams of different productions were grouped in the same way. By inspection of the result, it was found that the granddams producing up to 21 lbs., bred qualitatively the same. At this point appeared a sharp line of demarkation, above which the production in the granddaughters averaged about 21 lbs., while below the production was 17 lbs. The figures for these groups are as follows:

12 lb. granddams—mean production of granddaughters	17.41	lbs.
13 lb. granddams—mean production of granddaughters	16.89	lbs.
14 lb. granddams—mean production of granddaughters	17.68	lbs.
15 lb. granddams—mean production of granddaughters	17.5	lbs.
16 lb. granddams—mean production of granddaughters	17.66	lbs.
17 lb. granddams—mean production of granddaughters	17.2	lbs.
18 lb. granddams—mean production of granddaughters	18.48	lbs.
19 lb. granddams—mean production of granddaughters	17.69	lbs.
20 lb. granddams—mean production of granddaughters	16.32	lbs.
21 lb. granddams—mean production of granddaughters	15.5	lbs.
22 lb. granddams—mean production of granddaughters	25.0	lbs.
23 lb. granddams—mean production of granddaughters	20.44	lbs.
24 lb. granddams—mean production of granddaughters	20.66	lbs.
25 lb. granddams—mean production of granddaughters	23.0	lbs.
26 lb. granddams—mean production of granddaughters	23.5	lbs.
27 lb. granddams—mean production of granddaughters	20.0	lbs.
28 lb. granddams—mean production of granddaughters	20.33	lbs.

A tabulation of the variates within these limits reveals the fact that the granddams having records above 21 lbs. produced F_2 descendants, as follows: 54 above 21 lbs. and 60 below. The granddams below 21 lbs. produced 764 below 21 lbs. and 104 above. The latter appears to be a 7:1 ratio, indicating a linkage of two factors,—one a pure dominant, the other probably sex-linked acting in a simple 3:1 ratio.

These facts, it is true, go but a very short way in the solution of this problem, but it is hoped that they may afford an indication of the means for further investigations.

In the work just reviewed, the points to be noted are:

1st. The relation between the percentage fat composition of milk, and the proportion of fat globules of different sizes.

2d. The prepotency of dams in transmission of fat production to their offspring as evidenced by the correlation coefficient .29 indicating sex-linkage of some of the factors of fat inheritance, and,

3d. The segregation of fat factors in a 7:1 ratio showing further evidence of linkage of factors in the inheritance of fat content of milk.

COMPLETE SUCCESSION OF IOWAN CRETACIC TERRANES.

BY CHARLES KEYES.

For several reasons the section of Cretacic strata in northwestern Iowa is of especial interest. It was in this section, near the mouth of the Big Sioux river, that for the first time in the New World the stratigraphic equivalents of the English Cretacic formations were clearly recognized. In this section true chalk, made up of countless myriads of microscopic organic remains, was first discovered in this country. This section is also a part of the classic locality for the Mid-Cretacic formations of America.

Notwithstanding the fact that the Cretacic terranes constitute the surface rocks over a very large part of the state of Iowa their stratigraphic relationships were never clearly made. For a period of 50 years, from the time of Meek and Hayden's visit to the Upper Missouri country, in 1858, the exact geologic position of the several terranes was largely misunderstood. In all this time only a single correlation of any of the formations appeared which was eventually proved to be correct. This was my own reference in 1894 of the chalk beds in the extreme northwest corner of the state and the neighboring portions of South Dakota to the Niobrara horizon, those chalk-exposures farther southward, along the Big Sioux river, belonging not to the Niobrara as generally regarded but to a lower part of the section. The relations of White's Nishnabotna sandstone to the rest of the Iowa Cretacic section remained from the first enigmatical. Correlation, and naming of the several members displayed above Sioux City, with the southeastern Colorado sequences, 400 miles away, without a single intervening exposure of the rocks seemed unwise.

Quite recently the logs of certain well-sections obtained near Sioux City have disclosed the long missing data for establishing a complete section of the Cretacic rocks of Iowa. This section may be expressed as follows:

Coloradan Series	7. Niobrara limestones	150 feet.
	6. Hawarden shales	125 feet.
	5. Crill limestones	100 feet.
	4. Woodbury shales	150 feet.
Dakotan Series	3. Ponca sandstone	25 feet.
	2. Sergeant shales	75 feet.
	1. Nishnabotna sandstones	200 feet.

As here defined the Niobrara chalky limestone is not the so-called Niobrara chalk commonly noted in Iowa by Meek and Hayden, Calvin, Bain, and others, but a bed much higher in the section which has been recently directly traced in the field to the typical outcrop of the Niobrara limestone. It has a very small areal extent within the boundaries of Iowa. This member has quite generally escaped observation.

The Hawarden shales are tentatively referred to the Pierre shales in the early Iowa geological reports. In some of the reports of the Federal government these beds are called the Carlile shales and they are considered the exact representation of the similarly named shales in Colorado. There appears to be no valid grounds for such reference except the very uncertain one of lithologic similarity, or similarity of lithologic sequence. Until there is better evidence forthcoming than now seems possible it appears best to designate the Iowa beds by a distinctive title, by a name from the town where the formation is well exposed, and at which the section has been fully described.

The Crill chalk, or limestone, is the well-known formation exposed at various points above Sioux City, especially near Westover and the old site of the Crill mill. It is this layer which has usually gone by the name of the Niobrara chalk—a correlation and mistake which Meek and Hayden first made and which the majority of later writers followed. Others have correlated the formation with the Greenhorn limestone of the Rocky Mountain region. It is the Inoceramus limestone of White.

With slight modification of limits the Woodbury shales of White seem to be a useful subdivision. The formation has been so long recognized without challenge that it appears proper to retain the title for the Iowa section rather than to try to adapt the much later named Colorado section under the term Graneros shales.

The Ponca sandstone is the massive bed so well displayed near Sioux City, and on the opposite side of the Missouri river, especially at the village of Ponca. At Sergeant Bluff this layer forms a prominent ledge; and at Crill mill it lies at the water's edge.

Beneath the massive sandstone of Ponca are 75 feet of sandy and argillaceous shales. They are best exposed at Sergeant Bluffs, six miles below Sioux City on the Missouri river. Farther downstream they also outcrop, particularly on the Nebraska side of the river.

On the Iowa side of the Missouri river the lowest sandstone appears to be hidden for a distance of many miles. Recent wells put down in the vicinity of Sioux City clearly show that this sandstone is quite massive, and homogeneous in character, and has a thickness of fully

200 feet. It rests directly upon Carbonic limestones. In Nebraska the Missouri bluffs are composed of this rock for many miles. By means of well-sections this rock is easily traceable far to the east, southeast and south, and there becomes the typical Nishnabotna sandstone—the basal member of the Cretacic section of the state. It everywhere rests in marked unconformity upon the older rocks.

In Bain's general geological section of Woodbury county (Iowa Geol. Surv., vol. V, p. 256) No. 1 is the Nishnabotna sandstone, Nos. 2 and 3 the Sergeant shales, No. 4 the Ponca sandstone, Nos. 5 to 11 the Woodbury shales, and No. 12 the Crill chalk.

Iowa's Mesozoic section was formed in Mid-Cretacic times. It comprises no less than seven well defined members. It has a maximum thickness of over 800 feet.

RECOGNITION OF BEDS OF TERTIARIC AGE IN OUR STATE.

BY CHARLES KEYES.

Iowa has been repeatedly and so thoroughly planed off and worked over by continental glaciers of no less than five great ice-invasions that it could be hardly expected that any remnants of the softer pre-glacial formations, if there ever were any deposited within the state's boundaries, would survive. Moreover, the state is now everywhere so deeply covered by the several till-sheets and the vast eolian soil-mantles as to effectually conceal all traces of the existence of pre-glacial deposits which we ordinarily refer to the Tertiaries.

In spite of these unfavorable conditions I have never, in the twenty-five years during which I have been more or less closely connected with geological work in the region, given up hope of some day having disclosed true Tertiaric beds of some kind or other. Further, it has been surmised that certain of the numerous sections which had been usually referred wholly to the drift were in reality partly of earlier origin.

Several years ago opportunity was offered to examine rather carefully, with this idea in mind, some of the sections of central South Dakota. In tracing the formations eastward certain of the sands, known to be Tertiaric in age, were found to extend in broken patches nearly to the Iowa line.

During the past year it was possible to make comparison of the undoubted Tertiaric beds mentioned and sundry isolated bodies of lithologically similar character but which reclined beneath the great till-sheet of western Iowa. One of these great beds in particular deserves especial mention. It is rather fully described by Bain in his report on the geology of Woodbury county, so that no further account of its characters and peculiarities need be here reiterated. So remarkable and distinctive in its stratigraphic relations was this bed that the author mentioned designates it the Riverside sands. With the evidence which Bain records and with the later data received there appears to be but little doubt that this and other similar deposits of the region are really remnants of a once widely spreading formation which was laid down in Tertiaric time. It is not at all unlikely that this deposit represents Mid-Tertiaric, or Miocene deposition.

LATE DEVONIC SEQUENCE OF THE IOWA REGION.

(SYNOPSIS.)

BY CHARLES KEYES.

The great Devonic limestone succession in Iowa was long treated as if it were a single stratigraphic unit. To it the title Cedar Valley formation was generally attached. This vaguely defined term was suggested by D. D. Owen as early as 1852. Little or no attempt was seemingly ever made to differentiate this hundred-odd feet of limestone.

Singularly enough the only efforts to separate the section into subordinate terranes, based upon the lithologic differences and the paleontologic peculiarities and resemblances, have never been published. Twenty-five years ago, when yet a student at the State university, I made a very careful and complete determination of the vertical range and faunal elements of the various groups of organic remains, and as a result distinguished four principal subdivisions. These were easily and clearly contrasted by their contained faunas. The lines of demarkation were readily made out over half a dozen counties. Active work in other fields prevented giving the solution of the Cedar Valley problem its finishing touches. The subdivisions then determined were accepted by Professor Calvin and in his report on the geology of Johnson county they are distinctly recognized but no specific names appended, probably for reason of the fact that he considered the credit as properly belonging to another worker in the same field.

For these subdivisions the names Solen, Rapid, Coralville and Lucas, from well-known localities in Johnson county, are now proposed. The Devonic section as originally made out for the neighborhood of Iowa City, and as given by Professor Calvin, is as follows:

GROUPING OF THE CEDAR VALLEY LIMESTONES.

Series	Division		Feet.
SENECAN SERIES.	Lucas Limestone.	11. Limestone, white, fine-grained, *Straparollus* abundant at base	20
	Coralville Limestone.	10. Limestone, gray, fine-grained, (*Idiostroma*)	2
		9. Limestone, gray, earthy	6
		8. Limestone, gray, massively bedded, (*Acervularia* and sponges.)	10
		7. Limestone, bluish, thin-bedded and shaly, unfossiliferous	8
	Rapid Limestone.	6. Limestone, gray massive, compact, coralline	2
		5. Limestone, bluish, heavily bedded, (*Cladopora*)	3
		4. Limestone, blue, massive compact, (*Cystiphyllum*)	6
		3. Limestone, gray, shaly, unfossiliferous	20
	Solen Limestone.	2. Limestone, gray, shaly, (*Megistocrinus*)	15
		1. Limestone, bluish, compact, (*Phillipsastrea*)	10

The several terranes are fully described in the report on Johnson county. The point here to be especially noted is that subdivisions recognized should receive greater emphasis than they are likely to from mere perusal of the Calvin report. By definitely designating them by means of local names where the sections are best displayed this is partially accomplished.

THE PROPER USE OF THE GEOLOGICAL NAME, "BETHANY."

BY JOHN L. TILTON.

The proper use of the terms "Bethany," "Bethany Falls," "Winterset" and "Erie" formerly elicited considerable discussion, summarized by Bain[1] in his Guthrie county report. In that report and in the reports on Dallas and Madison[2] counties the term Bethany applies to the entire Winterset section. In the Decatur[3] county report also Bethany applies to the entire Missouri section found, which is there divided into the following sub-stages:

Stage.	Sub-stage.
Bethany	Westerville De Kalb Winterset Earlham Fragmental

Bain[4], in his discussion of the Bethany Limestone at Bethany, Missouri, states that "it is not the particular limestone which is of significance, but the whole group of limestones, all of which are well shown within the town of Bethany, Missouri." Since that time the correlation of the parts of this whole group of limestone has been carried to such an extent that the problem is no longer, What is the relation of these limestones to the coal bearing strata of the Des Moines formations? but, Which of these several limestone beds is it that outcrops in a given place? Indeed, Bain himself in the paper last named proceeds to describe the various strata of limestone outcropping within the town of Bethany and to correlate them with the various strata of limestone found in Madison and Decatur counties in Iowa, and in so doing he correlates the limestone over which the water plunges at Bethany Falls

[1]H. F. Bain, Geology of Guthrie County, Iowa Geological Survey, Vol. VII, pp. 449-450. 1896.

[2]Tilton and Bain, Geology of Madison County, Iowa Geol. Surv., Vol. VII. 1896.

[3]H. F. Bain, Geology of Decatur County, Iowa Geol. Surv., Vol. VIII. 1897.

[4]H. F. Bain, The Bethany Limestone at Bethany, Missouri, Am. Jour. of Sci., Vol. V, pp. 433-439, 1898. See also Geology of Decatur County, Iowa Geol. Surv., Vol. VIII, pp. 472-476, 1897.

(Broadhead's No. 78)[5] as the "Fragmental" of the table above given for Decatur county.

Last spring (1912) Mr. F. C. Greene, in correspondence with reference to priority of terms here in Iowa expressed the opinion that Broadhead's No. 78 is not the "Fragmental" of the Iowa section, but is the "Earlham." So important with reference to nomenclature did such a statement appear that in August, 1912, the writer accepted Mr. Greene's invitation to meet him at Bethany and review the situation. First we visited the heavy limestone outcropping by the river side about half a mile above the falls, and then the shale and limestone found on the hillside a few rods further upstream. The entire relation suggests that this heavy limestone is the Winterset limestone, and the shale and limestone on the hillside just beyond, is a small portion of the De Kalb limestone and associated shale (Cherryvale shale). From this place we walked over through the town to where the railroad crosses a small ravine tributary to Big Creek not far from the railroad station. Here the topmost limestone is clearly the De Kalb and not the Winterset, for beneath the thin beds of shale that underlie it is "Limestone, drab blue, two ledges, 9 and 3 inches thick" which with the associated shale rich in fossils is the most distinctive horizon in the entire succession of strata (the Cherryvale shales), a duplication of the deposits found near the brow of the hill in the southern edge of Winterset (close to the fork in the road southeast). There is no mistaking this horizon. A few rods below the railroad bridge at Bethany is an outcrop of the next ledge beneath, the Winterset limestone, characterized especially by a mass of very large Productus prattenianus, Pinna (?), and other fossils near low water in the pool close by and corresponding to a similar but less perfectly developed horizon seen in the Winterset limestone at Winterset a few rods east of the fork in the road previously mentioned.

The shale which lies beneath this limestone just below the railroad bridge is not there exposed, the next strata visible being the limestone, fragmental in character, at the falls itself. The relation of this limestone to that described above is slightly obscured by the dip of the strata; but as the general direction from one ledge to the next is approximately the direction of the strike there is no chance for the presence of so heavy a bed of limestone as the Earlham between the limestone exposed below the railroad bridge and the limestone seen at the falls.

[5]Broadhead, Trans. St. Louis Acad. Sci., Vol. II, p. 311, 1862. (In this report the Bethany Falls limestone is No. 766.) Missouri Geological Survey, Report on Iron Ore and Coal Fields, Pt. II, p. 76, etc. 1873. (In this report the Bethany Falls limestone is No. 78.)

The fragmental appearance and the separation into two distinct portions at the falls strongly resemble these features in the limestone at the base of the Missouri stage in Iowa (the Hertha, or so-called Fragmental); but even at Winterset a portion of the uppermost Earlham limestone is slightly fragmental.

At the falls there is a bridge over a small ravine which empties into Big Creek. A few hundred yards south along this small ravine one comes to quarries where heavy beds of the Winterset limestone are conspicuous. For a short distance back north toward the falls nothing is visible (the shale is concealed). Then one comes directly to the top of the limestone which is continuous with the limestone at the falls itself. A few rods downstream from the falls is another quarry where a section revealed but sixteen feet not exposed—too little by far to contain any considerable deposit of limestone and associated beds of shale. Then, standing on the limestone at the mill, we looked back up the stream to where the limestone (Winterset) which we had first visited appeared beside the stream. It is needless to say that in the face of such evidence it was necessary to agree that Broadhead's Bethany Falls Limestone (his No. 78) is not the "Fragmental" of Iowa but the "Earlham."

But the array of argument which Mr. Greene had to present was not exhausted. The next day we took a carriage sixteen miles across country to Gilman City, and then went afoot east down a ravine known as Tombstone Creek. In a short distance we came upon a ledge of limestone (De Kalb) over perhaps fifteen feet of very fossiliferous shale containing Meekella striatocostata, Productus costatus, P. nebrascensis, P. cora, P. longispinus, a bed of Chonetes verneuiliana, Rhombopora lepidodendroides, Myalina subquadrata and Ambocoelia planoconvexa. Here also were the two layers of blue limestone. (The beds above, which at Winterset contain so many Derbya crassa, were not well exposed.) Here again the horizon is unmistakable. It is the horizon exposed at the railroad bridge previously mentioned. Following the ravine down we came next upon about thirteen feet of Winterset limestone, then, as measured by the barometer, thirteen feet of Galesburg shale with included black shale as at Winterset, then eighteen feet of Earlham limestone splendidly exposed, and with the top fragmental as at Bethany Falls. Then, following this same creek bed down, the top of the "Fragmental" (Hertha limestone) soon appeared beyond a railroad bridge. To the south this Hertha limestone rises above the level of the track within a short distance, where this formation is seen divided by a foot of blue shale into two portions. In the upper portion fifteen inches of limestone is surmounted by two feet of fragmental limestone. Immediately beneath the foot of shale is two and a half feet of ferrugenous limestone, then seventeen inches of another grayish limestone, then blue shale, a succession entirely unlike that at Bethany Falls except that a fragmental limestone is the topmost portion at each place and a shale lies beneath the lowest limestone. At Bethany Falls the division of the limestone into an upper and a lower portion is not due to the presence of a bed of shale. Further, along the same ravine we had come upon four distinct beds of "fragmental" limestone, two of which I have mentioned. One other was at the top of the Winterset limestone and one on the De Kalb.

It is therefore evident, 1st, that the term "Fragmental" as the name of the limestone at the base of the Missouri series should be displaced here in Iowa by the geographical name which has the preference, Hertha*; 2nd, that the name Earlham limestone should be replaced by that time honored but misused name, Bethany Falls limestone, which is the name Broadhead originally used for this particular formation; and, 3rd, that the names for the limestones should no longer be made to include the beds of shale which separate them; but the beds of shale be recognized by names already given them elsewhere. This part of the geologic section in south central Iowa then stands as follows:

Group.	System.	Series.	Stage.	Sub-stage.
Paleozoic	Carboniferous.	Pennsylvania.	Missouri.....	Westerville limestone.** Chanute shale.* De Kalb limestone.** Cherryvale shale.* Winterset limestone.** Galesburg shale.* Bethany Falls limestone. Ladore shale.* Hertha limestone.*

Since the preparation of the above paper a communication from Mr. Greene gives the following "log of a well drilled one-fourth mile south of the center of section 9, T. 63 N., R. 28 W., on the flood plain near the falls of Bethany." This, like the preceding description, is printed

*Adams, Girty and White, Stratigraphy and Palaeontology of the Upper Carboniferous Rocks of the Kansas Section, Bull. No. 211, U. S. Geol. Surv.
Erasmus Haworth, Kan. Univ. Quar., Vol. III, 1895. Univ. of Kan. Geol. Surv., Vol. I, 1896. Univ. of Kan. Geol. Surv., Vol. III, 1898. Univ. of Kan. Geol. Surv., Vol. IX, 1908.
Adams, Haworth, and Crane, Economic Geology of the Iola Quadrangle, Kansas, Bull. 238, U. S. G. S., p. 18.
In certain of these references it appears that Bain's correlation has been followed on the supposition that it is correct.

**See above references to the reports of the Iowa Geological Survey.

with Mr. Greene's consent. It demonstrates on the spot that the top of the Hertha limestone is fifteen feet below the Bethany Falls limestone at the falls itself:

Driller's Terminology.	Interpretation.	Thickness. Ft.	Depth. Ft.
Soil		22	22
Falls limestone	Bethany Falls limestone	8	30
Shale, with some thin limestone	Ladore shale	15	45
Limestone	Hertha limestone	6	51
Sandstone, hard, loose grained	Top of Pleasanton	15	66
Sandstone, open, coarse grained		28	94

A PLEISTOCENE SECTION FROM DES MOINES SOUTH TO ALLERTON.

BY JOHN L. TILTON.

ABSTRACT.

1. A valuable series of exposures is now to be found along the railroad from Des Moines to Allerton.

2. A detailed description of some of the outcrops.

3. General observations and relations.

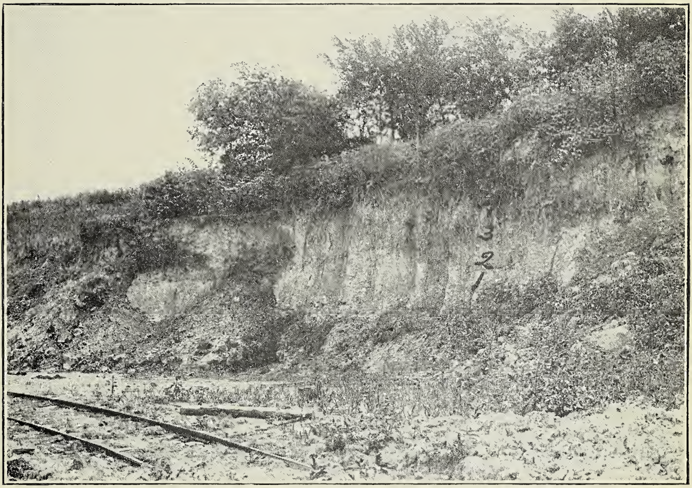
The grading of a new railroad line from Des Moines to Allerton, passing from Polk through Warren, Marion, Lucas and into Wayne county, affords an excellent opportunity to secure parts of a Pleistocene section from Des Moines south nearly across the southern half of the state from a series of exposures such as have never before been available in this region. The section is a key to the Pleistocene of south central Iowa, serves to connect previous work there with that yet to be accomplished in that region and in north central Missouri, and also affords data for comparison with the excellent records which Shimek has obtained along the Missouri river in western Iowa.

The first important exposure south of Des Moines is immediately north of the small railroad station known as Coon Valley (see Des Moines Quadrangle, T. 78 N., R. 23 W., Ne. 1/4 of Sec. 21). The cut is about a quarter of a mile long. For two-thirds of that distance from the west the Des Moines shales may be seen, the surface rising gradually to a height of twenty feet above the track near the center of the cut. What lies immediately on the shales is already concealed by talus in the west third of the cut; but just east of the highest point of the shale may be seen two bowlders of greenstone each about a foot in diameter embedded in a dense clay blotched with black and brown and resting on the disintegrated upper portion of the shale. Above these bowlders is three to four feet of dark brownish clay not distinctly separable from the clay enclosing the bowlders. Eighty feet farther east there rests on the Des Moines shales four feet of this dense clay, blue in color but brown along cracks, with pebbles of quartz and sandstone and fragments of shale. The upper portion grades upward into a distinct layer of dark oxidized material. Another eighty feet to the east the lower part of the reddish brown clay is found to be the weathered top of the Des Moines shale; and, in one place above the clay, with no plane of separation, is four feet of a dark brownish laminated silty material containing an abundance of plant fibers. Apparently this upper deposit is continuous under talus with the upper part of the brownish deposit to the west. Throughout the remaining distance to the east end of the cut a bluish silty deposit two to three feet thick rests on the clay containing fragments of plant fiber, with a two-inch plane of oxidation visible in places between them. Above this deposit to the soil is a bed of grayish loess which in places is very fossiliferous. Near the west end of the cut the loess is twelve to fifteen feet thick, distinctly laminated, and containing an abundance of fossils. For perhaps four feet there is a four-inch plane of oxidation between the brown loess above and the gray below, but elsewhere no such plane is visible.

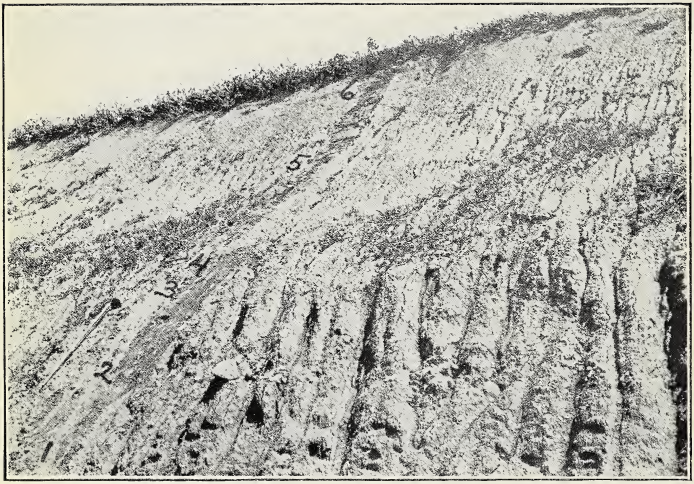
The drift containing the two bowlders is unquestionably Kansan, though local evidence here is not fully conclusive. In tabular form these descriptions stand as follows:

	Feet.
6. Soil, yellowish	1-2
5. Loess, brown above where weathered, brownish where less weathered, gray where not weathered, distinctly laminated; with a few horizontal planes of marked oxidation; and abundance of concretions and loess fossils	12-15
4. Fine clayey deposit like silt, white where dry, bluish where damp	2
3. Dark brownish laminated silty material, with abundance of plant fibers	4
2. Clay, dense, with streaks of black and brown, with a few pebbles of quartz, chert and sandstone, and two bowlders (Kansan Drift.)	4
1. Shale, mostly clayey, upper portion much weathered (Des Moines)	20

Half a mile south of Avon a steam shovel is at work opening a gravel pit close to the one where years ago Mastodon or Elephant remains were reported found at a depth of about sixteen feet. For five feet from the surface the deposit is a dark sandy loam, very slightly laminated, and containing Kansan pebbles of all kinds scattered through it and lying in all possible positions. The pebbles are of all sizes up to a very few three inches in diameter, the average of the largest being perhaps one inch. One rounded mass of sand (a sand bowlder or cobble) four inches in diameter contained a two-inch pebble in its lowest portion. At the bottom of the five feet the deposit is more distinctly a sand and gravel.



View of a portion of the cut near Coon Valley.



View of a portion of cut near Hartford.

The lowest sand and gravel with the Mastodon or Elephant remains is referred to the Aftonian interglacial interval.

A mile south of Hartford (see Milo Quadrangle, T. 77 N., R. 22 W., east half of section 29) a long and deep cut reveals considerable variety:

	Feet.
6. Soil	2
5. Loess, brownish above where weathered, gray below, laminated, root marks numerous, two places fossiliferous, traces of horizonal planes of oxidized iron visible	9
4. Clay and fine sand, like a silt	1
3. Clay, two inches of dark, then three feet of blue, changing into three feet of dark brownish crumbly clay, free from plant fibers but containing a large amount of oxide of iron; in places grading below into (Gumbo; Dallas)	6
2. Clay, light brownish above, darker brown below, with pebbles and small cobbles; layer of Kansan pebbles seen in places; drift filled with characteristic pebbles and small cobbles of red quartzite, greenstone and granite (Kansan Drift)	10
1. Shale, mostly clayey (Des Moines)	10

Near the center the Des Moines shales appear above the bottom of the cut and rise gradually southward till they attain a height of about ten feet, from which the surface drops rapidly beneath the level of the cut. This valley side in the coal measures is rendered conspicuous by a thin seam of carboniferous matter that follows the side of the valley. The Kansan drift, wanting in a portion of the cut, is here a conspicuous deposit filling the old valley side in the Des Moines shale. Toward the south the line of pebbles and the several deposits that succeed may be seen passing beneath the level of the cut. The weathered portion and the soil here become thicker. The lowest brown clay of No. 3, not clearly separable from the portion above, contains a few small pebbles, and rests on a layer of pebbles characteristically Kansan. The deposits above the distinct Kansan drift mantle the hill. The change toward uniformity due to weathering and to creep may be followed out horizontally from the more unchanged portion within the hill to deep black soil on the side of the hill.

In the long cut through the high ground two and a half miles east of Sandyville (see Milo Quadrangle, T. 76 N., R. 22 W., Ne. ½ of section 24) the following section appears:

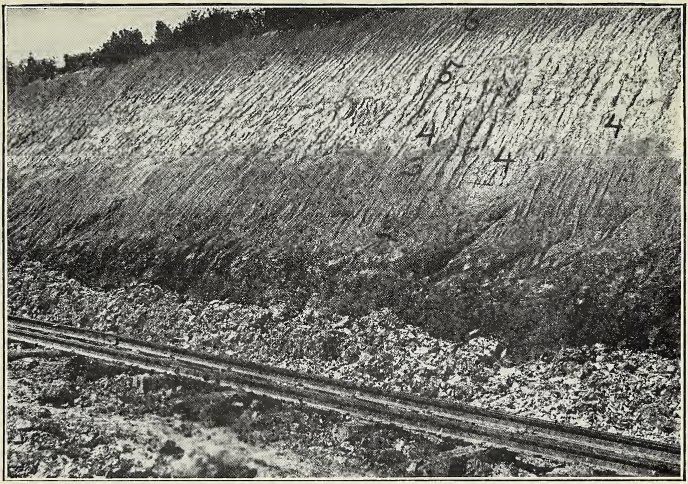
	Feet.
6. Soil	2
5. Loess, brown above, gray below, with numerous somewhat horizontal bands of oxidized material very conspicuous in places	8
4. Clay, bluish where damp, gray where dry, extending down into numerous holes somewhat hemispherical in shape three to five feet in diameter in the deposit below. (Gumbo; Dalls)	1-2

3.	Clay, brownish blue with many hemispherical holes three to five feet in diameter apparently worn into its surface; a few pebbles up to three-fourth of an inch in diameter; no gravel nor pebbles visible in bottom of holes............(Gumbo; Dallas)	6
2.	(Line of pebbles seeming to mark a plane of erosion); clay, brownish, with many pebbles and bowlders of red quartzite, decomposed granite, etc.......................(Kansan Drift)	3
1.	Shale, mostly clayey............................(Des Moines)	6

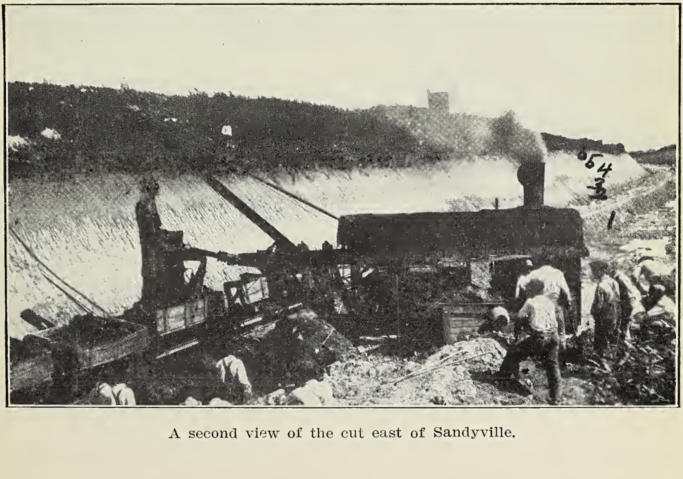
The gumbo (numbers 3-4) is separated into two portions by a plane that seems to be a plane of disturbance rather than erosion or weathering. No pebbles appear in the hemispherical projections of number 4 into number 3, as there would be if such places were potholes. The plane seems due to renewed advance of the Kansan ice.

In Lucas county close to the county line (Nw. 1/4 of Ne. 1/4 of section 2, English township) a steam shovel was at work cutting five feet deep into a dense blue clay beneath several feet of Kansan drift that contained characteristic bowlders and pebbles. One bowlder was a large bowlder of blue clay like the basal clay there found but also containing fragments of coal. This seems either a bowlder of Nebraskan drift, or a Kansan bowlder of Des Moines shale worked over and incorporated into the Kansan drift. In the latter case any evidence of stratification which the clay may have had when in the form of Des Moines shale had been lost. In the bottom of a trench a little further south is a somewhat similar dense bluish black clay with nothing separating it from the distinct Kansan drift seen in the hills. Several other somewhat similar cuts occur within six miles to the south toward Chariton in which the drift exposed is distinctly Kansan drift.

At Chariton a good section is obtained by combining the outcrops found in the three cuts beginning at the crossing of the Chicago, Burlington and Quincy railroad and extending south to Chariton river. At the railroad crossing the two feet of soil is on the gumbo, the upper portion of which is here brown through oxidation, the lower portion gray, containing small pebbles especially of quartz and granite rarely over half an inch in diameter. Next, without any line of pebbles and underneath the above mentioned clay, is the brownish, weathered and bowlder-bearing phase of the Kansan drift, well exposed in the long cut two hundred yards to the south, where the exposure gives about fifteen feet filled with large sand bowlders and numerous and characteristic bowlders of decomposed granite, greenstone, quartzite, and brown, yellow and red chert. In the trench by the river there is included a bed



View of a portion of the cut east of Sandyville.



A second view of the cut east of Sandyville.

of sand six feet thick, fine, irregularly bedded, and iron stained, beneath which lies fifteen feet of dense clay, brown above, blue below, with numerous small pebbles of chert and quartz, exposed down to low water in the river and apparently extending below the bed of the stream. Professor Kay finds the Kansan drift here continuous in one place from the top of the hill to the bottom of the trench.

Half a mile distant on the south side of the river sand that is apparently post-Kansan rises above the level of the track. Here the section is as follows:

		Feet.
4.	Soil, and brownish yellow subsoil	3
3.	Sand, fine, gray	7
2.	Sand, yellow and white, stratified, 1½ ft.; sand, very fine and white, 2 ft.; sand deeply oxidized, stratified	10
	(Bottom of trench west side of track.)	
1.	Sand in hole dug beneath bottom of trench	3

A somewhat peculiar enclosure of sand in Kansan drift is found in Benton township (T. 71 N., R. XXI W., Sw. ¼ of the Ne. ¼ of section 32). Here, beneath five feet of the weathered phase of the Kansan with numerous bowlders, cobbles and pebbles of greenstone, granite and red quartzite, is a thin sandy and brownish plane that appears to mark a plane of weathering. Beneath this plane there is exposed five feet of dense brownish clay free from grit, without red quartzite and without greenstone, but with numerous cracks filled with lime.

Further south there is but one cut that extends much into the Kansan drift. That is in section 31 of Union township, Wayne county (Tp. 70 N., R. XXI W., Ne. ¼ of the Sw. ¼ of section 31). Here, beneath the yellowish, oxidized phase of the Kansan is the bluish phase of the same clay with its grit and pebbles. Beneath this there is a layer of oxidized material found in the south third of the cut; elsewhere, an irregular undulating top of a dense brownish clay free from red quartzite.

GENERAL OBSERVATIONS AND RELATIONS.

The Des Moines shales are frequently found above the level of the track from the outcrop near Coon Valley to the northern boundary of Lucas county (section 2 of English township). Close to Whitebreast creek in Marion county (section 26, Franklin township) the railroad cut reveals a high hill of Des Moines shales with but a thin soil at the top. South of the northern part of Lucas county the shale appears but once (in section 10 of Lincoln township). Work in northern Lucas county, where grading is not yet completed, may possibly bring to light a few other exposures later.

No Nebraskan drift was found exposed. If present at all it should be looked for beneath the river deposits. Unfortunately for complete observation the cuts are, of course, in the hills only, while fills occupy the valleys.

Beds referable to the Aftonian interglacial deposits are found only at Avon in the deepest portion of the gravel pits. No sections of bog nor of peat are revealed. At the crossing of Wolf creek (Tp. 71 N., R. XXI W., Ne. ¼ of the Sw. ¼ of section 28) the creek in changing its channel has cut into a dark, somewhat stratified deposit, resembling an Aftonian deposit found in the Simpson College well; but there is no evidence at present at hand to determine the age of this deposit at Wolf creek.

The weathered phase of the Kansan drift is frequently exposed from Carlisle to Chariton. South of the high hills of Des Moines strata along Whitebreast creek all the deep cuts into the Kansan reveal bowlders of stratified sand, the planes of stratification dipping in different directions in even adjacent bowlders. The porosity of the sand bowlders has made it possible for surface water to reach various parts of the clay readily and help extend the zone of oxidation, the relative absence of sand bowlders in the deeper portions seeming one reason why those deeper portions have been less oxidized than the more sandy portion above.

The Gumbo; Dallas Deposits. One of the most important relations which this series of exposures illustrates is the relation of the gumbo to the previously recognized Kansan drift. The gumbo as exposed along the railroad is a blue clay of varying thickness up to ten feet, without stratification, and with small pebbles chiefly of quartz and granite here and there in it, but compared with the ordinary Kansan drift almost pebbleless. From relations along the railroad the gumbo appears closely related to the Kansan drift, in places not separable from it and in other places partly or wholly absent, its place being taken by stratified sand. In Clarke county what is apparently the same kind of a deposit is found definitely at lower levels in places where its position does not seem due to wash and creep. The only conclusion that seems applicable is that this gumbo was laid down not only on the upland but in places, at least, along drainage lines determined before the gumbo was laid down. As those drainage lines are on the Kansan drift, they, and the gumbo which is in them, must be post-Kansan in age. While the gumbo has not been traced across the state mile by mile, the work in the different counties seems to make it clear that this gumbo of south central Iowa corresponds to the gumbo of southwestern Iowa, which gumbo Shimek correlates as the Loveland. If the correlations of the gumbo alone were all that is involved it would be advisable to adopt the term Loveland for these gumbo deposits of south central Iowa. There is, however, a serious objection to the adoption of this term. The term Loveland as originally defined by Professor Shimek applies to a definite gumbo-like deposit and that only. In south central Iowa the gumbo may in places be traced horizontally into stratified sand; in places it is found to contain a few pebbles, and in places to be free from pebbles. The term Buchanan gravels was proposed by Calvin as the name for the gravels and the gravels only as found on the Kansan drift in Buchanan county. To adopt either of these terms would necessitate a change in the use of the term as originally defined. The writer therefore suggests the term Dallas for those deposits of whatever nature, partly gravel, partly sand, partly gumbo either without pebbles or with a few pebbles, formed in the closing stages of the Kansan ice age as the Kansan ice melted leaving a surface deposit over the Kansan drift in the Kansan upland and down along valleys which in places had by that time been eroded into the Kansan drift. The name is suggested by the town of Dallas in Marion county (Iowa) near which a considerable variation may be seen in the gumbo and associated deposits. A mile north of Dallas (Ne. 1/4 of the Ne. 1/4 of section 2) these Dallas deposits are pebble free beneath the soil, pebble bearing from eight to sixteen feet below the surface, and resting on a distinct sandy Kansan drift with its characteristic pebbles and bowlders, which in turn rests upon the Des Moines shales. A similar relation is observed in each of several exposures toward the south as far as the Lucas county line. To the north an excellent exposure may be found near the Fairview school house (T. 75 N., R. 21 W., Sec. 3, Se. 1/4 of the Sw. 1/4), where gumbo is seen not distinctly separated from Kansan drift. It may also be seen in the long cut east of Sandyville as previously described. In Lucas county it is especially noticeable in sections 23 and 34 of English township, 10 of Lincoln township, at Chariton at the crossing of the C., B and Q. railroad, and in sections 8, 16 and center of 21 of Benton township. In Wayne county the relation may be seen in sections 5, 18, 30 and 31 of Union township, in the northwest part of Corydon township, in section 24 of Benton township, and section 2 of Warren township. (From Allerton to Lineville the railroad follows a divide.)

The name Dallas for these deposits is suggested to meet the need for a name that has not as yet been fully supplied. Should later a more acceptable term be found, or even an earlier term be given a new meaning, such a term agreed upon will be welcomed by the writer; but Dallas deposits is the term which at present appears to him most acceptable.

The significance and bearing of the important fact mentioned in the above description of the Sandyville section, where a lower portion of the gumbo is described as presenting evidence that an upper portion had been pushed along over the lower, should not be overlooked. Such a relation has been used elsewhere as part of the evidence that an underlying drift is sub-Aftonian. Here the underlying drift is Kansan. This is the first time the writer knows of that such evidence has been presented of two movements in the Kansan itself (including the gumbo as a part of the Kansan drift.)

In places the low ground gumbo does not belong to the Dallas deposits but is a worked-over Dallas deposit washed from the higher ground along ravines and into the low ground, where a deposit similar to the gumbo of the upland may be found without a trace of stratification.

The brownish, laminated clay charged with plant fibers near Coon Valley (No. 3), and that crumbly and iron stained deposit without plant fibers near Hartford, seem related in time and possibly in conditions of deposition. The lower boundary of each is hard to distinguish from the gumbo; but the deposits are easily distinguished from the overlying silt-like deposits in the places named. They seem to mark varying conditions in an old land surface. In places dark bands appear at the surface, and in places traces of oxidation.

The loess. Distinct loess is only found in the northern portions of the area. The general difference between the brown and the gray portions seem due to weathering. It is also recognized that during the deposition great changes in climatic conditions took place which might affect what was surface at that time. Such is the similarity between weathered gumbo and weathered loess that it may be a portion of the soil in the southern part of the area should be described as partly loess; the deposit there immediately beneath the soil is gumbo.

PRELIMINARY NOTE ON THE SO-CALLED "LOESS" OF SOUTHWESTERN IOWA.

JAMES ELLIS GOW.

While exploring Adair county in the interest of the Iowa State Geological Survey, the writer made some observations upon the surface soil of that region, which have led him to differ with the conclusions of other geologists who have described the same soil in adjoining counties. This soil has usually been described as Iowan loess, sometimes simply as loess. The long controversy as to the nature and origin of the Mississippi valley loess has left in its trail such apparent confusion as to the precise meaning of the term that it seems almost necessary to define it anew before attempting to make use of it in a scientific way. The writer will accordingly begin his argument by defining what he understands by the term "loess."

WHAT IS LOESS?

This term was first applied by European geologists to the extensive deposits of homogeneous fine-grained clay found in China and the uplands of central and northern Asia. This clay is distinctive in its characteristics. It is so fine grained in texture as to be readily held in suspension in the air, and when deposited in any mass solidifies so perfectly that vertical banks disintegrate very slowly under the action of water, and may stand for many years. A clay of precisely these characteristics is found in Iowa, around the border of the Iowan drift sheet and in the valley of the Missouri river, and has long been known as loess. It was first regarded as loess because of its texture and physical characteristics. It was long believed by many geologists that the loess was formed directly by aqueous agencies; but it would have been a mistake to say that it was loess *because* it was laid down under water, else stratified sands, gravel, and alluvium would also have to be classified as loess. It is now generally believed—on evidence that seems to the writer to be absolutely conclusive—that the loess is of aeolian origin. But it is a mistake to say that it is loess *because* of its aeolian origin, else the material of sand dunes would have to be considered as loess.

In other words, the term in question refers not to the origin of the deposit, but to the nature of the material deposited. As a matter of fact, the nature of the material indicates an aeolian origin for it; but not all aeolian material is loess. Unless it possess certain well-defined and easily recognized physical characteristics it cannot be defined by that term. What are the characteristics that must be present in order to constitute true loess?

1. The material is fine-grained and, with two exceptions to be noted, absolutely homogeneous. It is so fine-grained that, to quote the late Dr. Calvin, when crushed between the thumb and finger it has a "greasy" feeling. In other words, the individual particles are so small and so uniform that they produce no separate effect on the touch nerves. The material is a perfect powder. It has no grit.

2. Because of its fineness, it is so light as to be readily transported by the wind; forming in fact an impalpable dust that even in still air remains in suspension for a long period of time.

3. Because of its homogeneous and uniform texture it is, when in mass, easily compacted. When so compacted it resists the action of erosion more perfectly than does the ordinary clay or sand of the glacial drift. This is shown especially well in the case of the Missouri valley loess, but is measurably true of all loess.

4. The color is not an invariable factor, since it depends upon the source of the material, and the sources in different localities will vary. It is usually yellow, yellow-brown or brown, but the grey and grey-brown tints are not unknown.

5. When in mass the loess is likely to contain lime nodules, or "loess-kindchen." These are often lacking. Similar nodules are sometimes found in joint clay. Their presence does not prove the material to be loess.

6. The loess is fossiliferous. It is this fact that first led to the now somewhat archaic theory of an aqueous origin. Since it has been shown that many of these fossils are land forms, and the others are such as frequent shallow prairie brooks and pools, or even "sloughs" and "draws" where the soil is perpetually damp, the aqueous theory has been largely abandoned in favor of the aeolian. An absolutely non-fossiliferous loess can be imagined, though the writer cannot find that such a loess has ever been found.

7. The loess is often, but not always, stratified. The strata are seldom horizontal, but are irregular, or else are inclined to follow the contours of the pre-loessian hills.

These are the characteristics of loess. The writer accepts the aeolian theory as to the origin of the loess. But to prove a deposit aeolion is not equivalent to proving that it is loess. *Unless it has the texture and physical characteristics of loess, it is not loess!* Sand, whatever its origin, is not loess. Joint clay is not loess. Heavy, "sad" soils are not loess. Soils whose materials are distinctly granular are not loess. We are not justified in calling any material by that term unless it possesses the requisite physical characteristics.

THE PROBLEM IN ADAIR COUNTY.

Adair county lies within the Kansan drift area of Iowa. The crest of the grand divide between the Mississippi and Missouri rivers passes through the county. Erosion has cut deeply into the drift, the county is greatly dissected by streams, and its drainage system is complete. It contains no lakes, except an occasional ox-bow in the flood-plain of one of the larger streams. As is to be expected in an area of this sort there is a very considerable variation in the elevation of different points within the county limits. This can best be appreciated by a few examples. The elevation at the town of Greenfield is 1,368 feet. Eight miles northeast, at the village of Howe, the elevation is 1,098. Half a mile east of Howe, on the banks of Middle River, it is 1,047. At the intersection of Middle River with the county line the elevation is 940 feet. At the town of Adair it is 1,442 feet.

The material of the Kansan drift in Adair is not unlike that found in the other counties of southern Iowa where this drift forms the surface soil. When not leached out, the till is a dark blue or blue-brown varying to purple brown or sometimes nearly black when moist. Near the surface it leaches to light yellow-brown or grey-brown. Small bowlders of granitic rock, and more particularly of Sioux Quartzite, are common in the drift, but are not evenly distributed, being very abundant in places, and in other places scarce or lacking. This uneven distribution is to be attributed to the accidental irregularity of glacial deposition. It is not to be expected that the glacial agencies would distribute the bowlders in a mass of till with absolute uniformity. One might reasonably expect *a priori* that there would be more at some points than at others. Gravels also are occasionally present. These are always more or less intermixed with till, except where post-Kansan erosion has been at work re-assorting the materials. Where the gravel and till occur in their original position, no trace of stratification can be detected. Like the bowlders, gravel is occasionally lacking at many points in the till, and this again is to be attributed to the accidental irregularity and lack of homogeneity in the materials laid down by the ice. Always and everywhere the principal ingredient of the Kansan drift is a joint clay—a clay that crumbles into small angular fragments when crushed in the fingers, and cracks in drying. It may be dark blue, or it may be leached out to a light yellow-brown, it may contain pebbles and bowlders, or may be free from them, lime-nodules may be present or absent, but without exception the clay shows the "jointed" character. This peculiarity is distinctive.

On traveling over the county, and observing the character of the surface deposits, one notices that scattered small bowlders and pebbles are much in evidence. Angular fragments of quartzite are particularly common. Every now and then, however, one gets into an area where the surface soil is free from stones of any sort, or practically so. This boulderless and pebbleless soil is, like the deeper drift, a joint clay. It is leached to precisely the same color as the superficial bowlder-bearing Kansan till on either side of it. It differs from the latter in no discoverable particular, except in the fact that it is free from bowlders and pebbles. It may occur at any level, and be of any extent. Sometimes it covers an area but a few yards square; sometimes one may observe it along the roadside for a mile at a stretch. It occurs on the crest of the divide at Greenfield, Grove Center and Adair. It also is found in the valley of Middle River at Howe, and near the county line, and in the valley of the Nodaway from Bridgewater down to the county line. It is scattered widely, is discontinuous, and one can never predict where it will be found. At Greenfield it is twenty feet in thickness, at Grove Center four or five feet, and at Adair it reaches a thickness of thirty feet or more. As has been said, its consistency is that of leached Kansan till. Wherever a section has cut deeply enough to penetrate both this deposit and the underlying bowlder-bearing Kansan, it is seen that there is no sharp line of demarkation between the two, but that the one shades off into the other. The bowlders and pebbles do not suddenly cease, as one follows the section upward, but they gradually become fewer and fewer. In fact a few small stones can almost always be found in the deposit under discussion if one hunts for them. Sections at Greenfield, Grove Center and elsewhere show this gradual gradation of the bowlder-bearing into bowlderless clay.

Finding a pebbleless and bowlderless clay scattered over the surface of the Kansan, one is at first inclined to conclude that it is a distinct formation, younger than the Kansan, and deposited on top of it. It is evident, however, that it cannot be of aqueous origin because of all absence of stratification, and because of the wide variation in altitude covered by it. It is also evident that it could not have been laid down immediately after the retreat of the Kansan ice sheet, because in that case it would have been cut away by subsequent erosion, and we would find it today only on the highlands. As a matter of fact it is as common in the lowest valleys as on the crest of the divide. Therefore, *if it be a purely superficial deposit,* it must have been laid down *after* the Kansan had been eroded to its present contours; that is to say, in very recent times. The only agency adequate to this sort of post-erosional deposition is the wind. No aqueous agent could, in recent times, and after the erosion of the Kansan to its present contour, have inundated the entire country —including the crest of the divide—and deposited a carpet of material four to forty feet thick, and then withdrawn leaving the surface otherwise unchanged. Such a grotesque hypothesis needs only to be mentioned to be rejected. But the wind is adequate to a task of this sort. It can carry material up-hill. It deposits it discontinuously, as this appears to be deposited. The natural first inference therefore is that the material is aeolian in its origin.

The writer at first believed this to be the case. He has now seen good reasons for correcting his conclusions. But at this point he wishes to insist on one thing: If the material in question is of aeolian origin, it is not therefore loess, any more than wind-blown sand is loess. This material is a joint clay, and joint clay is not loess. If it is aeolian, then it is an aeolian joint clay, not an aeolian loess. The term loess has reference to clay of a certain well-defined texture, weight, and structure, and this material, as has already been shown, differs from it in every way. Whatever its origin, it can be productive only of confusion to misname it in this way. There seems to be a tendency on the part of some geologists to make "loess" synonymous with "aeolian material." The error involved in this misuse of language has already been pointed out.

THE PROBLEM IN ADJOINING COUNTIES.

The western part of Madison County is covered with a clay similar in all respects to the one herein described. It has been regarded as being of aeolian origin, and is described in the report on the Geology of Madison County as "loess." The same is true with regard to Guthrie and Dallas counties. The author of the Dallas county report, indeed, was puzzled by the fact that in many places he found Kansan bowlders and gravels *on top of the so-called loess.* To explain this difficulty he was forced back upon the archaic theory of an inland post-Kansan sea, the bowlders and pebbles in question being the droppings from the icebergs that during many ages broke from the edge of the ice-sheet and floated out upon the waters that then covered Iowa. It is hardly necessary to call attention to the fact that the hypothetical sea was immediately post-Kansan, while the so-called loess was deposited subsequent to the erosion of the Kansan. The stratified silts, clays, and limes, that should have been deposited in such a sea, all are lacking, and of the morainic rampart hundreds and hundreds of feet in height necessary to dam back so vast a mass of water no trace remains. Leaving out of the question all such grotesque theories, let us inquire as to the possible explanation of the occurrence of the so-called loess, supposing it to be what at first glance it would appear to be, namely an aeolian deposit.

THEORIES AS TO THE ORIGIN OF THE SO-CALLED LOESS.

1. Finding this material near the edge of the Wisconsin lobe, which passes through Guthrie County, one might at first conclude that this is a phase of the Wisconsin loess. The fact that it is, structurally, not loess has been sufficiently dwelt on. The theory that would relate it to the Wisconsin is untenable, since it passes *under* the Wisconsin drift sheet in Guthrie county. It may therefore be laid down as a fact that it is older than the Wisconsin drift.

2. It has been suggested that this is an aeolian deposit whose materials were gathered from the outwash of the Iowan glacier, and it has accordingly been described as "Iowan loess." The true Iowan loess appears in abundance in Linn and Johnson counties. It is extremely fine-grained and easily carried by the wind. The Adair County material is coarsely granular, heavy, and is not readily moved by air currents. The adherents of the Iowan loess theory would have us believe that the finer materials were deposited near their source, while the coarser and heavier matter was caught up and blown half way across Iowa and there deposited in great quantities. The writer cannot yet accept this contradition of the principle of gravitation. On the face of it the theory is untenable.

3. The same objection prevents us from accepting the theory as to the source of this material being the valley of the Missouri river. The Missouri loess is fine-grained, easily blown, and travels far, but is not found in Adair County. This so-called "loess" is heavy and coarse, and does not travel readily. If the Missouri loess cannot travel as far as Adair County in appreciable quantity, this heavy material certainly could not.

4. It may be suggested that the deposit is of aeolian origin, and that the materials were caught up from the flood plains of nearby streams and deposited on slightly higher ground. To this it must be said that the streams of this region are small, their flood-plains are narrow, and could not possibly yield such a mass of material. It must be remembered in this connection that this material, *if it be indeed younger than the Kansan,* was deposited after the erosion of the Kansan was complete, and the time has been comparatively short. In so short a time, and with so inadequate a source of supply, such an extensive deposit could not originate. A further objection is that, if this originated from local flood-plains, it would be thicker near the flood-plains and thinner on the crest of the hills. This is not the case. The theory of a local aeolian origin is untenable.

5. One geologist, in conversation with the writer, has suggested that the material may have blown in from the plains of the southwest, and may be the accumulations of all the ages since the retreat of the ice-sheet. There are two objections to this theory. First, if this be indeed a post-Kansan deposit, it is not the accumulation of all the ages since the retreat of the ice-sheet, but was deposited after the Kansan had reached its present stage of erosion. The time is too short for the accumulation of so much material. Second: only the finer dust would travel so far, and the resulting deposit would be a very fine-grained loess. This deposit is not a fine-grained loess, but a coarse-grained joint clay. This theory therefore must be abandoned.

So far as the writer can see, these five theories exhaust every possibility as to the post-Kansan, aeolian origin of this deposit. And a close acquaintance with conditions in the field shows every one of the five to be entirely untenable.

ADDITIONAL EVIDENCE AS TO THE NATURE OF THE SURFACE CLAY.

The current theory as to the aeolian nature of the surface clay in the southwestern counties is based chiefly if not exclusively upon the fact that it is nearly devoid of pebbles and boulders. It is taken for granted that the latter must be present in all Kansan drift. They are not present (or are present sparingly) in the surface clay. Therefore it is presumed that the surface clay is post-Kansan in its origin.

In considering this question it occurred to the writer to question the universality of the presence of boulders and pebbles in the Kansan. In the very nature of things, it would seem strange that an ice-sheet should so arrange or assort its materials that the coarser would be distributed through the finer with absolute uniformity. It would be more likely that at one point it might deposit sand only, at another boulders only, at another clay only, at yet another sand, clay and boulders intermingled, at another perhaps clay and gravel intermingled, and so forth. One would expect that there would be at least a few places where there would happen to be little besides clay. At another place, boulders might be numerous in the clay. In all the vicissitudes of glacial action, this is the most natural expectation.

To test this theory, and find whether it has any basis in fact, the writer made some investigations of wells that have been bored in the Kansan and he finds that the data bear out the theory in every case. In the case of two wells in the town of Greenfield, the boring of which was watched by him, the auger passed through five and ten feet respectively in which no pebbles or boulders were present. These pockets of boulderless clay lay at a depth of about thirty feet below the surface. The material was a stiff blue clay, unstratified, and exactly similar to the clay above and below except for the absence of boulders and pebbles. In another well bored some years ago two miles southeast of the town of Orient, the boring of which was watched by the writer, the entire shaft cut through a boulderless clay which was leached yellow above, but showed the stiff texture and blue color at a lower depth; with the exception of about three feet of boulder-bearing clay through which the auger passed at a depth of some twelve or fourteen feet from the surface. In these cases there was no sharp line of demarkation between the boulderless and the boulder-bearing clay. The one graded into the other. With these cases in mind the writer consulted a number of professional well-diggers, asking them whether as a rule the clay in Adair County contains boulders and pebbles or not. In every case, the answer was that sometimes the clay contains them, sometimes not; sometimes they will appear at one depth, sometimes at another, and it is impossible to predict what the condition will be in any particular shaft. All agree that at a depth of from fifty to seventy-five feet there is a forest bed, (the Aftonian) with silts and gravel present, and this is the only constant factor in the problem. The Kansan is sometimes boulder-bearing, sometimes not, and the relation of the two phases at any given point depends entirely upon the accident of glacial conditions at that point. Both sorts of material were laid down by the ice-sheet, and they grade into each other.

Where the boulderless drift occurs at some depth, it consists of typical blue Kansan clay. Where erosion has cut into it and exposed it, it leaches out and becomes the so-called "loess" of Adair and adjoining counties.

Some fifteen years ago, a well was bored on a farm in the southeast corner of Jefferson township, Adair County. The writer was present, and well remembers that through most of the shaft no pebbles or boulders were struck. (The surface clay at that point is boulder-bearing.) The material from this shaft was piled within a rod or less of the well, and left there. When taken out it was a stiff blue Kansan clay. In 1911 the pile was still there, and the writer examined it. It contained no pebbles whatever, had leached out to the characteristic yellow-brown tint, still broke with the characteristic "joint" and was *in every respect exactly similar to the so-called "loess!"* No observer could possibly distinguish the two. As a matter of fact they are one and the same thing. The "loess" is, as its texture and appearance would indicate, merely weathered Kansan till. It is true that it bears no pebbles, and it is equally true that many deeper parts of the Kansan bear no pebbles. It were strange indeed had the glacier stirred the plums into the pudding with absolute uniformity. Some parts of it are richer than others, as every farmer and every well-digger can testify.

One bit of contributory evidence should be added. The loess of Iowa, wherever found, is fossiliferous. Were it to be proved that fossil shells occur, within the clay here under discussion, then the theory here advanced would not stand. But, as a matter of fact, long and patient search has failed to reveal a single fossil in the leached surface clay of Adair County. And the writer ventures the prediction that, if shells are found, they will be in the loose soil at the surface, or covered by the talus of some bank, but they will not be discovered by excavating in the depths of this deposit. It is non-fossiliferous.

Traversing a road that parallels the Nodaway valley, the writer followed a bank of clay for several miles. The road had been recently graded, a cut of three to five feet had been made, and the fresh bank gave an excellent opportunity for observation. The clay was typical joint clay, leached yellow, with no pebbles and no boulders. So it remained for a space of perhaps a couple of miles, when on a hilltop attention was suddenly arrested by an angular fragment of Sioux Quartzite as large as one's fist, imbedded in the clay, about eighteen inches below the surface, and three feet above the base of the bank. With only one side exposed by the scraper of the roadmaker, it hung there just as it had been left by the ice. That single fragment of quartzite was sufficient refutation of the theory that the surface clay of Adair County is of aeolian origin. It was imbedded in a mass of so-called "loess" but one may predicate with certainty that no wind ever swept over Iowa of sufficient power to blow two-pound stones up to the hilltops. Nor is this an isolated case. A few pebbles and boulders will almost always be found in the surface clay if one but searches. High up in the so-called "loess" at Greenfield was found a bowlder the size of a man's head. Better evidence could not be for the conclusion that the material was deposited directly by the ice, and not by any secondary agency.

NOTES ON THE NEBRASKAN DRIFT OF THE LITTLE SIOUX VALLEY IN CHEROKEE COUNTY.[1]

BY J. ERNEST CARMAN.

The work of Professor Shimek, of the Iowa Geological Survey, in western Iowa, has brought to light many exposures of Aftonian gravels and the underlying Nebraskan (pre-Kansan) drift. These exposures extend along practically the entire western border of Iowa.

While engaged in a study of the Pleistocene deposits of northwestern Iowa for the Iowa Geological Survey during the summers of 1910-1911 the writer observed a number of exposures of Nebraskan till along the Little Sioux valley in Cherokee county, and it is the purpose of this paper to call attention to this extention of the known distribution of the Nebraskan. The head waters of the Little Sioux river are within the area of the Wisconsin drift, but most of its course is through the region of the Kansan drift[1a] and through a part of this Kanasn area the river has cut down below the base of the Kansan, and flows at the level of the Nebraskan. The valley-bed is covered with alluvium and glacial gravels so that exposures of the Nebraskan are relatively few, although the actual area over which this drift occurs below the alluvium and gravels, may be considerable. The exposures of Nebraskan are found only in the valley bottom or in the lower part of the bluffs, at no place rising more than half way to the level of the upland.

Most of the Nebraskan exposures observed occur in Cherokee county in the valley of the Little Sioux north and south of Cherokee, and in the valley of Mill creek north of Cherokee (Fig. 1). Exposures were observed, however, as far up the river as Peterson in southwestern Clay county, and as far down the river as Anthon in Woodbury county. The total number of Nebraskan exposures recorded on the field maps of the writer between these two places is more than fifty.

At several places north of Cherokee the Nebraskan drift rises in the bluffs to an elevation of 50 to 60 feet and at one place to 80 feet above the river, while the length of individual exposures may reach 75 to 100

[1]Published by permission of the Director of the Iowa Geological Survey.

[1a]Part of the area here referred to the Kansan may belong to a post-Kansan, pre-Wisconsin drift sheet.

yards. No attempt will be made in this paper to describe or even locate all the Nebraskan exposures observed, but the location of a few of the better ones may be noted. In the east bluff of the Big Sioux valley, good exposures occur just east of the town of Cherokee along the road in the northeast quarter of section 35, and in central 24. Along Mill creek a large exposure occurs in the east bluff in northwest 4, Cherokee township, and the Nebraskan-Kansan contact is exposed along the road rising southward to the upland in the southwest quarter of the same section. Another good exposure is found along a tributary of Mill creek at the southeast corner of section 3. The approximate location of these exposures and many others, is shown on figure 1.

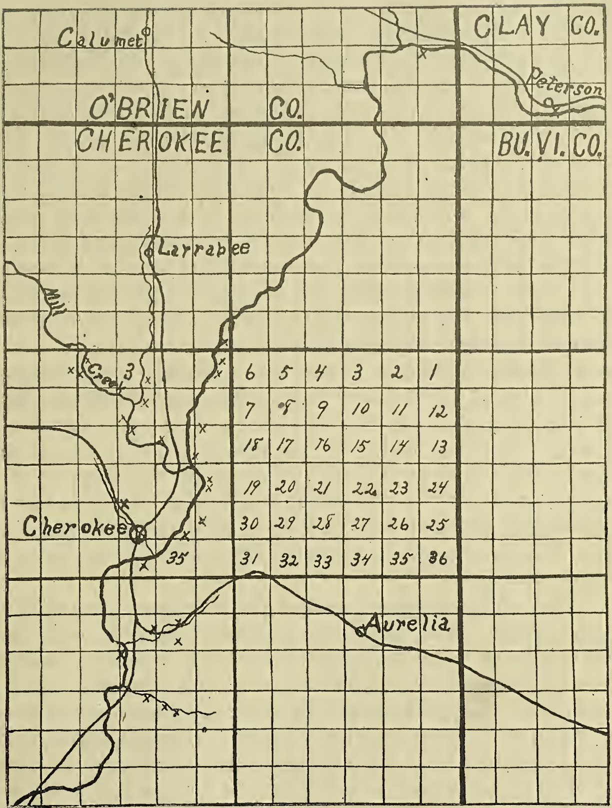


Fig. 1.—A map of northeastern Cherokee county and parts of adjoining counties, showing the location of exposures (x) of Nebraskan till.

The Nebraskan drift of the region to the southwest along the Missouri river has been described[2] as a dark bluish-black, tough joint clay containing a few pebbles and boulders and which when dry breaks up with a starch-like fracture into small angular fragments. The Nebraskan drift in this region along the Little Sioux differs somewhat from that of the region to the southwest. Here the color is gray, rather than black, and tints of various colors, chocolate, brown, purple and blue modify this gray color. The most usual surface colors are a chocolate-gray or a purplish-gray and generally the color darkens as you dig beneath the surface to the fresher material. The drift is almost free from pebbles or sand grains and is so fine-grained that usually very little grit is detected when a small piece is bitten between the teeth. Calcareous material is very abundant in the till, and often occurs as concretions, which resemble pebbles. These concretions range in size from small grains to masses 8 or 10 inches across, and are particularly abundant in the weathered portion of the Nebraskan. The till is compact and moderately tough when very fresh, but in the ordinary surface exposure it is weathered and can be dug easily with the hammer.

At the contact horizon of Kansan over Nebraskan there is usually a transition zone, of 4 to 6 feet or more, grading upward into the Kansan drift and downward into the Nebraskan. This zone represents the Nebraskan material plowed up by the Kansan ice, and mixed with the Kansan drift, but which did not lose all of its Nebraskan characters. At a few places, however, the contact is a definite horizon so that hand specimens may be taken which will show both Nebraskan and Kansan drifts. This is true at the exposure noted above in southwest 4 of Cherokee township.

In a few of the exposures studied the Nebraskan is overlaid by a horizon of grayish-black material very similar to the drift, being usually very fine-grained and without grit. It contains calcareous concretions even more abundantly than the Nebraskan, and at several places contains shells of small pond snails. An excellent exposure of this material may be seen in the southeast part of section 3, Cherokee township. This horizon is apparently of Aftonian age. It is overlaid by the Kansan either directly, or through a transition zone, composed of a mixture of the silt horizon and the Kansan drift. In the dozen or more exposures studied which include both Nebraskan and Kansan drifts, no gravel was found between the drifts and there is apparently no Aftonian gravel in the region, a point which is noteworthy in view of the great development of gravel material in the Aftonian farther southwest where it has

[2]Shimek, B., Science, vol. 31, p. 75. Also Iowa Geol. Survey, vol. 20, p. 307.

yielded the interesting mammalian fauna. There are, it is true, great gravel deposits within the Little Sioux valley, and in places these rest upon the Nebraskan drift, but they are of much later age.

It is difficult to differentiate between the Nebraskan and Kansan tills in the records given by well drillers but probably the major portion of the 200 to 300 feet or more of Pleistocene material which covers northwestern Iowa is of Nebraskan drift. The record of a deep well on the upland at Cherokee is interpreted as follows: Kansan 75 feet; Nebraskan 170 feet; bed-rock of Cretaceous age.

In summary the points made by the paper are:

1. A farther extension of the Nebraskan drift area.
2. The Nebraskan drift of this region differs from that farther southwest by being of a lighter color, by being less hard, and by being very uniformly low in sand and pebble content.
3. No Aftonian gravels have been recognized in this region and it is thought that none exist. A clay very much like the Nebraskan drift, but apparently a weathered, reworked and partly sorted silt material, is the Aftonian of this region.

THE WISCONSIN DRIFT-PLAIN IN THE REGION ABOUT SIOUX FALLS.[1]

BY J. ERNEST CARMAN.

The region considered in this paper is a small area lying to the south and southeast of Sioux Falls, South Dakota, and the problem is, the age of a drift-plain.

In 1883, Professor Chamberlin, in his paper on the Terminal Moraines of the Second Glacial Epoch,[2] outlined the extent of, and described the moraines of, the Minnesota-Des Moines valley glacier which extended southward through north central Iowa to the city of Des Moines, and the Dakota Valley glacier which occupied the James River drainage basin in the eastern part of South Dakota and reached to the southeast corner of that state (Fig. 1). Professor Chamberlin traced the moraine on the east side of the Dakota lobe southward to a point in northwestern Lincoln county, southwest of Sioux Falls, and then (p. 395) attributing the data to Professor Todd, he states that it ''bears eastward to the vicinity of the Big Sioux River, and thence follows the hilly tract bordering its west side southward into Union County.''

In 1896, Professor Todd, in bulletin 144 of the U. S. Geol. Survey, mapped a belt of morainic surface, which, leaving the Big Sioux valley opposite the Iowa state line, runs west along the Minnehaha-Lincoln county line and then northwest across the southwest corner of Minnehaha county. It is shown by the dotted area on figure 2. In bulletin 158 (1899), of the same series, Professor Todd showed the morainic belt as on the earlier map and described (p. 35) " a high massive ridge" as beginning on the west side of the Big Sioux, a mile north of the Iowa-Minnesota state line and running west along the course shown on figure 2. This ridge was interpreted as the northeast boundary of the Dakota lobe of the Wisconsin drift-plain. The area to the northeast, including Sioux Falls and beyond, lies between the Dakota and Des Moines lobes. The maps of Professor Todd show also two patches of morainic surface north-

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[1]Published by permission of the Director of the Iowa Geological Survey.

[2]Chamberlin, T. C., Preliminary Paper on the Terminal Moraines of the Second Glacial Epoch, Third Annual Rept. U. S. Geol. Survey, 1883, pp. 291-402.

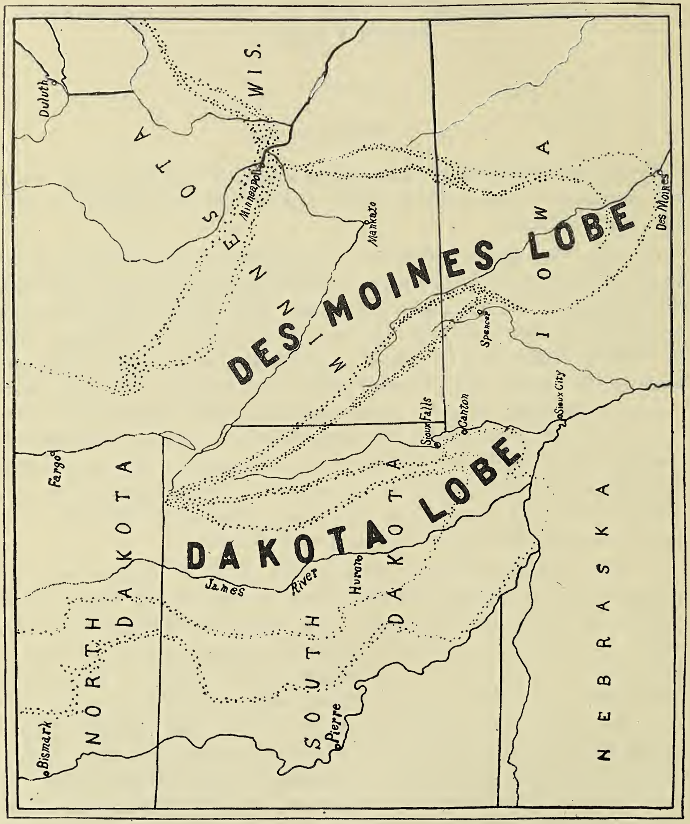

Fig. 1.—Map showing the extent of the Des Moines and Dakota lobes of the Wisconsin ice-sheet, and the location of the Sioux Falls-Canton region with respect to these lobes. After Chamberlin, Third Annual, U. S. Geol. Survey, Pl. 35.

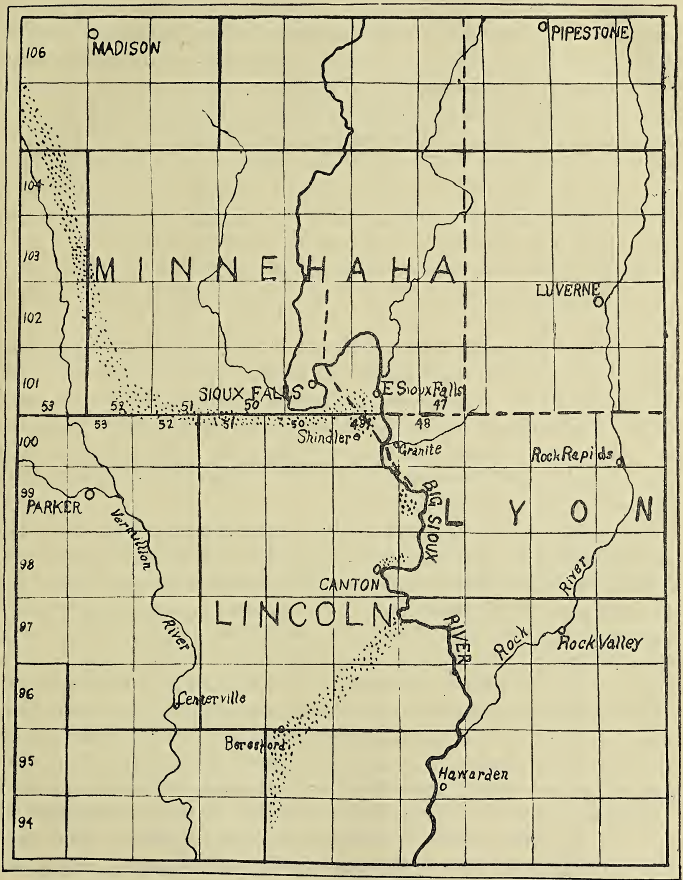

Fig. 2.—Map showing a portion of Eastern South Dakota and adjoining parts of Iowa and Minnesota. The shaded area shows the course of the Altamont Moraine as mapped by Todd in bulletins 144 and 158 of U. S. Geol. Survey. The broken line is the course of the Altamont Moraine as described by Wilder in the Lyon county report of the Iowa Geol. Survey.

east of Canton and a belt extending from south of Canton southwest through Beresford (Fig. 2).

In 1900, Professor Wilder studied the geology of Lyon county in the northwest corner of Iowa.[3] He accepted the mapping of the Dakota plain opposite Lyon county as Wisconsin, and further enlarged the area in two ways. He interpreted the Wisconsin moraine as crossing the Big Sioux river west of Granite and continuing southward along the east slope of the Big Sioux valley for 5 to 6 miles (Fig. 2). Concerning the Wisconsin border on the Dakota side Wilder says, "From the point where the moraine crosses the river west of Granite, to Sioux Falls it is easily traced as a well defined, boulder-strewn ridge. It passes east of Sioux Falls and crosses the river 2 miles northeast of town. * * * Thence for 10 miles it was traced nearly due north." The course of this border located from the statement just quoted is shown by the broken line on figure 2.

During the field seasons of 1910 and 1911 the writer was engaged in a study of the Pleistocene deposits of northwestern Iowa for the Iowa Geological Survey. In connection with this work the Altamont moraine mapped by Professor Wilder in western Lyon county was investigated and the decision reached that it is not Wisconsin moraine, and that in fact no part of the Wisconsin drift-plain of the Dakota lobe exists on the Iowa side of the Big Sioux river.[4]

Questions then arose as to the exact boundaries of the Wisconsin plain on the Dakota side, opposite Lyon county, for, as noted above, the statement of Professor Wilder concerning this boundary does not agree with the mapping of Professor Todd. It was also known that Professor Shimek, of the Iowa Geol. Survey, questioned the existence of the Wisconsin drift-plain in the Shindlar region just opposite Lyon county. These considerations led the writer to go into the Sioux Falls-Shindlar region during the latter part of the field season of 1911 to try to determine the identity of the Wisconsin drift-plain, and to locate more exactly its boundaries. The time available for the study was very short and only a partial covering of the data that is thought to exist was possible.

The results of the investigation of Professor Shimek, unpublished at the time the writer was in the field, appeared in the March, 1912, number of the Bulletin of the Geological Society of America. Among the conclusions of Professor Shimek's paper (p. 154) are the following:

1. "There is no Wisconsin drift in the western part of Lyon county, Iowa."

[3] Wilder, F. A., Iowa Geol. Survey, vol. 10, 1900, pp. 137-141 and map p. 118.

[4] Only a few weeks later Prof. Shimek of the Iowa Geol. Survey working independently of the writer and upon other problems, examined the so-called Altamont moraine of western Lyon county and reached the same conclusions concerning it.

2. "The ridges southwest, east and southeast of Sioux Falls and south of Canton are not a part of the Altamont moraine, but are Kansan."

3. "The plain extending from Shindlar to Canton, South Dakota, is Kansan and not Wisconsin."

With the first and second of these conclusions the writer agrees. But with the third, which is, that the plain from Shindlar to Canton, is Kansan, the writer does not agree, and it is against this conclusion that most of this paper is directed.

The western part of Lyon county, Iowa, is very rugged with a submaturely dissected topography. The divides are narrow, standing at an altitude of 1,400 to 1,480 feet, and below this, a relief of 100 to 150 feet exists. The surface material is loess and such drift exposures as occur are of yellow Kansan clay. The eastern portion of Lincoln county, South Dakota, opposite Lyon county, is however a relatively level plain, sloping gently to the south and east. Near its eastern margin at the Big Sioux a few narrow valleys occur, but the dominating feature of the region is the relatively level plain. This plain does not have a loess covering. The high divides on the east side of the river, from the state line south to a point opposite Canton, have a uniform elevation of about 1,460 feet. Opposite the state line the elevation of the Dakota plain is about 1,400 feet, which is about 150 feet above the river and about 60 feet below the Iowa divides. But the elevation of the plain decreases southward more rapidly than the fall of the river, and north of Canton the edge of the plain overlooking the valley has an elevation of only 1,320 to 1,340 feet, which is only 80 to 90 feet above the river and more than 100 feet below the divides of the Iowa side. These contrasts in the topography and elevation of the areas on opposite sides of the Big Sioux river are well shown in the northeast corner of the Canton topographic sheet of the United States Geological Survey.

This relatively level plain extending from the north border of Lincoln county southward to Canton and east to the Big Sioux valley is an area included by Chamberlin, Todd and Wilder in the Wisconsin drift-plain but which Shimek would make a Kansan plain.

Passing directly eastward from Sioux Falls, the topography is erosional, with a relief of 50 to 75 or even 100 feet (Fig. 3). The distance between the two limbs of the northward loop of the Big Sioux valley is here only 4 to 5 miles, and the small creeks have cut back from either direction until all the area is well drained. The slopes are moderately steep, but rounded, indicating sub-mature dissection; the region is covered with loess which is frequently seen in road cut exposures; the surface material, derived from the loess, is without grit of any sort; and no pebbles or boulders occur on the surface. In the more dissected parts, near the large valleys, the fresh, brownish-grey phase of the Kansan drift can be exposed. The region belongs to the loess-covered Kansan drift-plain.

Running in an east-west direction through sections 30 and 29 southwest of East Sioux Falls is a ridge. It rises to an elevation which is approximately that of the major divides to the north, has a rounded crest and is apparently erosional. The north slope has broad valleys leading down to the creek of sections 19 and 20, the bed of which is 100 feet lower than the crest of the ridge. This is the ridge described by Professor Todd and interpreted by him as a part of the outer moraine. From the crest of this ridge one overlooks the region to the north and the south. To the north is the rolling country of erosional topography noted above. To the south of the crest, the slope descends 30 to 50 feet in the first half mile and then an even plain of slight relief continues off to the south and southwest.

Passing out onto this plain, in sections 31 and 32 (T. 101 N., R. 48 W.) it is found to have a relief of 15 to 25 feet with frequent undrained depressions, which during the wet seasons, are occupied by swamps or small ponds. Just east of the southwest corner of section 32, is a small depression occupied by a pond, not more than 50 yards from the edge of a narrow valley cut sharply to a depth of 30 to 40 feet below the plain. Other ponds occur just to the east in similar positions with reference to this valley, and at the quarter section corner on the east of section 32 is an undrained depression within a short distance of the edge of the Big Sioux valley. This plain continues southward and southwestward to Shindlar and beyond. North of Shindlar the relief is 10 to 20 feet and undrained depressions with swamps occur in every section. The location of a few typical ones may be noted, as in the southeast corner of section 36, the southwest and southeast quarters of section 31, the northwest corner of section 9, the east part of section 8, and at several places in sections 17, 8 and 7 along the Chicago, Rock Island and Pacific Railway northwest of Shindlar (Fig. 3).

The loess loam, so usual in the Kansan area, is absent here and the drift continues to the surface, or is overlaid by a black soil. A field in the southeast quarter of section 31, showed a gravelly, pebbly soil turned up by recent plowing and the road beds contain pebbles and sand material which is quickly detected by the grating sound produced by the wagon wheels. Occasional boulders lie on the surface or have been gathered up and piled along the fences. They may be seen along the west line of section 32 southwest of East Sioux Falls, in sections 22 and 15 east of Shindlar, and a pile of them may be seen from the railway train just southeast of the station at Shindlar. They are also frequent in sections 15 and 16 of township 100 north, range 50 west, and were seen at a number of places farther northwest (Fig. 3).

The erosion valleys of this plain are narrow and steep sided. They are restricted to its eastern part near the Big Sioux valley and even here have determined the topography of only a small part of the area that they drain. The usual relief features of the plain are low hills and broad swales interspersed with shallow undrained depressions. The broad swales are usually followed by streams, but these streams did not make the valleys which they occupy but only the narrow shallow channels in which they flow. The low hills and ridges show by their position and form that they were not made by erosion, but that, like the broad winding depressions in which the streams flow, they are constructural. Sufficient characters have now been given, to indicate the type of plain with which we are dealing. It is a glacial plain with very definite characters and is in decided contrast with the erosional area to the north, and with the region on the Iowa side.

The boundary between the erosional topography and the glacial topography is not always a sharp line, but within one fourth to one half mile the transition from one to the other takes place. The boundary is shown on figure 3 as a heavy broken line. It leaves the Big Sioux valley about a mile south of East Sioux Falls and runs westward through south 29 and 30 along the south base of the ridge described above. Crossing into Sioux Falls township, it soon changes its course to southwest, and at a distance of one to one and one half miles from the Big Sioux, holds this course for about four miles, to northeast 16 of township 100 north, range 50 west. It then swings abruptly to the north and follows down a small creek valley through section 9, to the Big Sioux. To the southeast of this boundary is the slightly rolling glacial plain with its undrained depressions, boulders, and drift continuing to the surface. To the northwest, the surface is rolling to rough, is entirely controlled by drainage lines, and the surface material is loess or pebbleless loam.

From the mouth of the creek valley on the north line of section 9, the boundary is the edge of the Big Sioux flood-plain west and north to the union of Skunk Creek valley with the Big Sioux valley. The border is then the south edge of the Skunk Creek flat and runs northwest through the center of this township. The part of this township to the south of Skunk creek is a glacial plain while to the north the topography is maturely dissected and the surface exposures are of loess. The contract of the topography on opposite sides of this valley is very pronounced and an excellent example of glacial versus erosional topography.

In this entire distance along the Wisconsin margin from the Big Sioux opposite the state line to the center of township 101 north, range 50 west, a distance of 15 to 17 miles, there is not a single hill that might be called a terminal moraine hummock. The marginal part of the glacial plain is not even more uneven than that farther back, except for irregularities due to recent erosion or to incomplete obliteration of pre-Wisconsin surface features.

Professor Todd traced the course of the "outer moraine" across this area in the following words:[5] "Beginning on the west side of the Big Sioux, about a mile north of the northern boundary of Iowa, a high massive ridge begins to extend westward and southwestward around the Great Bend of the Big Sioux, and continues its westerly course to near the southwest corner of township 101, range 51." Near the Big Sioux valley south and southwest of East Sioux Falls this ridge is fairly prominent but it becomes less prominent westward and in southeastern Sioux Falls township is represented only by disconnected hills. These features, apparently taken by Professor Todd as morainic, are all on the Kansan just beyond the actual Wisconsin margin and are not morainic but erosional. However, the contrast between the glacial plain to the south and the erosional topography to the north was detected and its true significance realized. Westward from the Great Bend, Professor Todd states that this ridge "continues its westerly course to near the southwest corner of township 101, range 51." A broad ridge-like elevation does continue westward along the county line, from the Great Bend, but this elevation does not mark the Wisconsin margin, for as noted above the southern part of township 101 north, range 50 west, south of Skunk creek, is a glacial plain.

This separation of the Kansan and Wisconsin drift-plains, is based upon physiographic features, although the boulders of the Wisconsin plain and the loess-covering of the Kansan areas, are accordant stratigraphic lines of evidence. The Wisconsin drift is very hard to distinguish from the Kansan, at least in the marginal parts of the Wisconsin area, or else it is almost entirely lacking. In a few places the

[5]Todd, J. E., The Moraines of Southeastern South Dakota, Bull. 158 U. S. Geol. Survey, 1899, p. 35.

drift observed is not the typical Kansan and may be Wisconsin, but most of the exposures studied, are apparently Kansan. On the basis of the drift alone, one would not separate the areas, but the conclusive evidence is the topography, and along with this, the absence of a loess-covering over the Dakota plain, the presence of boulders on the surface and the questionable drift of the region agree.

Southeast of Shindlar, along the Chicago, Rock Island and Pacific Railway as it descends to the Big Sioux valley, there are a number of drift cuts. The plain above is Wisconsin but the drift exposures are Kansan with the possible exception of the first cut southeast of Shindlar, which comes at the very edge of the plain just as the descent begins. In this cut, there is a loose, sandy drift near the surface, which breaks out in rounded fragments and crumbles to a sandy mealy clay when crushed in the hand. It grades downward however to a harder, more plastic clay, which breaks with the more definite Kansan fracture.

Just south of the northwest corner of section 36 of Sioux Falls township (T. 101 N., R. 49 W.), a yellowish-brown, sandy drift comes to the surface, except for a thin covering of soil. This is just inside the Wisconsin area and good glacial topography continues off to the southeast. In passing only a half mile to the west, the Wisconsin boundary has been crossed and a loess covering of 4 to 6 feet overlies the Kansas drift (Fig. 3).

At the northeast corner of section 10, township 100 north, range 50 west, just outside the Wisconsin margin, there are several cuts of loess, one 12 feet deep, and some of them show Kansan drift below the loess. About 80 rods to the south, a road cut shows, at the surface, a brownish-grey drift with considerable sandy material and occasional pebble bands. Passing down the slope, through a vertical thickness of 8 feet, the drift is found to rest upon a brownish-yellow loess deposit, several feet in thickness, the base of which is not exposed. This is apparently a case where the Wisconsin ice near its margin pushed over some loess without tearing it up and mixing the material with its drift.

Is the failure of the Wisconsin drift-sheet real or only apparent? We are accustomed to think of the drifts of different ice-epochs as presenting each its own characteristic lithological features, but if two ice-sheets advanced over the same route and eroded the same rock formations, there is little reason why the drifts should differ. The Wisconsin drift was obtained from the same rocks as the Kansan drift, or is in large part simply reworked Kansan drift, so that we should not expect the drifts to be distinctly different. However it is not believed that any large amount of the drift exposed in the deeper cuts, as along

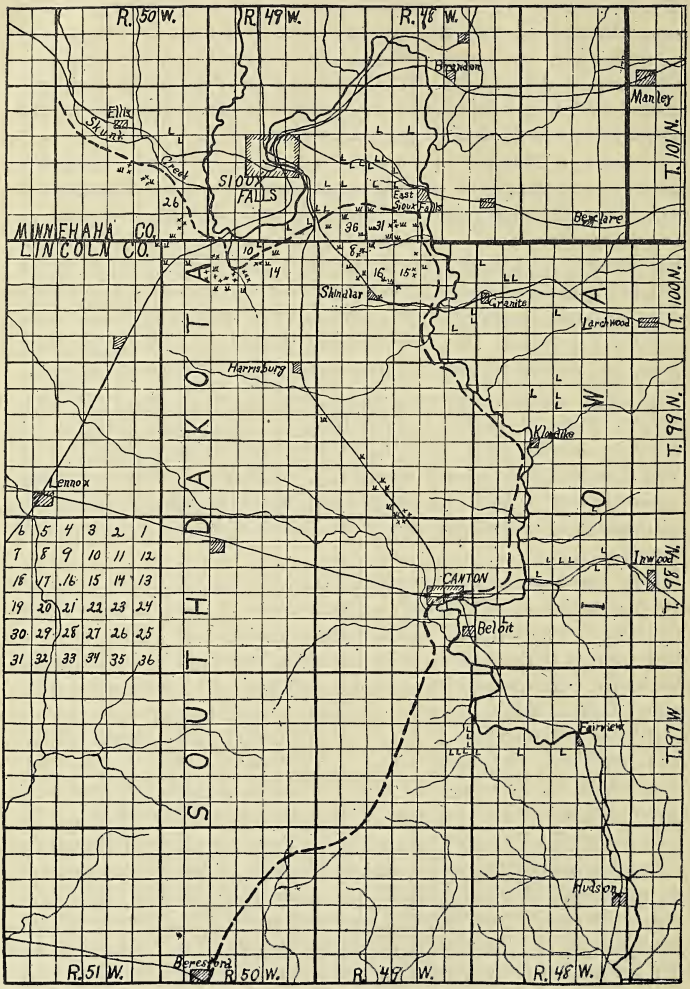

Fig. 3. Map of the Sioux Falls-Canton region. The broken line shows the eastern boundary of the Wisconsin drift-plain. L--loess exposures. X--boulders. ✱--undrained depressions.

the railway southeast of Shindlar, is Wisconsin. It is believed rather, that the amount of Wisconsin drift is small, amounting to only a few feet of material much like the Kansan and grading downward into the true Kansan. Detailed work in the region will however, probably show that the Wisconsin drift does differ slightly from the Kansan so that it will be possible to differentiate the drifts. But should this not prove true, the glacial plain remains, and this cannot be Kansan. It is a youthful glacial plain and nothing of this type is found in any known Kansan drift-plain.

Professor Shimek, in his recent article on the Sioux Falls region, speaking of the plain on the Dakota side states: "There are few entirely inclosed basins containing swamps and ponds."[6] Attention has already been called to the presence of undrained depressions with swamps and ponds in the region north of Shindlar, and they are shown on the accompanying map, figure 3. Farther west in township 100 north, range 50 west, swamps occur in sections 11, 14, 15, 16, 21, 17 and 7, and at several places in the south part of township 101 north, range 50 west. These swamp areas are not extensive and the ponds are not large, but they are a common feature and their presence is significant as showing the recency of the plain. Continuing, Professor Shimek says, "the general character of the surface is very similar to that of the Kansan in O'Brien and Osceola counties in Iowa." The Kansan plain of O'Brien county and southern Osceola county[6a] is in large part quite level, the relief being at many places no greater than that of the Dakota plain. But it is only in this matter of relief that the two regions should be compared. The relief features of a large part of the Dakota plain are independent of stream erosion. Narrow, sharply-cut valleys have determined the relief features of a narrow belt on either side of them, but only a short distance back from these valleys the low rounded elevations and the shallow undrained depressions so characteristic of recent glacial plains, are the dominant features of the region. The relief features of the Kansan plain of O'Brien county consist of very broad shallow valleys. The courses of the valleys are usually direct and the drainage pattern is the usual dendritic type. Long gentle slopes lead down to the valleys from either side, and the divides are rounded. Although the relief may be slight all the surface has some slope and belongs definitely to some drainage basin. Along the stream courses are many marshy flood-plain areas but there are no depressions away from the stream courses. It is a region of very slight relief in

[6]Shimek, B., Pleistocene of Sioux Falls, South Dakota, and vicinity, Bull. Geol. Soc. America, vol. 23, 1912, p. 149.

which all the slopes and surface features have been determined by stream erosion. The writer has studied quite thoroughly the major portion of O'Brien and Osceola counties and is very positive in making the statement that in all the Kansan area of O'Brien and surrounding counties there is not a single undrained depression of the type that is common on the Dakota plain.

The Chicago, Milwaukee and St. Paul Railway, running south from Sioux Falls, comes out onto the glacial plain just north of the county line, and continues southward across this plain through Harrisburg to Canton. At a number of places along this road swamps may be seen and boulders lie on the surface. It is evident that if the identity of the Wisconsin plain is established farther north it should continue south to Canton. The writer has not seen the region southwest of Canton, but from the topographic map of the area it seems evident that the southeast border of this plain is approximately as given by Professor Todd, running from the point of the upland south of Canton, south by southwest through Beresford.

It has already been noted that the loess is absent over the Wisconsin plain, but the matter is of such importance that a more complete statement is justified. The rugged region of the Iowa side is loess-covered, with numerous exposures in the road cuts. The area within the east loop of the Great Bend between Sioux Falls and East Sioux Falls, the area within the west loop of the Great Bend, and that west of the Big Sioux and north of Skunk creek, are all loess-covered, as well as the rugged area south of Canton. In contrast with this loess-covered, rugged area the Dakota plain is free from loess. On figure 3 twenty exposures of loess are mapped in the area north of the Wisconsin drift-plain to the east and west of Sioux Falls, nineteen exposures are mapped on the Iowa side and eight in the rugged area south of Canton. Many of these loess exposures are taken from the map published by Professor Shimek on page 131 of volume 23 of the Bulletin of the Geological Society of America. On this map by Professor Shimek only one exposure of loess is mapped within the area which is included in the Wisconsin drift-plain of figure 3, and this exposure is just at the edge of the Wisconsin plain, in or near the west bluff of the Big Sioux valley. On the other hand there are twelve exposures of loess mapped within the east loop of the Big Sioux, sixteen exposures along the Iowa upland between the state line and a point opposite Canton, and eleven exposures in the upland south of Canton. The plotting of these loess exposures brings out the fact that the loess-covered area is identical with the area of erosional topography, while the area without loess is identical with that having a glacial topography.

There remains to be noted a few isolated hills which rise above the level of the Dakota plain near its eastern edge along the Big Sioux valley. They are located from south to north as follows: (1) At the northeast edge of Canton. (2) Three miles northeast of Canton. (3) Just opposite Klondike. (4) Two and a half miles east of Shindlar. Professor Todd refers to them as the only representatives of the Altamount moraine between the highland south of Canton and the ridge south of East Sioux Falls, and says that the larger of them "show basins indicating their morainic character," and that the hill in northeast Canton is "composed largely of gravel."[7] Professor Shimek says concerning them "they are certainly Kansan, and are evidently related to the upland on the Iowa side."[8] Like the plain to the west they are not covered with loess and at least three of them have pebbles and boulderetts on the surface. The drift of these hills, in so far as seen, could not be differentiated from that of the surrounding plain and is apparently Kansan. These hills were apparently features on the pre-Wisconsin surface, or remnants left by the erosion of the Wisconsin ice, but they were over-ridden by the Wisconsin ice, stripped of the loess-covering and veneered with a thin coating of drift with gravels and boulderetts on the surface.

The results of this study would fix the extent of the Wisconsin drift-plain essentially as determined by Professor Todd. The writer does not however agree with Professor Todd concerning moraines at the edge of the Wisconsin plain. It has been shown that the features taken by Todd as the Altamont moraine, from a point opposite the north boundary of Iowa westward to the south end of the Great Bend are erosional hills and ridges of the Kansan plain just outside the Wisconsin boundary, and that the ridge running westward from the south end of the Great Bend is within the Wisconsin boundary with glacial topography to the north extending to the valley of Skunk creek. The isolated hills along the Big Sioux between the north boundary of Iowa and Canton are apparently remnants of the Kansan plain made up of Kansan drift but over-ridden by the Wisconsin ice. It is also probable that there is little true terminal along the border southwest of Canton toward Beresford.

In summary the evidence here submitted may be brought together as follows:

[7]Todd, J. E., Bull. 158 U. S. Geol. Survey, 1899, p. 34.

[8]Shimek, B., Bull. Geol. Soc. America, vol. 23, 1912, p. 150.

[8a]Those parts of O'Brien and Osceola counties here referred to the Kansan may belong to a post-Kansan, pre-Wisconsin drift sheet.

(1) The Dakota plain has a slightly rolling to gently rolling surface, with a relief of 15 to 25 feet, while the region to the north, east and southeast, is rugged with a relief of 100 to 150 feet.

(2) The Dakota plain has an altitude that is 50 to 100 feet below the altitude of the divides of the adjoining regions to the north, east and southeast.

(3) The relief features of the Dakota plain consists largely of low mounds and broad swales, interspersed with shallow undrained depressions. Such erosion valleys as occur are narrow and steep-sided and have determined the topography of only a narrow belt on either side. This is a true glacial surface and the time which has elapsed since its formation is comparatively short. There is no Kansan area known that has such undrained depressions. The relief features of the adjoining region are those produced by erosion by running water to the sub-mature stage of the cycle.

(4) The Dakota plain is free from loess, while the region to the north, east and southeast has a loess covering.

(5) Boulders and boulderetts are frequently seen on the Dakota plain, while in the area to the north, east and southeast, boulders are seldom seen, except in the beds of ravines that are being actively degraded.

(6) The Dakota plain has a dark pebbly, gritty soil, while over the surrounding area there is a pebbleless loam derived from the loess.

This combination of characters found on the Dakota plain calls for an entirely separate glaciation at a very recent geologic time. The conclusion then is, that the plain extending from just north of the north line of Lincoln county, south through Shindlar and Harrisburg to the upland south of Canton, and east to the Big Sioux valley, was covered by a part of the Dakota lobe of the Wisconsin ice-sheet, and is a Wisconsin drift-plain, while the areas to the north, east and southeast belong to the loess-covered, maturely-eroded Kansan drift-plain.

ADDITIONAL EVIDENCES OF POST-KANSAN GLACIATION IN JOHNSON COUNTY, IOWA.

MORRIS M. LEIGHTON.

Johnson County offers a field of phenomena that are strikingly applicable to the theme of our late Pleistocene controversy, namely, "Has the northeast quarter of Iowa, except the Driftless Area, been invaded by an ice-sheet later than the Kansan?"

It is with certain of these phenomena that this paper will attempt to deal. The area studied in particular was the northwest two-thirds of Johnson County. As shown in Fig. 1, it includes the North Liberty and Shueyville lobes of the Iowan drift, mapped by the late Professor Samuel Calvin, and the bordering areas of the Kansan drift.

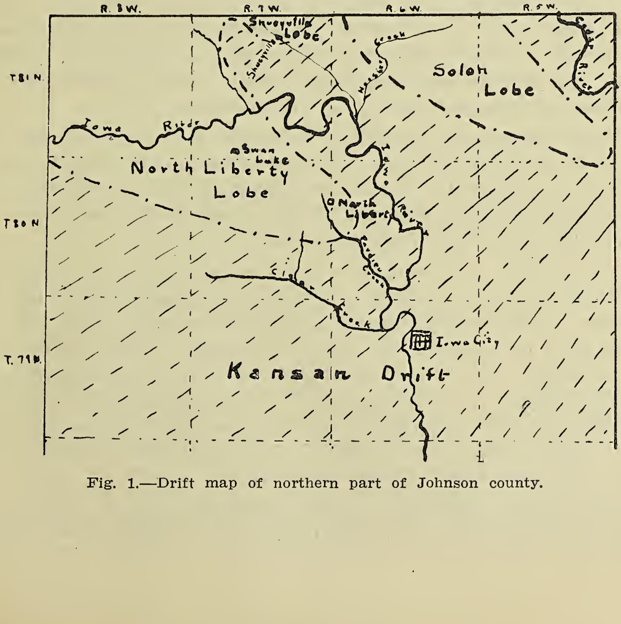

Fig. 1.—Drift map of northern part of Johnson county.

FORMER DISCUSSIONS.

A discussion of this area has been partially entered into by Calvin. The contrast between the youthful topography of the North Liberty lobe and the mature topography of the bordering Kansan, together with the marginal deposits of loess bounding the lobes of the Iowan, are noted in Volume VII of the Iowa Geological Survey, pp. 39-46 and 83-87. Reference is also made in several of the county reports to terraces of Iowan gravel in the valley of Iowa River, but no location, description, or adequate significance is pointed out concerning them. During the field-work of the present writer, some of these terraces, formerly unbeknown to him and perhaps the identical ones referred to by Calvin, were found. The typical ones of these will now be considered.

VALLEY-TRAIN TERRACES.

In valleys leading down from the North Liberty lobe and from the Shueyville lobe to Iowa River, and along Iowa River from Curtis to Iowa City, are the following terraces of sand and gravel:

Pardieu Creek Terrace.—A notable terrace occurs on the west side of the valley of Pardieu Creek about one mile below the North Liberty lobe, in the west central part of section 29, township 80 north, range 6 west. The terrace is about ¼ mile long, 15 feet high, and from 25 to 75 yards wide. Except where dissected it has a flat top, and is backed by a hill that rises 60 feet above the terrace. (See Fig. 2.)

Several exposures in the side of the terrace show stratified sand and gravel, with a few small lenses. The sand is dominant, but gravel ranging in size up to three inches, is mixed with the sand. The material shows no alteration, and it is so loose that it will not stand with steep face. In every way it presents a fresh appearance.

The deposition of the sand and gravel took place, it is clear, after Pardieu Creek had cut its valley. Whether the deposition took place by drainage waters from the North Liberty lobe or from a wash into the valley from the west, the significance is the same. The material is of glacial origin, and the fact that Pardieu Creek was changed from an eroding stream to a depositing one for a period sufficiently long to aggrade its bed 15 feet, together with the fact that it drains from the North Liberty lobe, indicates that Pardieu Creek was a drainage line from an ice-sheet after its valley was eroded.

Two deposits, apparently of similar character, occur in other drainage lines leading from the North Liberty lobe. One of these is in a tributary to Clear Creek, about the central part of section 26, township 80 north, range 7 west; the other lies in a tributary leading east from the lobe to Iowa River, about 1½ miles east of the village of North Liberty.

Valley-train Material from the Shueyville Lobe.—From the Shueyville lobe, a tributary flows southeastward through the village of Shueyville, joining Hoosier Creek just above its junction with Iowa River. In this tributary on the south side, where crossed by a north-south road, in the northwest quarter of section 13, township 81 north, range 7 west, occurs a terrace that extends for about ⅛ mile, and is 20 feet high and 50 to 100 yards broad. No good natural section shows the character of the material, but in a side-wash and along the slopes sand is evident, suggesting that it is a sand terrace and that it probably has the same relation to the Shueyville lobe that the terrace in Pardieu Creek has to the North Liberty lobe.

Along the north side of the ravine running parallel with the Cedar Rapids and Iowa City Interurban Railway from Swisher to Cou Falls, in Iowan territory, there is a bench-like feature averaging as much as 30 feet above the present stream. Apparently it has lost some of its former distinctiveness by lateral dissection. In the excavations made by the Interurban, sands mixed with coarse gravel, and in places cross-bedded, are exposed. The material is the same in character as that in the Pardieu Creek terrace, and is probably of similar origin.

Section in an Outwash-like Plain.—Three or four miles west of Cou Falls, in the southwest quarter of section 19, township 81 north, range 7 west, an intermittent creek has cut a vertical-walled channel 10 feet deep into a very gently sloping area which resembles an outwash plain and leads up to some morainic-like hills of drift capped with loess. The materials are outwash and afford the following section:

(3). Soil and clay, unstratified........................2′-4′
(2). Gravel parting, apparently residual...............0′-3′
(1). Sands, stratified in long lenses, yellow, medium-grained, arkose ....2′-4′

Terrace-like Feature at the Helman Sand-pit.—At the Helman sand-pit, situated on the north side of the bend of Iowa River just north of Iowa City and on the west side of the tributary that cuts the valley wall, is an exposure of silt, sand, and gravel, overlain by loess. The site resembles a remnant of a terrace. On both sides of the tributary, particularly on the east, the summit is flat-topped for some little distance back to the higher land. The uniform elevation to the west for a quarter of a mile, with higher land to the north, as shown in Fig. 3, still further suggests a terrace. Were it not for the break in continuity by the tributary, the semblance would undoubtedly be even more perfect.

In the bottom of the pit, are distinct pockets and lenses of gravel, sand, and some silt, with a range in texture from very fine to pebbles the size of a walnut. The outlines of the pockets depict well the courses of rapid currents, which afterward became filled with sand and gravel. About 4 feet higher the material grades into sand and silt. From the dominancy of sand the material grades upward until it becomes dominantly silt and finally loess, containing terrestrial molluscan shells. The material at the bottom is unquestionably a running water deposit, that at the top is clearly eolian, but no line between them can be drawn. However, at least ten feet of the bottom of the exposure is aqueous. Just how much lies below this is not shown. At present the deposit is separated from Iowa River by a "second-bottom" one-eighth of a mile wide, and by a vertical distance of 24 feet. The materials are heterogeneous in composition, fresh, and unconsolidated.

Inasmuch as the materials are of glacial character and similar to those in Pardieu Creek and other tributaries to Iowa River upstream, it seems best to refer them to the same origin.

There are several other terraces along the course of the river between the one mentioned above and upstream to where the Iowan drift-area crosses the river, some of which are quite perfectly developed. One especially deserving of mention occurs just above the Mehaffey bridge, in the southeast quarter of section 32, township 81 north, range 6 west. It is about 30 feet high, ¼ mile long, ⅛ mile wide at a maximum, and is backed by a distinct valley-wall 40 to 60 feet high. A well by the house on the east end of the terrace has the following log, as given by the digger: Depth 63 feet (dug 27 feet, drove 36 feet); yellow clay 16 feet, river-sand and gravel about 27 feet; hard-pan 20 feet.

CONTORTED BUCHANAN GRAVEL.

An excellent exposure of folded and contorted Buchanan gravel in intimate relations to weathered and unweathered Kansan and overlain by till, is shown in the first Interurban cut north of the upper Interurban bridge across Iowa River. The railroad grade here runs through the south end of a divide projecting somewhat into Iowa River Valley, the summit of the divide at the surface of the cut being about 30 feet above the valley flat. This is within the area mapped as Iowan Drift by Calvin.

The cut is about 250 yards long and attains a maximum depth of 20 feet. One hundred twenty yards of the east end is till, 100 yards of the west end is yellow fossiliferous loess, and between these are the contorted folds and rolls of Buchanan gravel in peculiar relation to the Kansan below and overlain by 2 to 8 feet of till. The arrangement of the materials is shown in Fig. 4.

The oldest material in the cut is Kansan till—blue at the bottom and grading up in places into a grayish to yellow color according to the degree of weathering. The blue drift is very clayey, contains small pebbles, many of which are greenstone, and breaks with polyhedral fracture. Joints are prevalent in the yellow clay and in the upper part of the blue, but instead of being vertical they dip to the west, suggesting that they are the result of pressure from that direction. In that case they might be regarded as slight shear-planes resulting from the same force that produced the distortion of the gravels above. Overlying this, in a peculiarly folded and contorted manner, is Buchanan gravel, the textural range of which is from fine flour to bowlders 1 foot in diameter. The gravel exhibits the oxidized, weathered, and decayed character common to the Buchanan, iron-stones being not uncommon and cementation by iron oxide sufficiently prevalent to have preserved stratification lines at many points.

Referring to Fig. 4 from left to right, the gravel appears at (1) in a narrow band and rises at an angle of about 45 degrees to a point near the top of the cut, from which it takes a horizontal course and assumes various forms of folds and loops to where it ends rather abruptly against till.

A striking feature of this cut, besides the contortions, is the fact that the gravel deep in the cut is as much weathered as that near the surface, whereas the till is not. Also at several points there is no gradation of weathering from the gravel into the underlying till. At (1) the gravel, so altered that some bowlders can be picked to pieces by the fingers, rests against the blue unweathered till; along the lower contact of (2) and around the lenticular body (3) the contact is sharp; and around the lower part of (4) and between (4) and (5) the till is scarcely changed whereas the gravel is much altered.

Overlying the gravel is a yellow, blue-streaked till, 2 to 4 feet thick along the summit and attaining a thickness of at least 8 feet along the west monoclinal limb. On the western slope of this, beginning at the point (X) and lying in contact with the drift along a diagonal line (made clearer by dotting), lies yellow fossiliferous loess which is not contorted but which shows deposition after the disturbance of the gravel. This body of loess makes up the west end of the cut.

Interpretation.—To account for such folds and contortions of Buchanan gravel into Kansan till in such a way as is revealed here, only one possible interpretation can be given. The uniform weathering of the gravels at different depths in contrast to the non-uniform weathering of the underlying till, and the sharp contacts of the decayed gravel with the more or less fresh underlying till proves that the time of the disturbance was after the weathering had taken place. If the weathering had taken place since the disturbance there should be a gradation zone between the weathered and unweathered portions. Such, however, does not exist.

It is therefore clear that an ice-sheet, capable of distorting and molding this hill of material, invaded this region after the Buchanan gravel and some of the Kansan had been much weathered.

In view of the above interpretation there are four important points embodied in this cut: first, the Kansan drift and the Buchanan gravel record the invasion and retreat of the Kansan ice; second, the weathering of the same represents a considerable time interval after the Kansan invasion; third, the sharp contacts record the close of the interval and these and the folds give identity to the presence of a later ice-sheet and its movement; fourth, the yellow loess, at least in this exposure, was deposited subsequent to the advance and retreat of the later ice-sheet.

GENERAL CONCLUSIONS.

The last evidence seems to be conclusive proof that an ice-sheet later than the Kansan advanced upon the area mapped as Iowan drift. The significant features that were noted preceding the last evidence—namely, the valley-train terraces and outwash features—and the glacial topography of the North Liberty lobe and the bordering deposit of loess, noted by Calvin, add the corroborative phenomena to be expected.

Fig. 2.—Photograph of Terrace in Pardieu Creek Valley.

Fig. 3.—View of Terrace-like Feature at the Helman Sand-pit, one mile north of Iowa City.

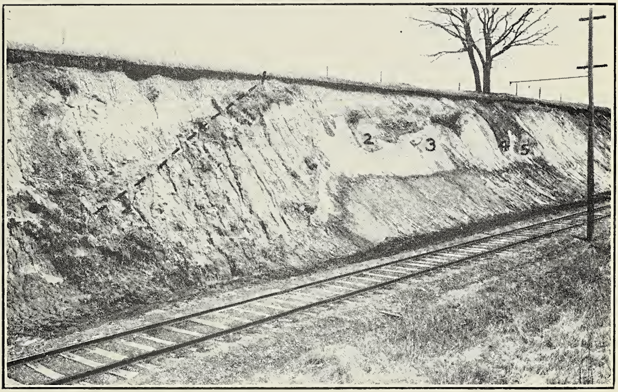

Fig. 4.—Photograph of the folded and contorted Buchanan gravel in the first Interurban cut north of the upper Interurban bridge across Iowa river.

MOUNDS AND MOUND EXPLORATIONS IN NORTHEASTERN IOWA.

By Ellison Orr.

Prehistoric earthworks are common in Allamakee, Clayton and Winneshiek counties, in the northeastern corner of Iowa, on the bluff tops and on the terraces of the Mississippi and its tributaries, the Oneota or Little Iowa, and the Turkey. They are always close to the stream along which they occur, none being found in such position that some part of the river cannot be seen from them, none being over a mile from the water and usually very much nearer.

Those found on the terraces may or may not be located along the side next to the river. Long embankments usually run parallel to the stream but round mounds may be found scattered over any part of the terrace, preferably on the slightly elevated portions.

The favorite sites selected by the builders, however, seem to have been the sharp divides separating the gullies and ravines that cut through the bluffs, opening into the river valleys.

On the bluffs bordering the Mississippi rows of mounds are found along the ridges of many such divides regardless of the direction they take. Such groups are most abundant near the mouths of the smaller tributary streams like Village Creek, Paint Creek, Yellow River, Bloody Run, and Buck Creek.

The largest are usually found on the point of the divide next the river. Back of these are found the smaller ones, and still farther back where the ridge widens are the long embankments and Effigy mounds. Only very rarely do they occur on a sloping hill side.

Four types are found. The most common being the round, dome-shaped form, having a uniform diameter, at the natural surface, of ten to sixty feet, an average being about twenty-five feet. Where they have never been disturbed by cultivation they range in height from one to eight feet, an average being about four feet. In many places mounds that are said to have been six or eight feet in height are nearly obliterated by cultivation.

This type of mound was probably used almost entirely for burial purposes or erected as a monument to relatives or tribesmen whose remains were elsewhere. Their structure is quite uniform. At the surface is a foot or two of clay or earth. Beneath this a more or less irregular floor or layer of rocks, usually flat. Sometimes this covers the part beneath completely, at others it is found in patches. Beneath this rock floor is found very compact clay down to the natural surface.

Very rarely are any skeletal remains, charcoal, pottery, ornaments, or implements found. Though we have opened many by trenching in them we have never but once found anything, this exception being a small, rude bottle shaped urn three inches in height, and a finely wrought chert spearhead or knife, 1 3-4 inches long, found in the largest mound of the Keller Group located on a terrace on the northeast, southwest of section 2, Township 98 north, Range 3 west, three miles below Lansing.

It is well known that the Sioux and some other tribes disposed of their dead by placing the bodies in trees or on platforms. It was also a custom with some tribes at intervals to gather up the bones of such dead and deposit them in one common grave. (See a translation of a portion of the Relations of the Jesuits in Annual Report of Bureau of Ethnology for the years 1883-4.)

It is possible that it was the custom to erect memorial mounds along the great river to dead slain in battle and whose bodies were not recovered, or to those whose bones rested far in the interior.

If bodies or bones were placed in these mounds when made, then the ones examined by us must be of great age. Time enough must have elapsed since their erection to permit the complete decay of all remains placed in them.

In a few of the round mounds, at the bottom and just above the natural surface is found a layer, several inches in thickness, of clay burned red, and resembling broken brick made without sand, or like the burned clay made and used by some railroads for ballast.

Such a mound is located on the bluff top just north of the mouth of Yellow River, and another is on the top of a point of bluff directly above and north of the few small stores and residences of Waukon Junction.

The second type of earthwork, and the form most abundant next after the round mound, is the long embankment. This type has an average width of 18 to 20 feet, a height of 1 to 4 feet, and may be any length up to over 400 feet.

No remains of any kind are found in them, and the rock floor of the round mounds is absent.

Their use or the reason for their erection is problematical. They certainly were not fortifications as they are so located that they could be flanked and attacked as easily from one side as from the other. They never are so arranged as to form even an approach to an enclosure, and they are mostly located on the bluff tops at some distance from, and two to four hundred feet above the usual camp sites on the terraces and flood plains.

Effigies of animals and birds form the third type. It is quite well settled that these are representations of the totems of different families. The reasons for their erection were probably analogous to those for the erection of the totem poles of the Indians of the northwest coast.

They are fairly well proportioned representations in a general way of animals and birds made in demi-relief, though it is seldom that the animal intended to be represented can be determined with anything like certainty. The best executed and best preserved one known to us is the most easterly one of a group of three on a promontory top half way between McGregor and the Pictured Rocks. This one is a very good likeness of a buffalo, which each of the three in the group was without doubt intended to represent. They have lengths respectively of 80, 90, and 96 feet and are about 2 feet in height.

Only two bird mounds are known to us. One located on the bluff north of Waukon Junction, is now nearly obliterated by cultivation, and is one of the few instances where an earthwork is found on a hill side. The other, a well preserved form, is found on a terrace of the Oneota River near the center of the S E of Sec. 17, Town. 99, Range 6. Both represent flying birds, but whether eagle, hawk or some other bird cannot be told.

Within a few feet of the Oneota bird effigy is an example of the fourth type of earthwork, the enclosure, which so far as we know is found only on the bluffs, terraces, and flood plains of that stream.

Eight of this type are known to us, seven being circular or oval in outline, the remaining one rectangular. Three of these are on the bluff tops, three on terraces, and two on the flood plain.

They consist of an earth embankment said to have been 3 to 4 feet high when first seen by white man, with a ditch on the inside. In one case there is a gap in the embankment on opposite sides of the enclosure, at which points there is also no ditch. This is a small ovoid enclosure 96 by 126 feet on the top of the high bluff near the mouth of Waterloo

Creek on the S E 1-4 of Sec. 35, Town. 100, Range 6 west. It was probably used for ceremonial purposes, as was also the one near the bird effigy.

All the others are large, being several hundred feet in diameter, and in and about them are abundant indications that they were long used as dwelling places by man. They were probably real forts or rather fortified camps, the embankments supporting a palisade.

THE SIMILARITY OF ELECTRICAL PROPERTIES IN LIGHT-POSITIVE SELENIUM TO THOSE IN CERTAIN CRYSTAL CONTACTS.*

BY F. C. BROWN.

Many of the phenomena having to do with the electrical properties of selenium have been regarded as almost unique. Likewise many of the phenomena appearing in connection with the resistance of crystal contacts are considered as unique. Neither of the above sets of phenomena have been explained from a sufficiently simple and satisfactory basis.

It is therefore believed that certain striking similarities in the two above sets of phenomena are significant. The organization of facts in this paper will make it rather convenient to assume that the major portion of the resistance in light-sensitive selenium is of a like nature to the resistance in crystal contacts. The essential phenomena to which attention may be called are as follows:

1. The variation of the resistance with pressure.
2. The apparent invalidity of Ohm's law.
3. The change of resistance with the time of current action.
4. The effect of slight amalgamation.
5. The effect of abrasion.
6. The effect of alternating currents.
7. The breaking down of the resistance by high voltage.
8. The unlikeness of light action.

GENERAL CONSIDERATIONS.

The variations of resistance to be compared appear under apparently different circumstances. In crystal contacts the experiments were usually carried out with a simple crystal in contact with various metals. The surface and manner of contact has been varied in many ways, by using points, and contact surfaces of varying dimensions and treatment. But with selenium the case is more complicated, the crystals are of a very large number and not all of one kind. The current of electricity in selenium must pass through many contacts in series and in multiple

*Paper before A. A. A. S., December, 1912.

with each other. The arrangement of the crystals is probably irregular and complex. So it must be borne in mind that the experiments to be compared are not identical. There is only a general similarity, and the degree of likeness is not definitely known.

THE VARIATION OF RESISTANCE WITH PRESSURE.

That light-positive selenium changes its resistance to a remarkably large amount with pressure was accounted by the author some time ago (Phys. Rev. 20, 185, 1905, also paper by Brown and Stebbins, Phys. Rev. 26, 273, 1908). This large change may be produced by hydraulic pressure applied to the selenium between parallel wires less than one millimeter apart. The effect of pressure was studied more carefully by

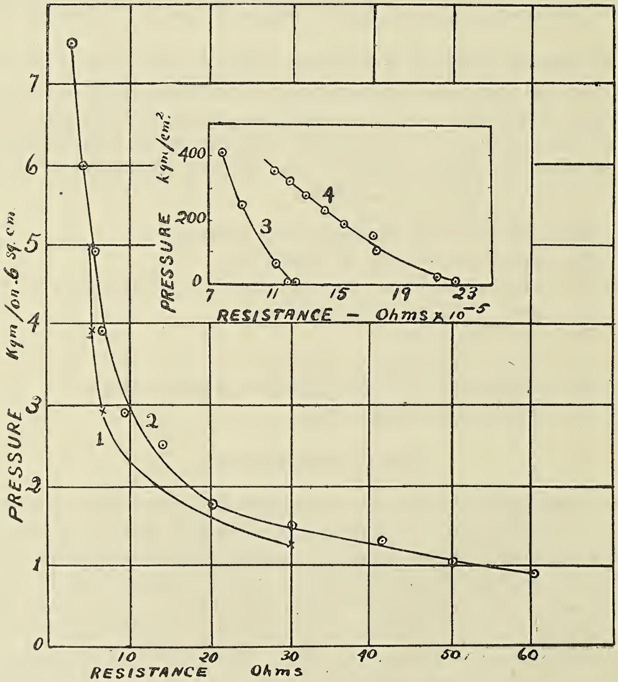

Fig 1

Monten as given in his dissertation at the University of Uppsala in 1909. According to him the conductivity increases more than seventy times in going from normal pressure up to 3,000 atmospheres. For certain samples of selenium the equation giving the relation between pressure and resistance is

$$R=2.5\times10^{6}.e^{-.00083p}$$

In the lower curve of fig. 1 is given the relation between pressure and resistance for galenite as taken from Streintz and Wellik's paper (Phys. Zeits. 12, 848, 1911) where 0.6 volts was the difference of potential across the crystal and its contacts. Curve 2 shows the same relation when 0.41 volts was the potential difference. These curves are typical of what would obtain with many other crystals.

Likewise curve 3 gives the variation of resistance of a selenium cell when the potential difference was 10 volts and curve 4 shows the same relation for 1.4 volts. A glance is sufficient to make obvious the similarity between curves (1), (2) and (3), (4). It will be observed that the pressure-resistance curve for selenium follows approximately the same curve for galenite, where the fall of potential across the latter was 0.41 volts. Evidently the agreement would be better if the fall of potential were yet less in the selenium. This is particularly noticeable at the higher pressures. However this might lead to the assumption that the selenium in the selenium cells is under an initial pressure of several atmospheres due to the packing of the crystals.

The different values for the scale divisions may obviously be explained in one or both of two ways. Either the selenium crystal contact may be inherently of higher resistance than those of the frequently studied crystals or the pressure of a single crystal may be only a small fraction of the pressure per unit area. Supposing the resistance of selenium to be essentially due to contacts and further that the resistance of each contact to vary precisely as it does with galenite, it can easily be deduced that the area of each selenium crystal is approximately .0003 sq. cm. But this assumption and conclusion are purely speculative.

Perhaps the well known change of resistance of carbon granules with varying pressure is more nearly akin to the change in selenium than those referred to in this paper. I have noted however that the resistance of a large number of carborundum crystals when packed under a given pressure is unusually large compared with the resistance of a single crystal contact.

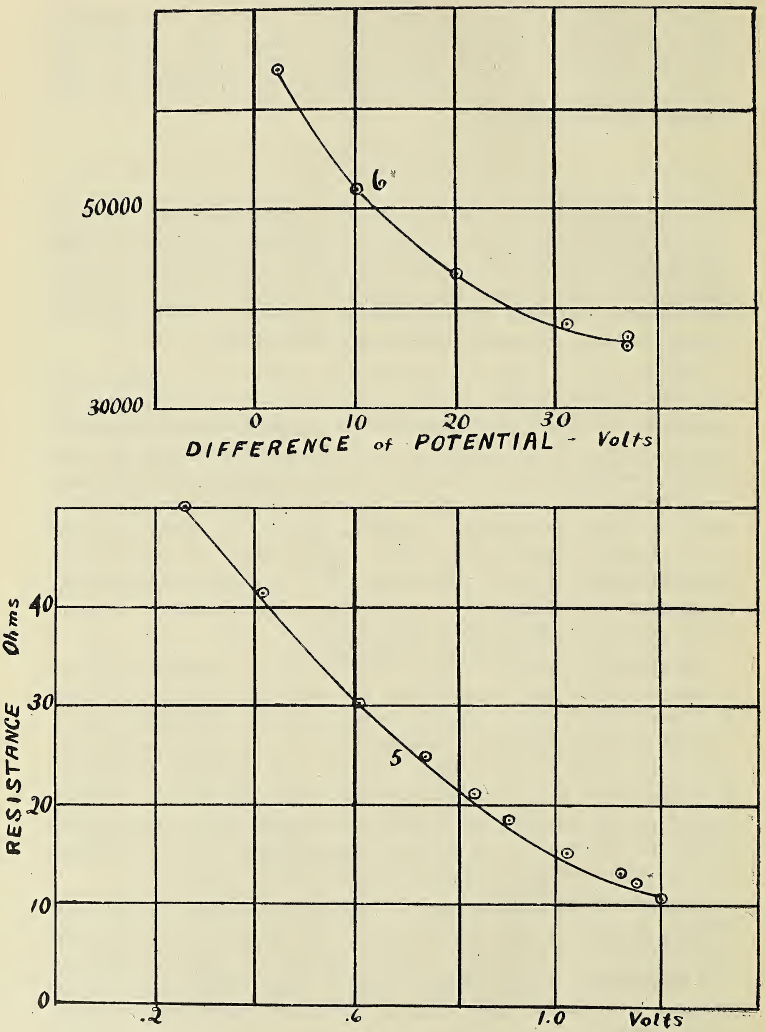
6
50000
30000
0
10
20
30
DIFFERENCE of POTENTIAL - Volts
RESISTANCE Ohms
40
30
5
20
10
0
.2
.6
1.0
Volts

Fig 2.

THE APPARENT INVALIDITY OF OHM'S LAW.

It is well known that the resistance of light-sensitive selenium is a function of the electro-motive force across the circuit. Practically every investigation of crystal contacts has recognized a similar phenomenon with crystals, although the relation has usually been expressed with the resistance as a function of the current. There is no obvious reason why the variations from Ohm's law in crystal contacts as well as in selenium can not arise from a common action. But there is no evidence that shows whether it is the action of the electrical current per se or the electrical stress as indicated by the fall of potential in the circuit, that produces the variation from Ohm's law. I prefer to attribute the change of conductivity in crystals and in selenium to the electric intensity. This notion makes it somewhat easier for me to perceive the relation of the phenomena to the dynamic equilibrium of selenium. In the lower curve of fig. 2 is shown the manner of variation of the resistance of galenite in contact with gold plates* when the potential is varied. The upper curve shows the corresponding variation in light-positive selenium. With the scale chosen the rate of changes of resistance is nearly the same in both instances. Where the potential difference in the selenium changes from 10 to 30 volts, the resistance changes from 50,000 to 38,000 ohms, while with the galenite when the potential difference changes from .2 to .6 volts the corresponding drop of resistance is from 53 ohms to 30 ohms, i. e., with the same ratio of increase of voltage there is not only a decrease of resistance in both, but the percentage decrease is of approximately the same order of magnitude. Perhaps if the data for galenite covered the range from 0.1 to .3 volts we should find the percentage change of resistance more nearly equal to that of selenium. It is noteworthy that the potentials are of the order of 100 times greater in the selenium when the same slope of the curve is approximated. This compares favorably with the increased scale of pressure as shown in fig. 1, necessary for the comparison of the pressure-resistance curves.

THE CHANGE OF RESISTANCE WITH TIME AFTER THE POTENTIAL DIFFERENCE IS APPLIED.

Selenium and crystal-contact resistances present essentially the same behavior by continued application of potential differences across the resistance. In general the resistance of selenium decreases after closing the circuit as it does in crystal contacts. According to Pierce if (Phys. Rev. borundum and then in the same manner the voltage is decreased, it is

*Streintz and Wellik Phys. Zeits loc cit.

found that the same ratio does not exist between volts and amperes in the two instances. The current is larger after the maximum voltage has been applied. Pierce describes it as a slow building up of the current. In a later paper he quotes Braun on (Phys. Rev. 29, p. 478, 1909) the subject, in part as follows: "I obtained in general the phenomena that the cur-25 p. 36, 1907) first voltages increasing step by step, are applied to car-rent strength was different for different directions of the current; and that this difference increased with increase of the current, and then on keeping the circuit closed, the current for that direction in which the resistance was smaller increased, while for the opposite direction it decreased."

With selenium the usual occurrence is for the resistance to decrease with the time of flow of the current but this is not always true. In a former paper (Phys. Rev. 33, p. 21, 1911) I gave results which showed first an increase followed by a decrease of resistance for a high voltage. This held only with the selenium in the Giltay cell.

THE EFFECT OF AMALGAMATION.

It was first observed by Moss (Proc. Roy. Soc. XXV, p. 22, 1876, and Nature 77 p. 198, 1908) that mercury decreases the resistance of selenium in a rather peculiar manner. A small amount of mercury according to him forms a film over the crystals of the selenium and renders the cell thereby quite conducting. More recently Minchin contended with the same effect under other circumstances. A certain selenium cell had a resistance of $61x10^6$ ohms in the dark at atmospheric pressure. (Nature, 77 p. 222, 1908.) In a vacuum with a partial pressure of mercury vapor the resistance fell to 17.5 ohms in 12 hours. More recently the author has outlined the extent and the (Phys. Rev. Ser. 2, Vol. 2, p. 153) probable nature of the action of mercury vapor on selenium. However the important feature in this connection is the remarkable increase of the conductivity, and the light-negative characteristics called forth by the mercury.

Likewise if amalgamated surfaces are brought in contact with certain crystals the contact resistance of the crystal disappears almost entirely, and only the resistance of the crystal itself may remain. Streintz and Wellik* call attention to a magnetite crystal which had a resistance of 0.17 ohms under a pressure of 3000 gms when the contacts were of gold. The resistance of this specimen fell by using gold-amalgam contacts from 0.17 to 0.008 ohms. This result is also typical of what is obtained by

*Phys. Zeits, 12 p. 845, 1911.

using amalgamated surfaces, according to Koenigsberger, Reicenheim and Schilling.* But we can not be certain that mercury acts in the same way in selenium that it does with other crystals. If a small globule of mercury is put on a crystal surface* the contact resistance will not be destroyed. It is probable that the surface tension of the mercury keeps the globule from making the intimate contact that is made by the amalgam under pressure. A gold electrode in contact with a crystal of galenite had a resistance of 50 ohms with 150 gms pressure. After the gold was amalgamated the resistance was .067 ohms with 150 gms pressure and .057 ohms with 1224 gms. The change of resistance with pressure and with the current is comparatively very small after amalgamation. This together with the fact that the change of resistance by pressure is greater than the resistance of the crystal itself, furnishes almost a conclusive proof that the pressure effect and the current effect is of the nature of a change of resistance at the point of contact with the crystal.

In selenium the mercury vapor forms mercuric selenide. Whether it is this selenide or the free mercury molecules or semi-free molecules in the selenide, that makes the light conductivity can not be definitely settled yet. However, if we take amorphous selenium and let the mercury vapor act on it, we obtain almost as high a conductivity if only about one per cent of the selenium is acted upon as we do if the entire quantity of selenium is transformed into selenide. This is very much in favor of the presumption that it is the free or free acting mercury molecules that is responsible for the very high conductivity. The speculation that we may find it convenient to make is that mercury in a finely divided state may bring about the same action in crystal contacts that it does in selenium. The presumption is based on the apparent similarity of the effects.

THE EFFECT OF ABRASION.

In two earlier papers* I have described the effect of rupturing the surface of light-sensitive selenium by abrasion. The immediate effect of the abrasion is to increase the conductivity. This effect is likewise duplicated in crystal contact resistance. I may quote from Flowers,* "A crystal having a rectifying surface was often found to have other rectifying surfaces underneath and parallel when the layers were split

*Phys. Zeits, 12 p. 11, 39, 1911.

*See paper by Alan E. Flowers on crystal and contact rectifiers, Phys. Rev. 29, p. 451, 1909.

*F. C. Brown, Phys. Rev. 34, 201, 1912, Phys. Zeits. 1912.

*Phys. Rev. 29, p. 453, 1909.

off, but scratching or scarring a rectifying surface usually spoiled more or less completely its rectifying properties. In order to destroy the rectifying properties, the resistance must have changed in one direction or the other.'' However, he does not state whether mutilation increased the resistance that was least or decreased the resistance in the direction of largest value. I assumed that he meant the latter. However, in order to be more certain I experimented with a crystal of galenite which had slightly greater resistance in one direction than in the other. I rubbed one contact surface quite vigorously with rouge on chamois cloth. This caused the resistance to decrease about ten times. After several months the crystal did not recover from this abrasion, but no doubt it would do so in time.

It is, therefore, obvious that abrasion produces certain very similar results in crystals that it does in selenium.

THE EFFECT OF ALTERNATING CURRENTS.

Alternating currents produce varying results depending upon the light-sensitive selenium and the frequency of the current. Certain frequencies have been noted to decrease the resistance while other frequencies have increased the resistance. Alternating currents produced effects in crystal contacts that might be regarded analogous to those in selenium. However, we should investigate the exact conditions of the phenomena before we can presume as to the likeness of the effects.

THE BREAKING DOWN OF THE RESISTANCE BY HIGH VOLTAGE.

If a very high voltage is applied across a light-sensitive selenium all the resistance breaks down and the light sensitiveness is destroyed. Ordinarily the voltage from the secondary of an induction coil is necessary for this result. Just how much lower the potential might be I am not certain.

In crystal contacts a potential difference of 30 or 40 volts is almost certain to break down the resistance. However, this potential is partly determined by the pressure on the crystal surface and the number of contacts in series. A number of crystals in series approach more nearly to the conditions existing in selenium.

THE ANTIMONITE CELL.

If we could establish like behavior between crystal contact resistances and the selenium cell, when the two are illuminated, we should have a strong presumption in favor of the identity of the two sets of phenomena.

But thus far I have not been able to detect any change of resistance in crystal contacts because of any direct or even indirect action of light. At present my hope is that I may find some crystal or crystals that change form or volume under the action of light. If such are packed among small crystals that show resistance because of the surface contacts, then we should have a variation of the resistance of the mixture by illumination by virtue of the change of pressure. Theoretically we should be able to produce in this way an approximate working model of a selenium cell.

It may be that W. S. Graepenberg has duplicated the action of the selenium cell in his antimonite, a mixture of antimony and sulphur. By properly cleaving these crystals he is able to produce a light-sensitive cell. The resistance is apparently like that in ordinary crystal contacts in that the resistance exists between a gold foil and the surface of the crystal. The crystal is illuminated through the gold foil. This cell structure is about as sensitive to light as the selenium cell and it seems to have all the properties common to both selenium and crystal contacts. But so far as I am at present able to judge, it is only surmised that antimonite crystals bridge over the gap. If we should find definitely a crystal or crystal mixture which was known to be light-sensitive like selenium and at the same time know that its resistance depends on contact surfaces, we should have a new and very simple approach for explaining the complex behavior of selenium. A curve showing how the resistance of the antimonite cell varies with potential difference is given in fig. 3. This is strikingly similar to such curves for selenium and elementary crystal contacts.

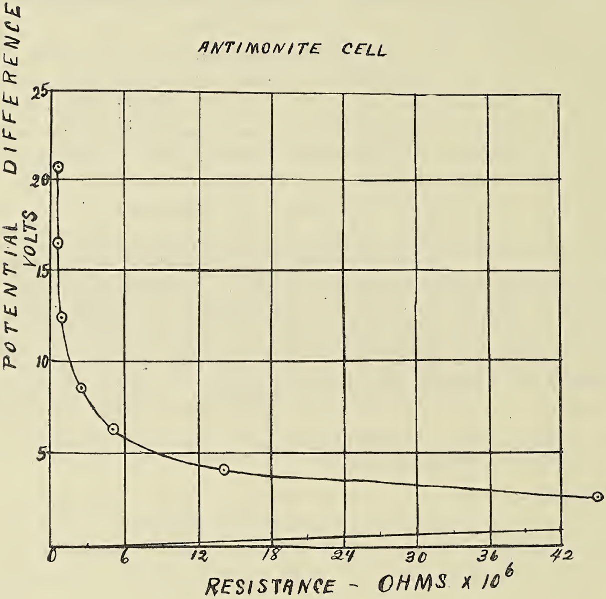
ANTIMONITE CELL
POTENTIAL DIFFERENCE
VOLTS
25
20
15
10
5
0
6
12
18
24
30
36
42
RESISTANCE - OHMS x 10^6

Fig. 3

A PRACTICAL ELECTRICAL METHOD OF MEASURING THE DISTANCES BEWTEEN PARALLEL CONDUCTING PLANES, WITH APPLICATION TO THE QUESTION OF THE EXISTENCE OF ELECTRON ATMOSPHERES.

BY F. C. BROWN.

In the Philosophical Magazine for August, 1912, Professor R. W. Wood raises the interesting question concerning the existence of conducting atmospheres surrounding metallic surfaces. The necessity for this hypothesis arose from a number of experiments, in which electrical conduction took place between metallic surfaces, when they were separated between 20 and 30 wave lengths of sodium light. The result appeals to the imagination but it is not easy to reconcile it with the well known experiments by Earhart,[1] Hobbs,[2] Kinsley,[3] Almy,[4] Williams,[5] and others who found using interferometer methods that there was good insulation when the conductors were much closer than the distances observed by Wood. Perhaps the argument may be urged against the interferometer methods that no allowance was made for a possible deformation of the metallic surfaces under the electrical stresses, nor have such methods as used been infallible in detecting the absolute point of contact between the surfaces.

And Wood's experiments considered alone do not seem consistent with the electron atmosphere hypothesis, for such an atmosphere should extend out the same distance from the surface regardless of the insulating material between those surfaces, particularly so when the material is in discontinuous sheets. His results should not have shown a greater variation than the variation of his optical flat from that of a true plane.

I have tested out an electrical method for measuring small distances in order to gain information toward explaining the above discrepancies. I have found the method useful and the application interesting. The

[1]Phil. Mag. (6) 1, p. 147, 1901.
[2]Phil. Mag. (6) 10, p. 617, 1905.
[3]Phil. Mag. (6) 9, p. 692, 1905.
[4]Phil. Mag. (6) 16, p. 156, 1908.
[5]Phys. Rev. 31, p. 212, 1910.

application can be most readily understood, after the method has been explained.

The electrical method of measuring the distance between two plane conductors is based on a measurement of the electrical capacity which the two planes possessed by virtue of their nearness. For small distances such as I used the distortion of the lines of force at the edge of the planes was so small that no appreciable error accrued therefrom, and the capacity of the connecting wires and the upper plane isolated was only from three to five units and could be corrected for or neglected. This method involves the elementary but fundamental and absolute formula,

$$C=S/4\pi d \quad (1)$$

where C is the electrical capacity of the two neighboring surfaces of area S, and, d, is the distance between the electrical charges on opposite planes.

Now if it should be revealed that the distance between the opposite electrical charges is the same as the distance between the mechanical surfaces, then obviously it should be concluded that within the accuracy of measurement the electrical and mechanical surfaces are identical. In other words the identity would establish that an electron atmosphere does not extend beyond the mechanical surface. The question as to whether both negative and positive atmospheres exist need not be considered at this time.

The capacity of two parallel plates can be measured readily to a satisfactory degree of precision by the method of mixtures. I used a Dolazaleck electrometer of 20 e.s.u. capacity for comparison capacity and also for measuring the necessary potentials. The procedure was first to charge up one pair of quadrants to a potential V_1, represented by a deflection of the needle, D_1. The quantity of electricity on the needle was then allowed to distribute itself between the electrometer of capacity Ce, and the parallel plates of capacity C. The resulting potential V_2, gave a deflection D_2. As usual the capacity of the parallel surfaces is,

$$C=\frac{Ce\ (D_1-D_2)}{D_2} \quad (2)$$

Substituting the value of the capacity in equation (2), the distance between the conducting surfaces is obtained in the form

$$d=S.D_2/4\pi Ce\ (D_1-D_2) \quad (3)$$

Because of the low capacities to be compared this method requires a high degree of insulation for all the parts. But I have been very much surprised to find how easy it is to obtain almost perfect insulation when the neighboring plates are separated by only a few wave lengths of light. The only precaution thus far found is that the insulating material should be free from moisture and impurities. In general if material once dried out is kept a few degrees above the atmospheric temperature, trouble due to moisture will be avoided. But for very thin insulating material hours of heating may be required, so that it may insulate properly the conductors which it separates.

In these experiments I measured the distances between planes when the resistance was of the order of 10^{12} ohms, whereas Wood measured the distances when the conductivity could be measured by a galvanometer and a milli-ammeter. Naturally then I should have expected to work with planes separated farther than 20 or 30 wave lengths, but I was a little surprised to find almost complete insulation at one or two wave lengths, when the precautions mentioned were taken.

In 1908 (Phil. Mag. (6) 18, p. 649) I obtained insulating films which were only about 10^{-6}cm. thick. This is nearly a hundred times less than certain minimum insulating distances obtained by Wood. One of Wood's experiments indicated that a coating of oil did not interfere with the conductivity. So I tried first a film of turpentine. I evaporated a film of turpentine at high vacuum and allowed it to condense on a highly polished brass surface. After condensation I was able to bring up in vacuum a globule of mercury from below. The globule of mercury when earthed and brought up to the film altered the capacity of the electrometer system by the amount of the condenser formed. I was able to obtain by this method insulating distances of about 6×10^{-5}cm. As I was unable to measure the film thickness by a check method, it was not safe to conclude that the electron atmosphere did not extend into the turpentine.

The first experiments were made with conducting planes of hardened steel. They were made and polished by our instrument maker, Mr. M. H. Teeuwen, but the surfaces were not tested at the time optically for planeness, and the miscroscope showed them not to be free from scratches. However at the conclusion of all my experiments they were tested and found to vary from a plane by less than two wave lengths. The area was about 1.8 sq.cm.

The two planes were separated by sulphur particles collected from an air suspension. Somewhat more than a thousand particles covered the surface of one of the plates, of which about 20 were larger than 0.007cm. as seen by the microscope. When one of the plates was laid on the other there was complete insulation, i.e. when the condenser was charged the potential did not vary noticeably in five minutes. The observations are shown in the following table:

Approximate potential across sulphur particles. Volts	4.3.4	3.4	1.8	0.6
Zero reading of electrometer, D_1	186	186	186	186
Reading of electrometer when charges are mixed, D_1	310, 329, 313,	286, 289, 286,	245, 247,	205, 201, 201
Reading of electrometer when charges are mixed, D^2	228, 237, 234,	225, 223, 226,	205, 206,	192, 193, 192
Capacity, e. s. u.	36	32	40	28
Mean distance				0.0044cm.

These results indicate that the electrical method gives a shorter distance than the diameter of the sulphur particles, but it was not certain if the few largest surplus particles might not crush or give or roll into the scratches under the pressure of the upper plate. Further it was not clear what action so many small particles would have on the dielectrict constant of the intervening space.

Because the sulphur particles were not uniform in size and possibly not rigid, together with the difficulty of ridding of the moisture, I decided to try quartz fibres. A small fibre was broken into two parts and placed between the two surfaces. It was a day in early May when the humidity was low, and the fibres were not previously heated, except in the oxygen flame when blown. Nevertheless the insulation was regarded as perfect. The following are the observations with these quartz threads separating:

Approximate potential between plates, Volts	2	0.9
D_1	320, 319, 317,	242, 245, 245, 244, 245
D_2	209, 208, 208,	195.5, 196, 195, 197, 195
Capacity	100	103
Corrected capacity	97	100
Mean distance		.00151cm.

Now the size of the quartz fibres separating the planes as determined by the micrometer eyepiece on the microscope was

$$.00165 \pm .000086 \text{cm.}$$

This difference between the distance then varies by only about two wave lengths. But I found later in reading the size of fine fibres by the microscope, that it was much easier to err by obtaining values too large than too small. This experiment then leads to the conclusion that if there be a conducting atmosphere, that it must not extend out more than two wave lengths.

Obviously the conclusion just arrived at is inconsistent with Prof. Wood's experiment where he obtained a current of several milli-amperes when parallel planes were only five wave lengths apart. I therefore thought it advisable to repeat the experiment using smaller quartz fibres, this time three in number. The sizes were, first, .00052cm : second, .00053 ; third, .00059 and the mean probable distance of separation was therefore .00056cm. The electrical method by the mean of five observations, with 0.3 volt across condenser, gave a separating distance of .00054cm.

There are two conclusions that should be drawn from this experiment. First there was almost perfect insulation when the two planes were separated by only ten wave lengths and second the conducting atmosphere could not have extended as much as two wave lengths outside the mechanical surface.

A further attempt to repeat the above experiments with yet finer quartz fibres met with failure owing to unsatisfactory insulation. I did not try heating the quartz fibres at this time because I feared that it was steel surfaces might vary by ten wave lengths. I observed that it was impossible by the electrical method to obtain insulation at distances less than those measured by the microscope. Unless some unknown factor is involved this observation obviously leads to a third conclusion, which is that conduction at short distances arises from conducting material and not from an electron atmosphere of unvarying depth.

The question as to the imperfect insulation at less than 9 wave lengths was still unanswered. Possibly the insulating properties of certain dielectrics break down when a certain minimum thinness is reached. It was thought that a constant minimum thinness for any given material would strengthen this view. Or perhaps as Wood suggested moisture films about small particles might readily explain the imperfect insulation if not also the high conduction. We shall recur to this point in a succeeding paragraph. But the most opportune explanation, whose plausibility should be considered, was the possible irregularity of the steel surfaces.

The question of the planeness was answered in two ways. First a glass plate with plane sides was moved over the surface of the plates, and the character of the interference fringes noted. By this test the extreme variations of the surface was not as much as two wave-lengths.

Second two optical flats on speculum metal were obtained, whose surfaces by optional test did not vary from a plane as much as one wave length. With these my surprise was certainly great when I found imperfect insulation when the surfaces were separated by quartz fibres of 24 wave lengths diameter. As my supply of quartz fibres, and also of oxygen was exhausted, I now turned to the use of mica flakes for insulation material. First when a continuous sheet of mica of 25 wave lengths separated the flats the insulation was imperfect. If charged to a potential of 4 volts, three-fourths of the charge would leak off in 10 seconds, but by thoroughly heating the plates and the mica over an electric oven the insulation became quite perfect. This was more than a month after my experiments with the iron surfaces, and I now found it quite impossible to obtain good insulation without heating the plates and the insulator. Presumably the excess humidity was the trouble.

In one instance the speculum surfaces were separated by three mica flakes of total area about 5 mm^2. By the microscope one was about 14 wave lengths, the second 12, and the third was lost. When the electrometer was charged to +5 volts and mixed with the speculum condenser the capacity was 310 cm, and when it was charged to —5 volts the capacity was 315 cm. The total pressure on the upper plate was about 50 gms. From this capacity was subtracted 59 units as a correction due to the added capacity due to the mica flakes and to the plate aside from its condenser action. The area of the plates was 1.84 cm^2. The distance between the surfaces was therefore calculated to be .00060 cm. It seems safe to conclude from this experiment that the difference between the electrical and optical methods is not more than three wave lengths.

It was observed that if the pressure on the plates was increased to 100 gms. that the insulation became very poor. Sometimes the insulation would be restored by removal of the pressure and sometimes not. However, increased pressure did not always alter or destroy the insulation.

Again three very thin mica flakes were selected. By direct reflection they all appeared a brilliant green, but when viewed by the light that struck at a very large angle of incidence some of them appeared orange colored. With these flakes between the flats the speculum slid over each other freely as if nothing was between, and likewise they resisted pulling apart. The resistance between the plates was very low, although I did not measure it. Continued heating with the two plates together did not restore the insulation, although the mica had been heated for hours before the flakes were separated off the sheet mica.

Then the plates were separated and heated for two hours over an electric oven. The temperature of the plates was kept at about 215°. The mica flakes stuck tight to the plates during this procedure, although some of them did break in pieces. By this the insulation was made almost satisfactory, as may be seen from the following observations. It was necessary to determine the deflection from the first few swings of the needle. The period of the electrometer needle was about 10 sec.

	Pressure 90 gms.				30 gms.				
Zero	0	0	0	0	00	0	0	0	
D_1...	+33	+33	—43	—43	—82	—83	—80	—80	
D_2...	1	1.5	— 2	— 1.5	— 3.5	— 3.5	— 3.6	— 4.0	after 10 sec.
								— 3.2	after 20 sec.
								— 2.2	after 30 sec.
Mean of D^2 1.5									
					Mean 3.65				
					Corrected mean 4.45				
Distance			.00031 cm.					.00043 cm.	

Since heating the mica and plates to 215° had made the insulation so nearly satisfactory, it seemed wise to repeat this treatment. The plates were kept covered with japanese silk tissue to prevent dust particles from settling on the plates. After six hours the plates were removed while hot and tested at once. The insulation was not perfect but it was improved and at the same time the capacity was larger. At the beginning of the test the natural leak was such that the electrometer needle went from 3 div. to 1 div. in 50 sec. At the end of the observations the natural leak was from 2.7 to 1 in 20 seconds, from 1.0 to .5 in 30 sec., showing that the insulation deteriorated with time, possibly owing to the formation of a moisture film as the plates cooled. The natural leak was corrected for in calculating the distance. The following observations were obtained before the insulation deteriorated seriously:

Zero	0	0	0	0	0	0	0	0	0	0	0	Mean	
D_1	32	32	32	—81	—81	—82	—82	—82	+83	+83	—82		
D_2 10 sec.	.25	.5	.5	—1.0	—1.25	—1.3	—1.25	—1.0	+1.0	+.8	—1.25	1.1—	.14
20 sec.				—.5	—1.25	—1.0	—1.0	—.85		+.4	²1.0		

Mean corrected 1.4.
Capacity 1170.
Distance, cm., .00013.

I was not able by the microscopic method to determine the thickness of the mica flakes, further than to limit their probable size to less than five wave lengths. This much also was determined by a micrometer screw gauge. Then interference fringes were formed by bringing two optical flats on glass into contact along one edge and allowing the opposite edges to be separated by the mica flake. The number of fringes between the point of contact and the mica obviously gives twice the thickness of the mica in wave lengths. However, the great difficulty in this measurement was that sometimes considerable pressure had to be applied in order to bring the plates into contact at one edge, much greater than was applied to the speculum metal plates. However, there was considerable irregularity in the pressure required to cause contact, and it may have been that after heating the speculum metal plates were separated only by the thickness of the mica. At any rate one of the mica flakes measured two and a half wave lengths, another one two, and a third one only one wave length.

I observed after the second heating that the mica flakes on speculum surfaces showed the same deep green color that they exhibited when free. This rather indicates close contact between the mica and the speculum. Also the fact that long continued heating permitted the electrical charges to become closer together, when separated by mica, indicates that heating either drives off something that conducts and separates, or alters the structure of the surfaces. If the mica flakes were in contact with the speculum, then there can be no conducting atmosphere of more than two wave lengths of light, for this I regard as about the safe accuracy of my experiments, but if on the other hand there exists a conducting atmosphere which is at the same time a mechanically separating medium, then it would not be safe to set such a low limit on the thickness of a possible electron atmosphere. The question will not be definitely settled until the distances are measured simultaneously by the two methods. We propose to do this by using very thin films of platinum deposited on plane glass surfaces. It is hoped thereby to finally decide to a fraction of a wave length whether or not an electron atmosphere exists, and also to obtain information on the role played by insulating materials of small dimensions.

Inasmuch as heating certain insulators such as mica and quartz restored their insulating properties, it is certain that the conduction obtained by Wood at such long distances was due to the presence of the insulating material, and it is presumed that moisture films and conducting particles were responsible for it.

In conclusion it may be said that while the electrical method was satisfactory as here used, it can be more accurately adapted to the problem in hand by more suitably choosing the suspension for the electrometer needle and by using a larger capacity in parallel with the electrometer.

The State University of Iowa.

THE USE OF THE RAYLEIGH DISK IN THE DETERMINATION OF RELATIVE SOUND INTENSITIES.

By Harold Stiles.

In the second volume of his Theory of Sound, Lord Rayleigh presents a method for determining mathematically the intensity of sound at very great distances from a rigid sphere, the source of sound being confined to a small area on its surface. Prof. G. W. Stewart* has extended the work of Rayleigh and has calculated the relative sound intensities for sets of points lying on circles concentric with the sphere, the planes of these circles also passing through the source of sound. The points on any one circle were 15 degrees apart and the diameters of the four circles used were respectively 2, 3, 4, and 5 times the diameter of the sphere.

During the summer of 1912 at the State University of Iowa, Prof. Stewart and myself undertook to verify experimentally the theoretical determination and to test the Rayleigh disk as a means for determining relative sound intensities.

Although Rayleigh suggests the possibilities of the disk, we were unable to discover any report of its use in the actual determination of sound intensities in the open. A modification of the Rayleigh disk apparatus which we used consisted of a brass tube 5 cm. in diameter and in length about three-fourths of the wave length of the sound produced.

The tube is drawn to scale in Fig. 2. At the point t is located a thin paper diaphragm one-fourth of a wave length from the open end of the tube. In the constricted portion B a circular mirror 6 mm. in diameter is delicately suspended by a quartz fiber so as to make an angle of 45 degrees with the axis of the tube. Light from an illuminated scale passes through a small window at B and is reflected by the mirror along the axis of the tube through another window at C to the observing telescope. Alternating currents of air in the resonating tube deflect the disk, the deflection being proportional to the energy.

*Phys. Rev. vol. XXXVIII, No. 6, December, 1911.

Fig. 1 shows the sphere and tube mounted near the edge of the roof of the new Physics building about 75 feet above the ground and no other buildings within several hundred feet. The roof in the neighborhood of the apparatus was covered with ¾ inch hair felt. The sphere was constructed of cement, the wall being about 5 cm. thick. The sound was produced by an electromagnetically operated C fork placed in a funnel from which the sound was conducted along the roof through a pipe 25 feet long to the vertical pipe shown in Fig. 1. A watersealed joint at L made it possible to rotate the sphere about a vertical axis. A set of observations was made by placing the sphere so that the opening was turned away from the Rayleigh disk tube and then rotating it through 180 degrees until in the position shown in the figure, readings being taken for each 15 degrees. The results were then plotted as shown in figures 3 and 4, the curves indicating the theoretical values and the small circles the experimental results. These results are from single sets of observations and not the average of several.

The chief sources of error in the experiment were the inconstancy of the tuning fork, the absorption of energy by the resonating tube, and air currents which tended to disturb the disk. It is quite possible that the experiment may be performed under more favorable conditions, giving even closer agreement between the experimental and theoretical values.

The results already obtained seem to indicate that the Rayleigh disk may prove to be very useful apparatus in the determination of relative sound intensities. A more complete account of the experiment may be found in the Physical Review, Vol. 1, No. 4, April, 1913.

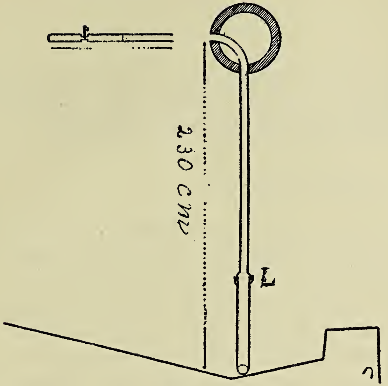

Fig. 1.

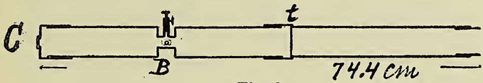

Fig. 2.

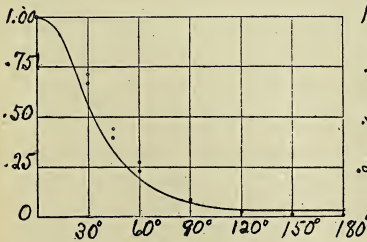

Fig. 3.

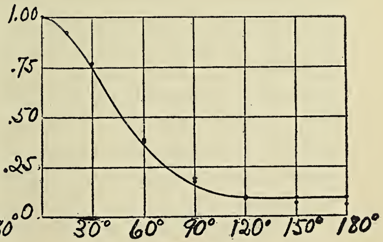

Fig. 4.

AN EXPERIMENTAL INVESTIGATION OF THE RELATION BETWEEN THE APERTURE OF A TELESCOPE AND THE QUALITY OF THE IMAGE OBTAINED BY IT.

By Fred Vorhies.

The subject of telescopic vision was presented to the scientific world a few years ago in a series of articles written by Dr. G. J. Stoney.[1] At that time Dr. Stoney discussed the proposition as applied to the vision of distant planets and drew the conclusion that astronomers were not able to detect certain details upon the planet Mars. Since the appearance of this series of articles a considerable discussion has taken place but no definite conclusions have been drawn.

With these things in mind I set up in one of the physics research laboratories of the State University, apparatus designed especially for the purpose of investigating the effects that we get when viewing an illuminated surface through telescopes of different apertures. It is understood that the focal length of the lens is not important if the magnification is sufficient.

For the purpose of clearness and simplicity, I made the following assumption which I later proved, experimentally, to be correct. In looking at the planet Mars, or any illuminated surface the same effects are obtained, whether we illuminate the surface from in front with diffused light or whether we remove the object and place in its stead a transparent object with the same details painted upon it and illuminate this new object from behind.

Taking it for granted that the above assumption is correct, let us imagine that the planet Mars is removed and in its place a transparent object is located. In order to simplify matters still more let us illuminate this transparent object from behind with a point source of light, instead of with an infinite number of point sources, as we have in diffused light. If we then imagine a large lens placed in front of this transparent object we shall be ready to consider the different effects that appear. The lens is introduced for the purpose of analysis and has no effect on the image. This lens will focus the image at some definite point. If we should imagine this light after it has been focussed we would find that it consists of a central bright spot surrounded by a

[1] Philosophical Magazine vol. 16, 1908.

series of diffraction rings. Allowing this diffraction pattern to fail within a telescope we find that it gives us an image of the illuminated object. Airy investigated this diffraction pattern and gave us a formula for measuring the diameter of these rings.[2] Since most of the light is contained in the central bright spot and the first five diffraction rings, we shall make use of this particular number in our discussion.

In order better to understand the last paragraph let us refer to Fig. 1. Light from the monochromatic illuminator M, is focussed by lens L_1 upon the pin hole S. The lens L_2 focusses this pin hole upon the aperture A, and provides the light for an image of object O in the camera or telescope C. If we wish to use diffused light from the back, S is replaced by a carbon lamp which has a ground glass in front of it. If we wish to illuminate O from in front, the lamp can be moved to the position R, which is in front and a little to one side of O. In the last case as a matter of convenience, it is well to remove the lens L_2.

Now Airy's formula for the radius of the fifth diffraction ring is Sin $y=2.621\Delta/r$ where y is the angle of diffraction, Δ the wave length of the light used, and r the radius of the lens casting the image of the point. Since the radius of Mars is about 2,100 miles, we have Sin $y=2.621 \times .000055/2100$ where .000055 cm. is the average wave length of light in the visible spectrum. Let X equal the radius of the fifth minimum diffraction ring and we have Sin $y=X/35{,}050{,}000$ where 35,050,000 miles is the closest distance Mars gets to the earth. From these two expressions for Sin y we get the value of X which is 2.406 cm., the radius of the fifth dark ring, or 2X equal 4.812 cm. the diameter of the fifth dark ring for Mars.

If we use a 24 in. telescope, we find that the telescope diameter is 12.66 times as great as the diameter of the diffraction pattern, out to and including the fifth dark ring from Mars.

Taking as the object which represents Mars, a hole 1.05 mm. in diameter, I illuminated it from behind with a point source of light and brought this light to a focus with the lens L_2 as shown in Fig. 1. Focussing a lens on the point where this light was focussed I was able to study the diffraction pattern, and by means of a scale on the lens, I measured the diameter of the fifth ring. This observed value was 6 mm., a value a trifle smaller than that computed for these conditions.

If the telescope aperture is 4 mm. in diameter, the diameter of the fifth diffraction ring admitted should be 4/12.66 which equals .3159 mm. Reasoning from this, .3159 : 6 :: 1.05 : X and X equals 1.994 cm. which

[2] Wood's Physical Optics, p. 237.

is the diameter of the object which is to represent Mars. This value was so near to an even number that I made the object which I used 2 cm. in diameter. We are told that Astronomers are able to detect certain so called "canals" upon Mars which vary from twenty to sixty or seventy miles in width. To represent these I used wires of suitable dimensions and placed them in such shapes that they formed patterns which could be studied in the different photographs which I later took.[3]

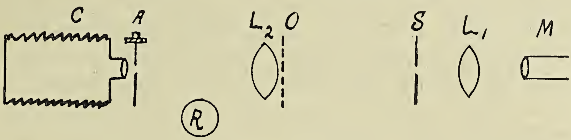

Fig. 1.

The apparatus in its final form is shown in diagram in Fig. 1 and in the photograph, Fig. 2. To the right and not shown in the picture is a large box containing an arc light. Light from this is passed through a lens in the front of the box and is focussed after reflection by a mirror onto the slit of the monochromatic illuminator which appears to the right. From the illuminator green light of .000055 cm. wave length passes through a lens and is focussed upon a pin hole. This in turn acts as a final light source and illuminates the object which is mounted upon the optical bench. Directly in front of this object and on the same support is a large acromatic lens which focusses the light from the point source upon the camera aperture to the left of the figure. The camera in this case taking the place of a telescope. The aperture of the camera is separate from the camera itself and is mounted upon a support which has a micrometer screw attached. This permits a motion of the aperture and thus enables me to admit any portion of the diffraction pattern that I wish.

To get the effects of a smaller sized telescope, all that is necessary, is to remove the 4 mm. aperture which is made in a plate of tin, and replace it with a smaller opening. In my work a 4 mm. aperture represents a 24 in. telescope; 3 mm., 18 in.; 2 mm., 12 in.; 1 mm. 6 in.; and .4 mm., 2.5 in.

Fig. 3 is a series of photographs which show not only the different effects that we would get in looking at an object optically similar to Mars with telescopes of different sizes but also gives an analysis of the image. Nos. 1-9 form a series taken with a 24 in. telescope. No. 1 was

[3]Because of a slight error in my calculations the apertures used are about seven per cent too small.

taken with the diffraction pattern directly in the center of the camera. The rest were taken by moving the aperture of the camera 1/2 mm. to one side each time. This means that the central bright spot was not in the camera when Nos. 5-9 were taken. You will notice that the lines have changed from black to white and that some of the original single ones now appear double. This is simply a diffraction effect that we would expect to get under these conditions. No. 1 was taken under the best possible conditions and is a better image than can be obtained in actual observations of Mars or of my substitute for Mars. I have chosen to call this an optimum image. Now if we had used diffused light instead of light from a point source we would have obtained the sum total of an infinite number of images like the ones shown in this series. To investigate this point I made a composite picture of the first nine by making all of these exposures in one place instead of moving the plate as I had done before. From this exposure I obtained No. 10, which you see is not as good as No. 1. Realizing, however, that I had over emphasized the poorer images in this series by longer exposures, I made No. 11 which is also a composite picture of Nos. 1-9. In this case I exposed the plate one minute for each one of the nine different exposures. This picture is equivalent to one obtained with diffused light and is almost as good as No. 1. From this I drew the conclusion that under normal conditions one should be able to see such details as those of the dimensions I had chosen, upon the planet with a 24 in. telescope.

Nos. 12-20 form another series taken under the same conditions as the first series, except that the equivalent of a 12 in. telescope was used. While in the second series the optimum is very good we see that the images rapidly fall off in distinctness and that where above we have five good images and four poor ones, we now have two good ones and seven poor ones. The total composite, No. 21, is very poor while No. 22, the normal composite, is fairly good. It is quite evident, however, that No. 22 is not as good as No. 11.

Nos. 23-27 form a series of optima made with telescopes of 24 in., 18 in., 12 in., 6 in., and 2.5 in. respectively. While these images are better than can be obtained in actual practice they do show an interesting point. It is quite evident that the larger telescopes are the more efficient.

Nos. 28-32 and 33-36 were taken with the above telescopes with diffused light from the back, and reflected light from the front, respectively. These images give us an idea of what we should expect in actual observation work and they correspond to telescope apertures given for the images immediately above them, from Nos. 23-27. The main point brought out by these is the fact that there is no difference between those taken with the diffused light from behind and those illuminated from the front. This is an important point for it proves the assumption which I made early in the paper.

As I have already explained, this diffused light from the back was obtained by placing an incandescent light covered with ground glass, in the place of my point source. To get the illumination in front, I moved this light in front and a little to one side of the object, removed the lens, and placed just back of the object a piece of white card board which acted as a background. The removal of the lens did not change the optical conditions in any way.

You will notice that what would have been No. 37, which would have been taken with reflected light with the 2.5 in. telescope is missing. I made several attempts to get this picture but could get no effects. I made one exposure of eighteen hours but got no fogging of the plate.

After making one hundred forty different exposures and studying them carefully I have come to the conclusion that astronomers can see, without question, certain details upon the planet Mars. While I do not have absolute evidence, yet I also believe that there is very little advantage in using a telescope larger than twenty-four inches for obtaining details of objects as large as 20 miles across.

For fear that I may be misunderstood I want to say that I have not taken into account the different atmospheric conditions with which the astronomer has to contend. I wish to state also that this investigation does not apply alone to the planet Mars but may be applied to the study of any illuminated surface.

My work is by no means completed. I expect to continue by investigating smaller details upon my object and by varying the atmospheric conditions and noting the effects produced.

In closing I wish to express my thanks to Dr. L. P. Sieg for the valuable advice he gave me during the course of my work and for the assistance he rendered on many occasions.

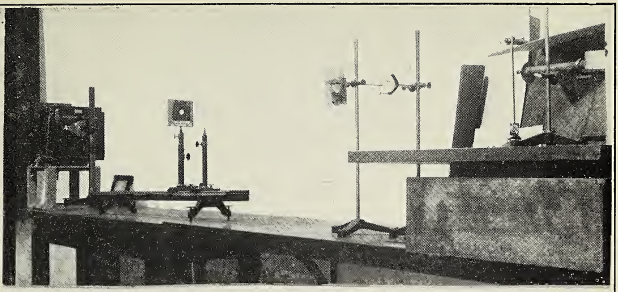

Fig. 2.

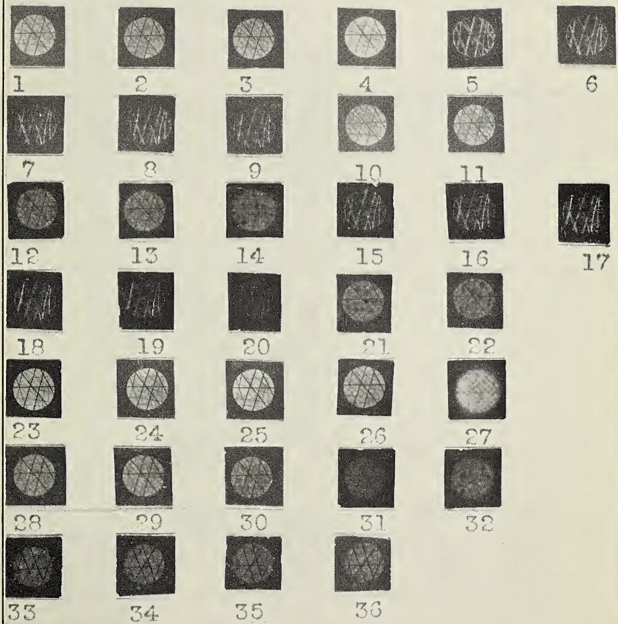
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Fig. 3.

ON THE EXISTENCE OF A MINIMUM VOLUME IN SOLUTION.

By LeRoy D. Weld.

This research has for its general object to inquire into the physical condition of substances in near-saturated aqueous solution.

The subject was attacked by means of experiments at different temperatures on the *apparent specific volume in solution;* by which is meant, the volume of that amount of solution which contains one gram of the solute, minus the natural volume of the water contained therein. This quantity is always somewhat less than the volume of the solid solute.

The experiments were made upon the sparingly soluble salt, potassium chlorate, dissolved in water at ordinary temperatures, by means of a specially designed pyknometer and thermostatic apparatus, and by employing special precautions against errors due to evaporation, unequal heating of the balance, etc.

The results are of surprising interest, as they clearly indicate the existence of a minimum specific volume (maximum density) in the dissolved substance itself, in the near vicinity of the saturation point, which is very strongly suggestive of the maximum density of water just above its freezing point. The minimum volume of the potassium chlorate occurs slightly below its saturation temperature, that is, when slightly supersaturated; this is attributed to the presence of the water, just as the presence of a solute in water may bring the minimum volume temperature of the latter down below freezing, the impure water being then supercooled. The greater the amount of water present, the farther is the minimum specific volume point of the dissolved potassium chlorate found to be below the saturation temperature, which is also in agreement with the behavior of impure water. Special observations were made to detect the slightest trace of crystallization in the supersaturated solution, without success; while, to account for the results on this supposition, it would be necessary to assume that fully one-fourth of the chlorate had crystallized. The writer believes these results indicate a true minimum volume, analogous in all respects to that of water at four degrees centigrade.

Further experiments are in progress, and it is expected that a detailed account of the work will be duly published in the proceedings of the American Physical Society.

ON CERTAIN POINTS IN THE ANATOMY OF SIREN LACERTINA.

BY H. W. NORRIS.

In connection with a study of the distribution of the cranial nerves of Siren, the results of which will be published in the near future, the writer found certain features of the general anatomy that seem worth especial notice.

Vaillant (1863) in describing the muscles of the head in Siren mentions "l'abducteur de la machoire supérieure," a small muscle said to be inserted in part upon a small bone believed by Cuvier to be a maxilla. The writer has not had access to this paper on Siren by Cuvier, but has made use of the reproduction of his figures by Hoffman (1878). Fischer (1864), Wiedersheim (1877) and Wilder (1891) have not been able to find either the muscle mentioned by Cuvier and Vaillant or the small bone on which it was said to be inserted. Parker (1882) mentions and figures two "small seed-like centers opposite the middle of the premaxillaries" as maxillaries, but he says nothing of muscles connected with them. The writer finds in the position described by Parker a minute ossification on each side. This may, however, be larger on one side than on the other, in fact, is wanting altogether on one side in some specimens. Its minute size, and possibly complete absence on both sides in some instances, may explain the failure of some investigators to find it. It has no muscles connected with it. It probably represents a maxilla, as Cuvier, Vaillant and Parker believed.

In the lower jaw of Siren Wiedersheim describes three skeletal elements, dentale, angulare and meckel's cartilage. Huxley (1878) mentions "a dentigerous splenial element." Parker describes a splenial as "a very delicate, styliform, dentigerous splint." Gadow recognizes a splenial in Siren, but says that "with the exception of small teeth on the vomer the mouth is toothless." The writer finds the operculare (spleniale) as described and figured by Parker, and formed chiefly by the fusion of the bases of teeth.

The writer (1908) described in Amphiuma two muscles having their insertion upon the antorbital cartilage and innervated by a twig of the pterygoid branch of the ramus mandibularis trigemini. Two muscles similarly situated and innervated occur in Siren. In both cases they are evidently derivatives of the anterior part of the pterygoid muscle. In Amphiuma the action of these two muscles, as interpreted by the writer, is such that the movements of the antorbital cartilage are directly related to the position of the eyeball. One of the muscles raises the antorbital cartilage and brings the tip of the latter into contact with the eyeball, thus protruding the eye. The other muscle lowers and draws posteriorly the antorbital cartilage allowing the eyeball to sink in. These two muscles in Amphiuma the writer termed levator bulbi and retractor bulbi respectively, although neither one is directly connected with the eyeball. In Siren a close relation of the antorbital cartilage to the position of the eyeball is not so apparent. But it is clear that the movements of the cartilage are directly related to the opening and closing of the postnaris. The antorbital cartilage extends laterally from its attachment to the orbitosphenoid around the posterior border of the postnaris, then curves anteriorly along the lateral border of the opening. One muscle, that corresponds to the retractor bulbi of Amphiuma, has its origin on the orbito-sphenoid bone (in Amphiuma on the pterygoid cartilage and maxilla) and running anteriorly is inserted on the ventro-lateral border of the antorbital cartilage. As in Amphiuma its action is to pull the cartilage posteriorly and ventrally. This movement from the relation of the cartilage to the lateral valvular fold of the postnaris will open the latter. The other muscle, which has its origin on the side of the orbito-sphenoid (as in Amphiuma) and its insertion on the posterior dorsal part of the antorbital cartilage, by its contraction raises the latter and pulls it somewhat anteriorly, thus closing the postnaris. Fischer (1864) and later Wilder (1891) noticed the relation of the posterior of these two muscles to the lateral valvular fold of the postnaris, but neither detected the other muscle, nor, apparently, determined the insertion of the retractor muscle on the antorbital cartilage. As this cartilage in Siren has no close relation to the eyeball it is hardly appropriate to designate its muscles as bulbar muscles. They are here termed retractor and levator antorbitalis muscles, as they should have been designated in Amphiuma. Their origin, insertion and innervation in Siren point to their complete homology with the muscles in Amphiuma termed retractor and levator bulbi. They evidently do not correspond to any of the muscles described by Bruner (1901) in the Urodela and Anura, which are concerned with the regulation of the size of the opening of the prenaris.

Wilder states that in Siren a "ramus palatinus posterior" of the facial nerve innervates a few of the anterior fibers of the cerato-hyoideus externus muscle. Such an arrangement seems anomalous and calls for a critical examination of the evidence. The writer finds that from the common trunk of the rami palatinus et alveolaris facialis there is given off posteriorly a small nerve, the ramus palatinus posterior of Wilder, which contains among its non-medullated fibers some deeply medullated ones. Most of the latter pass into a branch that terminates in a small vestigial muscle which has its origin on the fascia between the quadrate cartilage and the lateral edge of the parasphenoid bone and its insertion on the lateral border of the ceratohyal cartilage. That motor fibers should occur in a branch of the alveolar and palatine rami seems so improbable that the writer ventures little more than the mere statement of the fact. The muscle concerned is certainly not a part of the cerato-hyoideus externus muscle. It is, however, without exception present in all the specimens examined, but like most vestigial structures varies greatly in the degree of its development. In the larval stage, of which the writer has no material, it is doubtless of some functional importance. A search through the literature on this subject reveals no mention of a muscle in the Urodela similar to this rudimentary one in Siren. Schultze (1892) describes in the larva of the anuran Pelobates fuscus a muscle, m. suspensorio-hyoideus, that has its origin "von der lateralen Randparthie der Unterseite des Corpus suspensorii und des dicht hinter dem Corpus suspensorii folgenden Theiles des Suspensoriums," and is inserted on the "processus lateralis" of the ceratohyal. In the larval condition of Rana pipiens and R. catesbiana the writer finds a similar muscle innervated by a branch of the truncus hyomandibularis facialis.

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HELPFUL AND HARMFUL IOWA BIRDS.

BY FRED BERNINGHAUSEN.

Forty million dollars is the estimated loss annually to the United States on account of weeds, according to Prof. Beal, member of the Department of Agriculture. That a generous share of this loss belongs to Iowa we must all admit, for Iowa is a great agricultural state. Since such is the case it would not seem at all strange if Iowa people should take steps to make this loss as small as possible.

Further than this estimated loss, Iowa has to put up with a loss in crops through insects and their work.

That the loss to the United States and to Iowa through these two causes is as small as it is, is due in a large measure to the presence of helpful bird friends. For the better protection of these feathered friends of the farmer and of all the people in fact, we would solicit your support. Before proceeding further let us look into the details a little more. Here is what Prof. Judd of the Biological Survey has to say. "No less than fifty different birds act as weed destroyers, and the noxious plants which they help to eradicate number more than three score species. Among these are pigweed, knot-weed, thistle and chickweed." Prof. Beal goes on to say that "It is estimated that the tree sparrows of Iowa alone will destroy during the year 875 tons of weed seeds." Wild canaries, and the mourning doves follow in rank as named. Still another government authority, W. L. McAtee, gives the robin a high ranking, especially as an insect destroyer. According to naturalists every bird of the owl family excepting the great horned owl is a helpful bird. Some few people hold that all owls are helpful, others say all are harmful, but such seems not to be the case, at any rate we can see easily enough by the foregoing that "Birds" means money to Iowa.

Knowing then that our financial welfare is to an appreciable extent dependent upon the activities of our bird friends the most natural and expected thing for us to do is to set about means to assist them. In so far as Iowa has game laws and statutes to prevent the slaughter of her native birds, a step has been taken in the right direction, but is this enough? Provision has been made to control the hunter with the gun and dog, but no step has been made to check the destructive work of the feathered foes of our helpful birds. Iowa laws allow these birds to be killed by any random hunter, but no attempt has been made to exterminate them. A small bounty would work wonders in this situation and our helpful birds would soon be rid of their harmful feathered foes.

The two birds most dangerous to the welfare of our seed and insect eaters are the great horned owl and the crow. Other birds frowned ou and much despised by naturalists seem to be the English sparrow and the blue jay.

Concerning the great horned owl let me quote from N. Blenchan in "Birds that hunt and are hunted."

"The horned owl should be extermintaed for it does much harm. Chickens, ducks, geese, turkeys and pigeons on the farm will be decapitated if too large to eat entire, for the brains of the victims are the choice bits that this executioner delights in. Coops and dove cots are boldly entered, entire coveys of Bob Whites destroyed, grouse, wood-cock, water fowl and snipe know no more relentless enemy. Song birds do not escape this stealthy murderer that picks them from the perch as they sleep, and all the rats, mice, squirrels, rabbits and other mammals eaten can not off-set the valuable birds destroyed."

Here then is one bird that is hindering the good work of our helpful birds and we owe it to ourselves to become active at once.

Of all the thieves among our birds I believe the crow holds first rank. Did he do no more than to steal the seed corn the farmer has just planted, we might forgive him, for he is a wise bird, in fact much more so than the owl. But when added to this evil he persists in the habit of carrying eggs from hen's nests and later on even grabbing young chickens, his smartness becomes a nuisance. But even this is not the whole of his work, and I imagine most men have known him to do much more. If he takes hen eggs and very young chicks it stands to reason that bird eggs and young birds are also his legitimate prey, and such is the case, many times have I seen three or four little birds pursuing or driving off this destroyer. Granted that the crow eats some seeds, or some insects and feeds on carrion, he is an enemy of our helpful birds and should meet the same end as the great horned owl. Blue jays are a pest to our good birds for much the same reason as the crow.

One argument set forth as to why the English sparrow should be exterminated is that they are crowding out our native birds. Since such is the case some step towards wiping them out is needed.

One other bird enemy needs special attention and that is the hawk. So many hawks are of value to the farmer because of the mice, rats, and insects that they destroy making it a problem as to just which ones should be exterminated. According to N. Blanchan, and above named authority, four hawks at least deserve to be wiped out. These are the large and the small Coopers Hawk and the Goshawk, and for the protection of our friendly birds especially, the small sparrow hawk should not be spared.

This is but a brief and incomplete survey of the field as to the birds of value and those of harm. Some authorities state that the yellow-bellied woodpecker and the sap-suckers should be exterminated also.

But of greatest important to us just now is the further and immediate protection of our helpful birds. Iowa laws are good, but not good enough. Iowa laws in respect to birds, both harmful and helpful, are merely passive. What we need are laws that result in action, and not until such are obtained will our bird friends be amply protected. The great horned owl, the crow, some of the hawks, the blue jay and the English sparrow and the yellow-bellied woodpecker and the sap-sucker are placed on the black list, hence should be exterminated.

Material for this paper has been taken from:

1. ''Birds that Hunt and are Hunted,'' by N. Blanchan.

2. ''Bird Enemies of the Codling Moth,'' in U. S. Agriculture Department, Yr. Bk. 1911, p. 237-44.

3. ''Craftman'' 23, Nov., 1912, pp. 233-6, extracts from, W. L. McAtte, Prof. Judd and Prof. Beal.

4. ''Woodpeckers,'' Harpers Weekly 56:23, Feb. 18, 1912.

No. 4 is good, but gives nothing on the harm done to any other birds by the woodpecker.

GOOD AND BAD WOODPECKERS.

Harpers Weekly.

Sap-suckers never pay for their keep. These birds peck holes in trees, but instead of withdrawing the destructive insects that may be lurking under the bark they feed upon the pieces and the soft parts of trees. In getting their food they often destroy so much of the growing layer that the death of large limbs or even that of whole trees may result. There is no record in this country of any woodpecker killing a tree by drilling except of these two species of sap-suckers, one the ''yellow-bellied" and the other the "red-breasted." In many cases where the tree is not killed outright by the action of the sap-suckers the wood is stained and distorted to such an extent as to reduce considerably its value for ornamental and even structural purposes. From this source alone there is a yearly loss to this country of more than a million and one-fourth of dollars. How many birds could nest in this timber? There is practically nothing in the activities of these birds to compensate us for the harm they cause. An examination of the tongue of such birds discloses the fact that they are incapable of drawing insects out from under the bark like other woodpeckers, since they have not the appropriate barbs at the tip of the tongue. On the other hand they have a peculiar swab-like arrangement that makes sap-sucking a very simple operation.

These birds it seems all have yellow bellies, whereas very few other woodpeckers have. All sap-suckers have a white patch on the upper part of the wing, as seen from the sides. Other woodpcekers having white patches on the middle or lower portion of the wing. Also it is a destroyer of the bluebird's eggs.

A FURTHER STUDY OF THE HOME LIFE OF THE BROWN THRASHER—Toxostoma rufum Linn.

BY IRA N. GABRIELSON.

During the summer of 1911, the writer made a detailed study of the nesting habits of the Brown Thrasher which covered a considerable part of the nesting period. The report of this study was published in the Wilson Bulletin.*

During the summer of 1912 the writer made one full day's observations on a nest of the same species under somewhat different circumstances, such that some additional conclusions are reached regarding the nestling food.

The nest in question was located in a cherry orchard, about two and one-half feet from the ground, in one of the cherry trees. At the time of the study the trees were loaded with an abundance of ripe fruit. The nest was discovered on June 17. It was of the usual type and contained four eggs. Between the tree rows and on all sides of the nest was a dense thicket of raspberry bushes. These bushes and the loose moist earth beneath them was a favorite hunting ground for the thrashers and furnished an abundant supply of grasshoppers, beetles and cutworms.

On June 18 the four eggs hatched. On the 22nd the observation blind was erected by the nest. Observations began on the 23d at 3:30 o'clock in the morning and continued without a break until 8:30 in the evening. All of the records were taken by the writer and Mr. Howard Graham, to whom I wish to express my thanks.

The proximity of the food supply kept the parent birds in the immediate vicinity of the nest the greater part of the time. Occasionally one of them flew down the hill to a small creek, but at other times one could either see or hear them in the bushes near by.

It was very easy to distinguish the male from the female. The plumage of the female was of a much duller color, especially on the head where the markings were obscured by a dirty gray color. The female also possessed one or two badly worn and broken tail feathers. These

*Vol. XXIV June 1912.

were of great assistance in distinguishing the parents when they came to the nest at the same time or in rapid succession. In the tables the four young will be designated as A, B, C, and D.

During the day the parents made 169 visits to the nest with food. The first feeding was recorded at 4:20 A. M. and the last at 8:03 P. M., the active day being 15 hours and 43 minutes. This would be an average of one feeding every 5.57 minutes. Of the total of 169 visits, 85 were made by the male and 84 by the female. These were not made in regular alternate turns but very irregularly, sometimes four or five trips being made by one bird between the visits of the other. Table I will show something of the variety and amount of the food.

TABLE I.

	By male	By female	Total
Unidentified	6	9	15
Grasshoppers	15	23	38
Maybeetles	35	30	65
Cutworms	15	14	29
Spiders	8	10	18
Earthworms	2	8	10
Crickets	8	5	13
Flies	..	2	2
Damsel flies	..	2	2
Centipede	1	..	1
Wireworm	..	1	1
Dragonflies	1	..	1
Beetles	2	1	3
Cherries	16	3	19
Totals	109	108	217

From this table it will be seen that out of 217 insects, cherries, etc., fed to the nestlings, 109 were brought by the male and 108 by the female, a very equal division of the work.

Some significant facts concerning the economic value of this species are revealed in this table. Grasshoppers, cutworms, and maybeetles furnish over one half the food supply. The exact figures are: grasshoppers 38 out of a total of 217 morsels fed, or 17.51%; maybeetles 65, or 29.95%; and cutworms 29, or 13.36% of the total. These three varieties thus make up a total of 132 out of the 217, or 60.82%. These forms are very destructive in the small truck farms of the immediate vicinity, particularly the cut worms and the larvae of the maybeetles.

Both were more abundant than usual during the season of 1912, due undoubtedly to a favorable season. The cutworms destroyed many cabbage and tomato plants by cutting them off one or two inches below the ground. One man who makes a specialty of raising cabbage estimated his loss at from 25 to 30% of the total number of plants set out. On an adjoining plot, especially noticed by the writer, out of 500 tomato plants less than 50 remained three days after they were transplanted. On investigation one to five cutworms were found around each plant examined. Of course this unusually high percentage of loss was due to some condition in this particular plot especially favorable to the cutworms. In the strawberry beds the maybeetle larvae did considerable damage by cutting the plant just below the crown. From the present observations it would seem that this species might be of considerable value to the market gardner and fruit growers.

Before estimating the economic value of the species we must take into consideration the fruit consumed. During the one day's observation the young were fed 19 cherries out of 217 morsels of food, or 8.75%. Spiders formed 8.29% of the total and miscellaneous worms and insects the remainder. One fact noted in connection with the feeding of the cherries was that the male fed practically all of them, 16 out of 19 being credited to him. The larger portion of these were taken from the nest tree, many of them being taken from the tree and fed during visits to the nest with insect food. The most striking fact about the latter is the low percentage of fruit consumed considering its availability. It would seem that this amount represents the maximum fruit eating proclivity of this species, at least in regard to the nestlings, since it would be difficult to conceive of more favorable conditions for its use. The remaining 22.13% of miscellaneous insects consists of such small numbers of each species that their destruction has little economic importance. Their use as food indicates that the birds have no aversion to them. It might also warrant the conclusion that if for any reason any of these forms should increase in numbers enough to become economically important, the Brown Thrashers would help keep them in check.

Summing up these facts the balance seems to be strongly in favor of the birds. Against the actual loss caused by the consumption of fruit to the extent of 8.75% of the food, can be placed the destruction of injurious insects amounting to 60.82% of the total. As previously stated the conditions were very favorable for the use of fruit as food, and this makes it probable that the amount of fruit consumed would rarely exceed 10% of the total food supply. In determining the economic status of these birds it is easy enough to estimate in dollars and cents their depredations on fruit; but it is impossible to state in similar terms the value of their work in destroying noxious insects because we deal here not only with the actual insects destroyed with but numerous other generations which would follow.

Comparing these results with those of the previous report, we find that while the two studies were made in different localities, and during two quite dissimilar seasons, the results compare very favorably. In the former report we find a total of 1,260 morsels of food consumed. 425 of these were mayflies; 247 grasshoppers; 103 cutworms; 38 beetles and 22 larvae, practically all of both being maybeetles; and 425 of various forms in small numbers, including 237 moths of various species. The two greatest discrepancies shown by a comparison of Table III of the previous report and Table I of the present article are first, the large number of mayflies and moths consumed by the first brood studied and their total absence from the list of insects fed to the last brood and second, the absence of fruit in the first table and its presence in the latter. These facts will be discussed in the next paragraph. Selecting from the previous study the data on the three forms of insects most numerous in the present data, viz., grasshoppers, maybeetles, and cutworms, we find the three forms total 410 out of 1,260, or 32.54%. Mayflies form 33.73% of the total and the remaining 33.73% consists of moths and miscellaneous species. From the data furnished by these two studies, it seems that these three forms mentioned above furnish a considerable percentage of the nestling food of the species. No definite figures can be given as the percentages will vary somewhat in individual birds and will also fluctuate from day to day in the food of the same individual. This fluctuation will depend on two factors; first, on the number of individuals of each species of insects that are in the immediate vicinity of the nest; and second, on the availability of other food supply.

There are two general facts that may be stated from the data obtained which have some bearing on the economic status of the species.

First, a great number of species of insects are acceptable to the brown thrasher as food. A glance at the two tables previously mentioned will be sufficient to demonstrate this fact and further study would undoubtedly greatly extend the list.

Second, the birds easily adapt themselves to varying conditions in the food supply and so act as a check on different species of insects. For example at Okoboji in 1911 the mayflies were present in great numbers and the food of the brood studied consisted of over 33% of this form. Grasshoppers were numerous and formed 20% of the food and 19%

was made up of the various kind of moths. On the other hand no fruit was fed to the nestlings. At Sioux City in 1912 the mayflies were not noted among the forms fed. This was due to the absence of any considerable body of water in the vicinity of the nest. The moths were also absent. Maybeetles, cutworms, and grasshoppers were the most abundant forms and they constituted over 60% of the total. If some other of the species consumed by the brown thrasher should become plentiful and easily obtained it would undoubtedly be found to furnish a large percentage of the food. Data from other localities would furnish a basis for an interesting study of the effect of varying food supplies on the nestling food of the species.

Table II will show the distribution of the food among the nestlings.

TABLE II.

Parent feeding.	A.	B.	C.	D.	Total.
Male	22	21	30	22	95
Female	27	24	19	15	85
Total	49	45	49	37	180*

The apparent discrepancy between the 169 visits and the 185 feedings is explained by the fact that on 16 visits the parents fed two of the nestlings making 16 more feedings than there were visits to the nest. On 13 of these occasions the male did the double feeding and the female did it 3 times. In the case of five of the feedings the nestling receiving the food was not identified, leaving 180 recorded feedings or an average of 45 to each nestling. Actually A was fed 49 times, B 45 times, C 49 times, and D 37 times. A curious fact noted in the two studies in regard to the average feeding was that in both broods one of the nestlings received considerably below the average amount of food while the other three received very close to it or slightly above it. In both instances the one receiving less than the average amount of food during the period of observation was very noticeably smaller and weaker than the others. There was no regular sequence of feeding or any approach to it. At times one of the nestlings would be fed three or four times in quick succession and then might be neglected for an hour or more.

In the sanitation of the nest the same cleanliness was observed as in the previous study. Only once during the day did any of the excreta touch the nest and that occurred when one of the packages of excreta

*Five times the nestling fed was not identified. Three of these feedings were by the male and two by the female, making the actual number of feedings 185; 98 by the male and 87 by the female.

broke in the parent's beak. On this occasion the part retained was devoured and the remainder picked carefully from the nest and carried away. During the day the excreta was removed from the nestlings 36 times; 20 times by the female and 16 by the male. Out of the 16 times the male devoured the package 11 times and carried it away 5 times and the female devoured it 5 times and carried it away 15 times. Out of a total of 36 the excreta was removed 33 times from the bird last fed and 3 times from some other bird. Thus confirming the previous observations on this point.

NEST BOXES FOR WOODPECKERS.*

BY FRANK C. PELLETT.

An editorial in one of the well known magazines devoted to ornithology, several years ago, which suggested that it would probably be necessary to devise expensive machinery to bore out cavities in natural wood in imitation of those made by woodpeckers themselves, in order to attract these birds, first led me to attempt to supply their requirements.

As far as I could learn woodpeckers had never been known to occupy such boxes in America up to that time. I did not learn of the successful boxes in Germany until after my own had been occupied and believed that I was working in an unexplored field.

After giving the matter some study it became apparent that the reason that birds which supply no nesting material had not occupied boxes was because of the fact that the construction was such that there was nothing to supply the purpose of a nest. The fact that woodpeckers frequently make holes in the cornice of buildings or gate posts indicates that they would as readily occupy them if they could be made to serve the purpose. In boring out cavities in the natural wood the birds leave chips in the bottom on which to lay the eggs. During the season of 1909 a pair of redheaded woodpeckers appropriated the home of a pair of bluebirds in an old rabbit trap placed on a pole. They remained about for some time and the eagerness with which they took possession led me to think that all that would be necessary to meet their requirements would be the addition of some chips. Accordingly the following season several boxes were made of six and eight-inch lumber, varying in length from eighteen to twenty-four inches and placed in similar positions. The boxes were closed at both ends, a hole about the size the birds would require was made near one end and several inches of ground cork placed in the other. While the boxes were not round inside, the cavity was deep and conditions were approximately such as the birds would provide for themselves. A pair of flickers immediately took possession of one of these boxes but was dislodged by a pair of sparrow hawks. The little

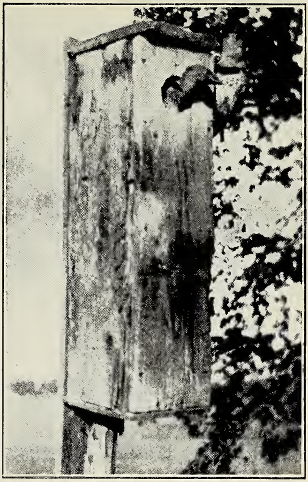
*See Bird Love—March, April, 1911.

hawks do not provide nesting material and the box fitted their needs as well. They reared a family of four successfully. The flickers soon took up their abode in another of the boxes near at hand where they reared their family. Flickers have occupied these boxes and reared their families each year since so that there is no longer any question that the boxes are readily received and that the acceptance was not a mere chance not likely to be repeated. In addition to the flickers the sparrow hawks and redheaded woodpeckers already mentioned have also reared their families with equal success, though not so frequently.

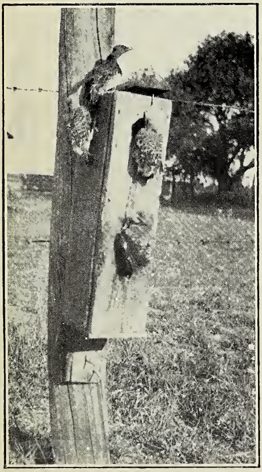
Our home is situated in a grove of native trees where ideal conditions exist for nesting places for these birds and they have not occupied the boxes for lack of suitable natural nesting places but because the boxes supplied their requirements equally well. While the boxes have been in use other families have occupied cavities in the trees in the usual manner. Old lumber has been used in every case to give the natural appearance as much as possible. As yet I have not tried the experiment of painted houses for these birds, but I doubt very much whether such boxes would be occupied. About sixteen feet from the ground seems to be the most favored height. Boxes a few feet lower have not been occupied. One box on a cedar pole at the edge of the grove has furnished a home for three successive families, while another similar one a few rods from the grove but near an apple tree has never been occupied. Boxes nailed well up to the side of a tree, or at the top of a broken tree trunk have been readily used. The most popular box is one about six inches square and two feet deep with six inches of cork in the bottom. The cavity between the hole and the cork is a little over twelve inches. The entrance hole is about four inches below the top of the box.

It is apparent that woodpeckers' requirements as to nesting sites are not difficult to meet. The cork or chips to supply the nest is the most essential thing and it remains to be seen whether they will not occupy almost any kind of box supplying this requirement.

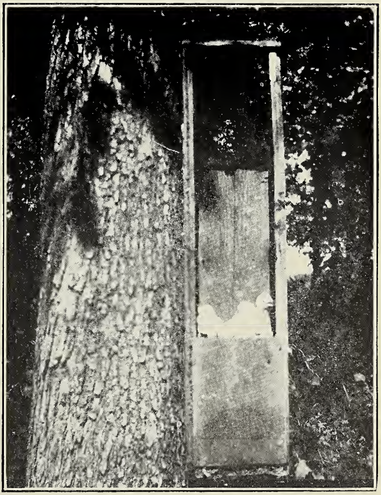
The most popular box.



Feeding the young.



Four of a family of seven young woodpecker's reared in this box.



Interior of box showing young sparrow hawks.

FOOD HABITS OF THE SKUNK.*

BY FRANK C. PELLETT.

In observation of the food habits of the birds of prey one can take advantage of the fact that food must be brought to the young in the nest. With the skunk, which is a nocturnal animal, many difficulties present themselves in gathering sufficient information on which to base a conclusion, and it must be confessed in the beginning that the results are rather of a negative than a positive character. Animals in captivity adapt themselves to their environment quickly and form habits which perhaps might not be normal when living under natural conditions. In making the observations on this animal extending over more than five years, the writer has used every means within his reach to acquire accurate information as to the natural food habits. Four individuals of the Northern Plains Skunk were kept in captivity for several months. About a dozen different individuals of the Little Spotted Skunk (spilogale interrupta) have been observed for varying periods of time without any restriction being placed on their movements, excepting for a day or two when they were brought to my home and released at nightfall.

Inasmuch as skunks are almost universally persecuted by farmers because of the impression that they destroy poultry, the special thought has been to determine to what extent poultry does furnish these animals with food. That skunks do kill poultry is of course unquestioned. I have a mounted specimen of the larger species that killed thirty chickens in one night and which was shot in the midst of his victims. That the habit is infrequently formed I have been compelled to believe after looking into the matter as fully as my opportunities would permit. To begin with, hens were placed in the same pen with the captive skunks, yet although apparently an object of great curiosity, the skunks seemed disinclined to attack them. When the hens were removed and a mouse or large insect thrown into the pen the skunks behaved very differently. They snapped up the mouse or insect so quickly as to suprise one after noting their usual slow and awkward movements. Hen's eggs placed field nesting birds were not tried.

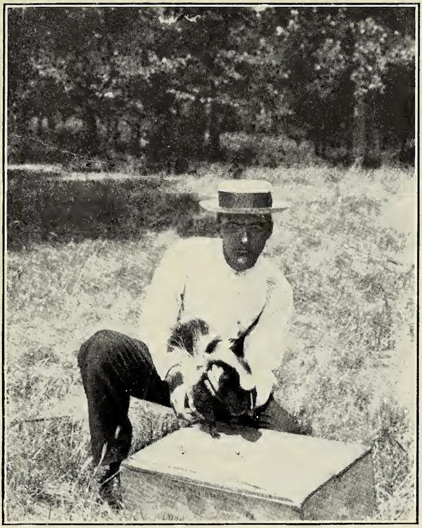
*See Forest and Stream November 26, 1910.

The captives were treated to almost every kind of food available from the kitchen as well as fruits, vegetables and various kinds of animal food. They seemed to relish a wide range of food, though apparently in the pen were sniffed and rolled about but no attempt made to eat them. Smaller eggs such as would ordinarily be found in the nests of preferring mice and insects to anything else. That the poultry killing habit is formed in times of scarcity, usually in winter, has been my conclusion after noting the habits of the captives and the behavior of those which lived unrestrained about the premises. To test the matter fully a young crow was placed in the pen without a roosting place and left there for twenty-four hours. Other food was available and the bird received scant attention. Later the bird was again placed there and left until the animals finally attacked it and would have killed it had it not been removed. On one occasion a neighbor caught a little Spotted Skunk (interrupta) in a wire trap. As the animal was uninjured I brought it home and kept it for twenty-four hours in a small pen with no food excepting one mouse. The hens were roosting in a small house near at hand on roosts not more than eighteen inches from the ground and with an open door. The second evening the skunk was released after dark when the family had all entered the house so that there would be no danger of frightening it away. The premises apparently were attractive to his skunkship for either it remained for some time or another similar in appearance did so, for we occasionally saw it moving about in the outbuildings or running across the yard. Neither cat or dog is kept on the premises as we do not desire to interfere in the least with birds or animals under observation. We have kept very close watch of the poultry during these observations and feel sure that no poultry has been lost from either carnivorous animals or birds of prey without our knowledge. Never did this skunk touch a chicken to our knowledge. On the other hand the place has been more free from rats and mice during its stay than usual.

On one occasion rats became very troublesome under a big pile of cobs in one of the outbuildings. A cat with a fine reputation as a ratter was borrowed and confined in the building. She made so little impression that she was soon returned to her owner. Not long after a small skunk took up its abode in the same building and the rats moved out with little delay and less ceremony. The same thing was repeated a year or two later minus the cat. During cold weather one winter one of these little skunks killed a full grown hen. A trap was promptly set beside its victim and the animal disposed of. This was the only instance of the kind among a dozen or more observed. They are expert in catching pocket gophers and I have several times found them in the holes apparently in pursuit of the gopher. In winter they frequently catch rabbits and I have found tracks in the fresh snow leading to the hiding place of the cottontail, while the blood-stained remnant of the carcass of that animal told the story of a tragedy. On several occasions I have known the little skunks to follow the cottontail into a box trap where both were caught together.

The animals seem to be fond of apples and will sometimes eat tomatoes. I have seen them scratch out the seeds from a pumpkin and devour them and have known them to eat cabbage when hungry. They eat honey very greedily when available. The captives soon learned to eat almost anything in the way of table scraps in much the same way as the ordinary family cat.

During the five years that we have cultivated skunks and tried to become intimately acquainted with them we have used every inducement to attract them, even to releasing captives. The hens have all this time roosted in houses not more than three feet high and on roosts not more than eighteen inches above ground. Excepting a few extremely cold nights the doors have been constantly open and poultry has been easily available. We have desired to know the real truth, not to justify a preconceived prejudice. The longer the experiment is conducted and the greater the number of individuals under observation the stronger becomes the conviction that the skunk is a valuable friend in reducing the rodent pests and destroying insects, especially grasshoppers, crickets and June beetles; and that the poultry killing habit is accidental and unusual and confined to a small percentage of the individuals of either species of skunks.



A captive skunk.

Little spotted skunk.

ADDITIONAL MAMMAL NOTES.

BY T. VAN HYNING.

In the proceedings of the Iowa Academy of Sciences for 1910 appears "a preliminary annotated catalogue of the recent mammals of Iowa," by T. VanHyning and Frank C. Pellett. The design in publishing that catalogue was for the purpose of obtaining more complete data for a monograph. It is now very gratifying to add the following notes as the results:

The following species were given in that catalogue as only probably occurring in the state. They are now established as belonging to our Iowa fauna:

Number 9 of the catalogue, Canada Porcupine. In about 1908 "some hounds in the same section," Allamakee County, "were badly stuck up by porcupine quills, which had to be pulled from their mouths. Last summer, on French Creek, Allamakee County, I saw some scrub Hemlocks freshly cut and gnawed by porcupines." Geo. H. Berry, Cedar Rapids, Iowa, April 8, 1913.

Number 17. Lemming Mouse, or Cooper's Mouse. "I have recently taken a fine specimen of *synaptomys cooperi* on the reservation right near the laboratory." Prof. Thaddeus Surber, U. S. Biological Station, Fairport, Iowa, Feb. 16, 1912.

Number 24. Western Harvest Mouse. "It may interest you to know that the harvest mouse, *Reithrodonomys dychei,* is quite common here." Prof. Thaddeus Surber, U. S. Biological Station, Fairport, Iowa, February 16, 1912.

Number 75. Pekan: Fisher. "Plenty of coons and some fishers ran wild in the timber." John G. Smith, in Register and Farmer, Algona, Iowa, February 11.

The following were noted in the catalogue as extinct in Iowa, but may now be considered as living in the state:

Number 69. American Otter. "M. W. Conwell, a local furrier, displays the skin of a large otter recently trapped on the Des Moines River, near Harvey, ten miles east of Knoxville. The pelt is in fine condition from the standpoint of the furrier, and is 5 feet 9 inches from tip to tip. The animal was trapped by John Morgan. About a week ago one of Mr. Morgan's traps was sprung by an otter which gnawed its leg off and escaped." Knoxville, Iowa, February 24, 1913.

"Two otter went up the Cedar River on the ice in December and were tracked in the snow for nearly eight miles. Dr. Bailey of Coe College is negotiating for the skin of one caught the past winter, near Albia." Geo. H. Berry, Cedar Rapids, Iowa, April 8, 1913.

Number 73. American Badger. "Coe College has two badgers in its museum taken in Iowa during the past year, and another one was killed about a mile from Cedar Rapids last July. I saw the animal when it was too far gone to save the skin." Geo. H. Berry, Cedar Rapids, Iowa, April 8, 1913.

"One was captured in the eastern part of Sac County about one year ago, and I saw many holes dug by one in digging out ground squirrels in our stubble and pasture fields the last summer." John A. Spurrell, Wall Lake, Iowa, February 23, 1913.

Number 86. Canada Lynx. "A hunter on the island south of the city today killed a Canadian Lynx. The animal was about the size of a wolf. At the present time the body of the animal is being mounted by a taxidermist, at Iowa City." Muscatine, Iowa, January 14, 1906.

Number 88. American Panther: Cougar: Puma: Mountain Lion. "After a furious battle this morning with a mountain lion, which sprung upon him while he was hunting on an island in Rush Lake, Walter Strauss of this place finally killed the animal with a well directed shot from his Winchester. The animal weighed 160 pounds * * * measuring six feet from nose to tip of tail. * * * John Mark, who heard Strauss' screams, ran to his assistance and helped carry the carcass to town." Ocheyedan, Iowa, April 13, 1909.

The following are additional to the catalogue and may be considered as belonging to the state's fauna:

Chickaree: Small Red Squirrel. *Sciurus hudsonicus* Pallas. "A small red squirrel, perhaps S. *hudsonicus,* is to be found in the timber around Waverly, Osage and Rockford, in all of which places I have seen it within the last four years." Geo. H. Berry, Cedar Rapids, Iowa, April 8, 1913.

This species has been observed by others about Osage, and the writer received a nest from there which we placed with the species.

The following species have been given in the geographical distribution (Bull. Field Col. Mus. Zool. Ser., Vol. 1) as probably belonging to Iowa:

Peromyscus michiganensis Audubon and Bachman. Wood Mouse.
Peromyscis leuecopus Rafinesque. Wood Mouse.
Tamias quodrivittatus neglectus Allen. Chipmunk.
Scalops argentatus. Audubon and Bachman. Mole.

More data on many species is yet needed and we will feel very grateful to those who may be able to add anything.

LIFE HISTORY NOTES ON THE PLUM CURCULIO IN IOWA.

Conotrachelus nenuphar Herbst.

BY R. L. WEBSTER.

During the summer of 1910 some insectary experiments were made at Ames with the plum curculio in apples, but since these were few, and of no great importance, no mention of them was made in print. However, when taken in connection with some notes on the insect made in 1889 by Prof. C. P. Gillette, then entomologist of the Iowa experiment station, these stray notes become somewhat more valuable, as they fit in nicely with the notes taken by Professor Gillette.* Since little definite data concerning the seasonal history of this insect in Iowa is available, these notes are incorporated in the present paper. The 1910 notes were made by Mr. T. M. McCall, insectary assistant at that time, and by the writer; most of them by the former. These notes are from the insectary records of the entomological section of the agricultural experiment station at Ames.

In the spring of 1889 at Ames Prof. Gillette jarred plum trees and examined fruit every few days from April 25 to May 14, but found neither the beetles nor their punctures. After May 14 only the fruit was examined and this was done nearly every day until May 25, when the first punctures were found. On June 12 Professor Gillette estimated that "the majority of the eggs then laid were still unhatched," and on June 18 he observed that nearly half of the punctures contained eggs yet unhatched. By June 19 larvae 3-16 inch long were found. June 24 eggs were still present but by this time were becoming more and more rare. Some larvae were then nearly mature. Again on June 26 and also on June 28 a single egg was found. However, as late as July 22 and 24, 1889, Professor Gillette found some eggs in plums, but these were evidently deposited by overwintering beetles.

In 1910 Mr. McCall and the writer collected apples badly infested with curculio larvae and placed them in jars in the insectary. These apples were collected in an orchard near Ames on June 13 and 28 and July 5 and 23, so are sufficiently scattered that the rearings from these should

*Iowa Agr. Exp. Sta. Bul. 9. p. 371.

give a fair statement of the life history during the summer months. When the larvae matured and left the apples they were transferred to jars of soil to rear the beetles.

June 23 several mature larvae were found that had emerged from apples collected June 13. By July 8 larvae were maturing and emerging from the apples in considerable numbers. The last record of emergence of a mature larva is August 8.

The emergence of 88 larvae from the apples was recorded and this is given in the following table:

TABLE I.

Emergence of Larvae, 1910.

		Larvae			Larvae
June	30	1	July	20	1
July	1	0		21	0
	2	0		22	0
	3	0		23	2
	4	0		24	0
	5	3		25	0
	6	0		26	0
	7	4		27	2
	8	15		28	3
	9	0		29	1
	10	6		30	0
	11	8		31	0
	12	4	August	1	2
	13	5		2	0
	14	4		3	0
	15	3		4	1
	16	7		5	0
	17	7		6	1
	18	1		7	2
	19	4		8	1

In 1889 Gillette reared beetles from early stung plums as early as July 22. In 1910 the first beetles emerged July 26 and continued emerging during August even into September, the last beetle coming out September 10. In table II the emergence of 47 beetles is given, according to the daily insectary records.

TABLE II.

Emergence of Beetles, 1910.

		Beetles			Beetles
July	26	5	August	19	3
	27	1		20	0
	28	2		21	1
	29	2		22	4
	30	0		23	0
	31	0		24	1
August	1	1		25	3
	2	0		26	1
	3	1		27	2
	4	2		28	1
	5	2		29	0
	6	0		30	0
	7	0		31	1
	8	1	September	1	0
	9	0		2	0
	10	0		3	0
	11	0		4	0
	12	1		5	0
	13	1		6	1
	14	0		7	0
	15	3		8	0
	16	5		9	1
	17	0		10	1
	18	0			

August 7, 1910, Mr. McCall gathered a number of apples which showed curculio injury from the same orchard where the other fruit was secured, but he was unable to rear any larvae from these. Evidently all had left at that time.

COLOR INHERITANCE IN THE HORSE.

BY EDWARD N. WENTWORTH.

While laboratory animals have yielded very nicely to the study of their inheritance of color, the horse still remains a mystery in many of the phases of coat transmission. Hurst and Bunsow have recognized chestnut with the sorrel and liver shades as a true recessive, and Hurst has shown black to be epistatic to this reddish pigment. Bays and browns have been with difficulty separated but have been considered as epistatic to both colors mentioned, while grays and roans seem dominant to the entire series of color. One difficulty which seems to have beset all investigators up to the present time, with the exception of Dr. Walther, is the tendency to arrange all colors as an epistatic and hypostatic series, expecting them, then, to conform to the simple laws of presence and absence. That this attempt has been a real stumbling block the writer hopes to show, by means of his arrangement of factors in a manner slightly similar to Walther's and Sturtevant's methods but differing in the factors themselves.

THE PIGMENTS IN THE EQUINE COAT.

A microscopic examination and simple chemical tests reveal only two pigments in the coat of the ordinary horse. These seem to correspond to the red or yellow and the black pigments found in rodents. There is quite evidently a lack of chocolate or else such a close linkage of the brown and black pigments that they are not readily separable.

Under both the low and high power red pigment granules may be discerned in the sorrel, chestnut, bay or red roan hairs. The granules are sharply distinct and typical in form but there seems also to be a diffuse red, slightly lighter in tinge, distributed quite evenly throughout the cortical layer. This is entirely separate from the effects of spherical aberration, and is quite evidently a basal ground pigment found in all but white or albino hairs.

Black pigment granules rather larger, coarser and more frequently clustered appear in the black horse. They are so numerous and typical that they quite obscure the red ground pigment.

Quantitative differences appear in the amount of pigment in the hair, intense and dilute conditions being readily recognizable. The effects of age and sun are quite noticeable also, fading usually being produced, in some cases the black hair losing its black pigment almost entirely and giving the rusty black so common in Percherons and general work horses.

THE INHERITANCE OF THE RED PIGMENT.

Hurst and Bunsow have shown that chestnut breeds true. The figures in the table, taken from various sources,* show that out of 1,610 matings all but 16 are chestnut. This is a deviation from a pure recessive of 1%, but since it has been shown that the average stud book contains 2% of errors, this 1% may be readily credited to that. It will be noticed that the variates are 6 bays and 10 blacks. Bay is the common color of a colt at birth and a rusty black is nearly as frequent. Since many colts are recorded at from one to three months of age and since the natal coat is not shed usually until the foal is twelve weeks old, errors here are not unexpected.

The black pigment seems more complicated in nature. 406 individuals show it to 41 without when black is mated to black and 200 bear it to 108 without when black is mated to chestnut. Since most of the individuals in the black by black matings are from the Percheron breed in which there are a large number of homozygous blacks the small ratio of chestnut segregation is not surprising. The 15 bays from the black by black mating are unexpected. Eleven of these came from Sturtevant's records. He offers the possibility of error explaining it on the ground of error in the natal coat, on the difficulty in distinguishing dark browns from blacks in the parents and by other means. These seem sufficient to the writer to permit disregarding them since he found none in his studies on actual individuals, (some 100 in number). Sturtevant and the other investigators are disturbed by the high per cent of bays from the black by chestnut matings, but this is probably due to the idea of bay held by them. It fits the writer's hypothesis perfectly. The factors so far considered may be lettered as Sturtevant has done, C for the chestnut ground pigment and H for the black pigment, (Hurst's factor).

*The Government Gray Draft Horse Experiment at Ames, pedigree and original animal study by the writer, Sturtevant's, Wilson's and Anderson's papers principally, with isolated cases from the agricultural press.

BAYS AND BROWNS.

Bay and brown are distinguished with difficulty by each of the investigators and by most practical men. On this account the writer has made no attempt to separate them but has lumped such records together.

Bay is a restriction factor, which will be called B, that limits the development of the black pigment to the eye, mane, tail, skin, lower limbs and the extremities in general. It can operate only in the presence of factor H, black pigment. Brown probably differs from bay in having the dapple pattern combined with the restriction factor B. This permits some black to appear where the dapples are located and gives a darker appearance. This idea would suit the microscopic as well as visual evidence since brown differs from bay in the presence of black hairs. Most writers have considered brown dominant to bay, a condition which would suit the above theory since the dappling pattern is apparently dominant.

Bay to bay gives 5,723 bay, 274 black and 672 chestnut. This varies quite a little from the expected 9:3:4 ratio. However, the bays are very largely, (all but about 500), from the American Saddle Horse and Standard Bred records, and bay has been the dominating color among them for seventy-five years. The deficiency in blacks may be accounted for by their lack of popularity. Bay to black and to chestnut give qualitatively similar results as would be expected, but there is a lower percentage of bays and a higher percentage of blacks in one case and chestnuts in the other than would be expected.

The high per cent of bays in the offspring of blacks to chestnuts has been non-conformable to previous theories. The restriction factor B does not appear except in the presence of H, black pigment. Theoretically three-fourths of the chestnuts ought to carry this restriction factor, so that the mating of these to blacks should always supply bays. From this standpoint there is a deficiency rather than an excess of bays.

THE DUNS.

Duns are little known. Their numbers are few and they may be grouped into at least three kinds. The ordinary buckskin with black extremities is probably a dilute bay, the yellowish dun a dilute chestnut and the cream colored with light mane and tail, a dilute sorrel with the yellow extremities, factor M.

Since the records do not separate them they will not be dealt with further. Factor I, the dilution factor, is probably epistatic to all but gray and roan.

THE GRAYS.

Gray is recognized as a separate factor by all writers. There seems some question as to whether it can operate in the absence of H, black pigment, but Sturtevant presents evidence to show that it does. It is dominant to all factors previously named, dappling D and restriction B excepted, and varies from a deep iron gray in young stock to the white or flea-bitten gray of the older animal.

It is a simple factor since animals heterozygous for it produce 50% grays and 50% other colors. Dr. L. J. Cole of the University of Wisconsin has told the writer in private communication that one of his students has totaled the offspring of grays in the Clydesdale studbook and has obtained exactly 50% of each of grays and other colors. The Clydesdale breeders have objected to gray and have always bred their gray mares to other stock in order to reduce the chances of its appearance. Gray stallions since 1831 have nearly all been castrated. This has resulted in all the grays being heterozygous.

Sturtevant shows 400 gray to 428 not gray for the same condition, while he exhibits 45 gray to 15 not gray where both parents are heterozygous.

Gray is characterized by an intermingling of pigmented with non-pigmented hairs, usually associated with dappling. It seems possible that gray may be a combination of dappling and the roan factor although the above evidence indicates that it is a unit in action.

THE ROAN PATTERN.

Roan seems dominant to all the other colors and is apparently a pattern entirely independent of the kind of pigment. Two kinds of roans exist visually, strawberry or red roan, and blue roan. These probably correspond to bays and blacks plus the roan pattern. It seems probable that there also exists a chestnut roan, in fact they are apparently quite common for roans with red pigmented manes and tails instead of black are seen frequently. Such a roan would probably be the type produced by the mating of blue roan to blue roan shown in the table. If the black factor were heterozygous in both sexes, the chestnut roan would result.

Roan differs from gray in lacking the dappling common to gray and in possessing quantitatively a much larger number of pigmented hairs. It has seemed to the writer that gray may be a combination of the roan, dappling and dilution factors coupled together in some way, but since from the present evidence that would necessitate considering gray epistatic to roan and since this latter is manifestly untrue it is best to consider them as separate factors.

Roan is epistatic to the entire series of factors as may be shown from the three following records. One a roan Belgian stallion owned at a small town in Iowa (the name and address are lost) sired 254 colts of which 230 were red roan and 24 blue roan, these colts coming from all colors of mares. The second a roan Belgian stallion which stood for two years in northwest Warren county, Iowa, sired 112 red roans, 7 blue roans and 6 chestnuts, from mares of various coats. The third, also a Belgian, owned in Marshall county, Ill., sired about half roan colts and the other half grays, blacks, bays, browns, and sorrels. His owner states that his sire was blue roan, his dam was bay, his second dam was chestnut and his dam's sire brown. A roan Belgian owned in southeast Story county has sired 256 colts, all red roans, from all colors of mares.

SPOTTING.

Spotting varies in type but may receive at least two classifications. The white stockings on the legs and the blazed face typical of the English breeds, Shire, Clydesdale, Hackney, Thoroughbred and allied breeds, seems to be inherited as a distinct kind of spotting although it fluctuates very markedly in amount of white. The "blaze" may become as small as the typical star in the forehead or may cover more than half the head. The stockings may extend well up to the elbow or stifle or may be restricted to the foot.

Dr. Walther recognizes another type of spotting, Schabrackenscheckung or saddle cloth marking and its recessive, absence of same. He finds it also inherited as a distinct unit although fluctuating in its limits. It is a spreading of white over the back, sides and croup, and down onto the legs. It is dominant and may appear with any color so far discussed. It is apparent what the horse breeder calls piebald or skewbald or what the average person calls a "calico" horse.

Albinos are uncommon, but extreme spotting with blue eyes (glass eyes) are frequently seen.

THE REDUCTION OF PIGMENT IN MANE AND TAIL.

Yellow manes and tails in sorrels and cream colored extremities in duns are very common. They are apparently recessive since one chestnut mare Bessie at the Iowa State College has produced eight chestnut colts, six with manes the same color as the body, two with the yellow mane.

Anther chestnut mare known as the half-hackney bred qualitatively the same producing two colts of the first class and one of the second. Four chestnut mares with yellow manes mated to three different chestnut stallions with yellow manes produced thirteen foals with yellow manes. The summary of data on this is appended.

	Chestnut Stallions without Yellow Manes		Chestnut Stallions with Yellow Manes	
Chestnut mares with yellow manes	25 without	6 with	13 with	
Chestnut mares without yellow manes	17 without	8 with	19 without	3 with

This shows it apparently to be recessive. A cream colored mare with light mane and tail produced three dun colts with black extremities when crossed to a bay. This would fit the above hypothesis although it throws no light on it.

THE DILUTION FACTOR.

The dilution factor I is apparently dominant. Mouse is a dilute form of black and three matings of mouse to black have given two mouse-colored and one black. The mouse-colored parent of the black was produced by a black stallion to a dun mare so was known to be heterozygous. The table shows that duns mated to other colors have produced 13 duns to 19 other colors, near enough to expectation in such small numbers to account for dilution being a dominant factor. It must be remembered that duns are not popular in America at least and hence there will probably be a deficiency. Also because of this most duns will be heterozygous.

SUMMARY.

The factors so far discussed will account for the following colors, those qualitatively alike being grouped together:

Sorrel-Chestnut-Liver.
Black-Mouse.
Bay-Brown-Blood bay-Mahogany bay-Seal Brown.
Dun-Buckskin-Cream-Isabelline.
Gray-White.
Blue roan.
Roan-Strawberry Roan-Red Roan.
Piebald-Skewbald-Blaze and white stockings.
Dappling.

The factors themselves follow with the tentative composition for the different colors:

Factor C equals Red or yellow basic pigment.
Factor H equals Black.
Factor B equals Restriction factor producing bay in presence of H.
Factor G equals Factor for gray pattern.
Factor R equals Factor for roan pattern.
Factor D equals Factor for dappling pattern.
Factor S equals Star or blaze in forehead and white on legs.
Factor P equals Piebald and skewbald markings, Dr. Walther's Schabrackenscheckung.
Factor M equals Light creamy yellow mane and tail.
Factor I equals dilution factor dominant to i, intense.
Chestnut equals C may have B and M in some cases.
Black equals C H may have D in some cases.
Mouse equals C H I may have D in some cases.
Dun equals C I, C B I or C M I according to kind.
Bay equals C H B.
Brown equals C H B D.
Gray equals commonly C H G D, maybe C G D.
Blue roan equals C H R.
Red roan equals C R or C H B R, latter commonest.

	Red Roan	Blue Roan	Gray	Dun	Bay	Black	Chestnut
Red roan x red roan	45				5		
Red roan x blue roan	33	11	2		2		
Red roan x gray	37	7	27		4	2	2
Red roan x bay	93	6	27		101	7	10
Red roan x black	14	4	1		5	11	1
Red roan x chestnut	18	2	4		12	2	4
Blue roan x blue roan	1	3	1				
Blue roan x gray			1		2		
Blue roan x bay		1			8	3	1
Blue roan x black						1	
Blue roan x chestnut		1			1		
Gray x gray			66		13	12	
Gray x dun			7	5	2		
Gray x bay		1?	50		54	6	9
Gray x black			18	5	14	20	5
Gray x chestnut			14		7	2	10
Dun x dun				2	1		1
Dun x bay	1?			4	4	1	1
Dun x black				3	1	1	1
Dun x chestnut				1	1		
Bay x bay					5273	274	672
Bay x black					1218	476	130
Bay x chestnut					826	70	497
Black x black					15?	391	41
Black x chestnut					135	65	108
Chestnut x chestnut					6?	10?	1594

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SOME FACTORS AFFECTING FETAL DEVELOPMENT.*

BY JOHN M. EVVARD.**

That the nourishment of the mother during the period of gestation should affect the weight, vigor, general relative size, bone and skin (with covering) of the offspring is quite evident from the results of some recent experimental studies made by us. Dr. A. W. Dox and S. C. Guernsey of the Chemical Section are working upon the chemistry of this problem in co-operation with the writer. Our work is being carried on with both sheep and swine in order that we may get a double set of records upon different species of animals.

How may the offspring be affected? This is a very important question. In the first place the new-born may possibly be affected through the dam, depending upon her nutrition, age, weight, stature (special emphasis being laid upon the conjugal diameter of the pelvis), health, shortening or lengthening of the period of gestation (from whatever cause), the number of preceding pregnacies, breeding and exercise (or confinement). Secondly, the sire may have some influence dpending upon his age, weight, stature, breeding and general health. Thirdly, through the character of the offspring themselves, depending upon their number and sex. The number may possibly be influenced by the nutrition of the dam during the breeding season, as some of our studies tend to show, but we will reserve this for a later report. There may be a general commingling of various factors in determining the character of the resulting offspring.

We are most interested in the nutrition of the dam during the pregnancy period, and its effect upon the developing fetus. Are there any specific food constituents or elements such as protein, carbohydrates, fats, calcium, phosphorus, water, or other specific materials which are instrumental in affecting development in utero, or, are the changes due to an abundance (or absence) of all of the needed food elements or to a happy combination in definite ratios (depending upon the environment) of many of the food elements? Will any one food stuff have a more marked influence than another? Many problems are involved in such a study.

I quote from Williams' most excellent treatise on Human Obstetrics:

"Prochownick pointed out, and his experience has been confirmed by Reeb and Noel Paton, that a diet poor in carbohydrates and fluids exerts considerable influence in lessening the weight of the child without otherwise affecting it, and in not a few cases these precautionary measures may obviate a difficult delivery, or even do away with the necessity for the induction of premature labor. *These conclusions stand in marked contrast to those usually held by the laity, who erroneously believe that abstention from proteid food is the essential point.*"

According to this Williams agrees with Prochownick indirectly in saying that the protein food allowed is not an essential factor in determining the size of offspring. Our results, as you will see later, show quite clearly that protein is a most essential factor in promoting a larger growth of the fetus.

In 1910-11 we fed a number of gilts (gilts are really young, immature, ungrown, prospective swine mothers) upon different food stuffs, the results upon five lots of which we append the data.

EFFECT ON OFFSPRING OF FEED FED PREGNANT SWINE.

Gilts—Five in a Lot, 1910-1911.

Gilt Record				Offspring Record					
Pregnancy Ration of Gilts	Av. daily gain lbs.	Feed Daily		Av No. Pigs in litter	Av. wt. new born pigs Lbs.	Vigor			
		Shelled corn Lbs.	Supplement Lbs.			Strong	Medium	Weak	Dead
Corn only	.354	3.65	None	7.6	1.74	68	16	16	0
Corn + Meat Meal (Light)	.582	3.21	.127	7.4	2.01	92	5	3	0
Corn + Meat Meal (Heavy	.635	2.75	.432	8.8	2.23	93	5	2	0
Corn + Clover	.528	3.67	.302	6.4	2.21	94	0	6	0
Corn + Alfalfa	.627	3.74	1.106	7.6	2.29	89	8	0	3

The basal ration was corn alone. Corn we know is quite deficient in protein (the zein which comprises practically 58% of said protein is peculiarly lacking in two quite important amino acids, namely, tryptophane and lysine) and calcium. It is somewhat surprising to know that calcium comprises practically two-thirds as much of the body substance as does nitrogen, the basal element of protein. Corn has other probable drawbacks such as an overabundance of magnesium, small percentage of general ash, acid character of the ash and so forth, but we must not linger upon this highly interesting theme.

Three different supplements were used as indicated, one being meat meal, which is really a packing house by-product composed entirely of meat products and which analyzes about 60% protein, 15% ash (largely bone phosphate) and 10% fat. Clover and alfalfa were the other two.

Note that the supplemented rations not only produced larger but stronger pigs at birth. A studied survey of the above figures shows most clearly that even though the carbohydrates were limited, as in the meat meal lots, the increase in protein and ash was such as to markedly influence the size and strength of the new-born pigs. That clover and alfalfa should also have a marked effect is logical because these hays are leguminous in character, run high in protein and calcium, and also have an alkaline ash which is probably beneficial.

That the litter weights should also be larger on the supplemented rations we found. On corn alone the total litter average was 13.2 pounds; corn and light meat meal 14.89; corn and heavy meat meal 19.62; with clover 14.17 and with alfalfa 17.41.

A further study with swine carried on in 1911-12 with yearling sows is derived from the data now presented:

EFFECT ON OFFSPRING OF FEED FED PREGNANT SWINE.

Yearlings—Ten in a Lot, 1911-12.

Sow Record				Offspring Record					
		Feed Daily				Vigor			
Pregnancy Ration of Sows	Av. Daily Gain Lbs.	Shelled Corn Lbs.	Supplement Lbs.	Av. No. of Pigs in Litter	Av. Weight New born pigs Lbs.	Strong	Medium	Weak	Dead
Corn only	.586	4.97	None	9.2	1.85	41	35	20	4
Corn + Meat Meal	.779	4.11	.500	10.1	2.42	85	5	5	5
Corn + Linseed Oil Meal	.671	4.06	1.129	8.8	2.22	76	15	5	4

The same conditions exist as in the previous year, the supplemented rations giving larger and stronger pigs. The meat meal ration gave somewhat better results than where a vegetable protein supplement, such as linseed oil meal, was allowed. The nutritive ration of these two rations was practically identical. Is the increased efficiency of the meat meal over oil meal due to a better constituted protein, richer in such amino acids as tryptophane or lysine, or is it due to a more acceptable bone building and vitalizing ash?

That the limitation of the carbohydrate was entirely overshadowed by the increased protein in producing larger and stronger pigs is clearly evident.

The litter weights upon the above three rations are respectively 17.06 pounds on corn alone, 24.42 pounds where meat meal was added and 19.50 where oil meal was the supplement.

That the character of coat should be changed by the ration is clearly evident from a survey of the following figures:

COAT CHARACTER.*

(In Percents.)

Ration	Heavy	Medium	Light
Corn only	53	33	14
Corn + Meat Meal	82	15	3
Corn + Linseed Oil Meal	88	8	4

*Based on hair quantity.

Oil meal has been noted from time immemorial as a coat producer, The data speak well for this time honored tradition. That both meat meal and oil meal should increase the coat as well as the color of the skin we who took the data anxiously affirm.

The coats were heavier, darker colored and more dense where the supplements were allowed than where corn alone was used.

That the size of bone should likewise be affected we were privileged to see. This data is presented:

SIZE OF BONE.

(Centimeters.)

	Circumference of	
Ration	Front Shin	Hind Shin
Corn only	4.63	4.39
Corn + Meat Meal	5.05	4.83
Corn + Linseed Oil Meal	4.92	4.67

That meat meal should produce a larger bone than oil meal is quite interesting. That the corn alone pigs should have the smallest bone is not particularly surprising.

Although we have three years' work with ewes and their offspring we are presenting the results for 1911-12 only. These show a general tendency of the ration to affect in some manner the size and vigor of the offspring although the differences are not so marked as where swine are fed entirely upon grain. It is interesting to note in the table which follows that the entire corn plant, as found in silage, fed in conjunction with the corn grain tends to produce quite vigorous offspring. This is largely due, of course, to the fact that silage overcomes some of the deficiencies of the corn grain.

The sheep offspring table follows:

LAMBS BORN OF DIFFERENTLY FED EWES.

Twelve ewes of various ages* in a lot—1911-12.

Ewe Record				Offspring Record					
Pregnancy Ration of Ewes	Av. Daily Gain Lbs.	Feed Daily		Av. No. Lambs to a Ewe	Av. Wt. new born Lambs Lbs.	Vigor			
		Shelled Corn	Roughage Lbs.			Strong	Medium	Weak	Dead
Corn + Clover	.231	.802	2.91	1.67	6.58	60	30	5	5
Corn + Alfalfa	.253	.799	2.71	1.75	7.91	85	5	5	5
Corn + Clover + Silage	.225	.587	{1.74Cl. }2.88Sil.	1.67	7.44	80	20	0	0
Corn + Silage	.237	1.021	4.72	1.33	8.36	81	19	0	0

*Age and breeding uniform for each lot.

It is well to call attention to the small number of offspring per ewe in the corn silage lot which contributes largely to the increased size of the young. Had this lot lambed as many individuals per ewe as the first three mentioned the results would have been problematically different. However, one notices that where silage is added in addition to clover that the vigor and size of the offspring is increased, whereas alfalfa as compared to clover (alfalfa is richer in protein and ash than is clover) produced the strongest and largest lambs even though there were more of them.

In general, therefore, the results on the ewes are in accord with those on the sows with the exception that they are not so marked. I might say, however, that the present season's lambing record shows quite clearly that cottonseed meal added to corn and corn silage increases the strength as well as the size of the offspring. Cottonseed meal contains 41% of protein.

The results of these animal husbandry experiments which show quite clearly that protein and ash when added to the ration are instrumental, especially the former, in increasing the size, fatness, strength, bone and coats of the offspring will be studied by medical men our correspondence affirms. One of our American obstetricians, Dr. J. B. De Lee of the Northwestern University Medical School, has signified his intention of carrying on some experiments along this same line in connection with his human practice. That flock masters and hogmen generally are interested in the production of strong, vigorous new-born individuals, the kind that will live and thrive, is self-evident.

Realizing that the development of the organism may be hindered as early as the embryonic and uterine stages is quite suggestive of a rational diet during the entire period of gestation. Those animals which are forced to subsist upon grain diets are much more unfortunate than those which have their digestive system so constituted as to avail themselves of considerable roughage, which if they be legumes, are very advantageous in the production of vigorous new-born offspring. It is quite fortunate indeed that the mother is able to store in the bones and tissues of her body a considerable amount of material which will tide her over periods of scarcity and enable her to give birth to her young even though the essential constituents are lacking to a large extent in the pregnancy feed.

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*Report of progress.

**Cooperative project undertaken by the Chemical (Dr. A. W. Dox and S. C. Guernsey) and Animal Husbandry Sections.

A CASE OF URTICARIA FACTITIA OBSERVED IN THE COE COLLEGE PSYCHOLOGICAL LABORATORY.

BY W. S. NEWELL.

Record of an unusual affection which appeared in experimental work in tactual space.

In submitting the following record upon a case of Urticaria, the writer has intentionally observed two restrictions, (1) to leave the technical discussion of the disease in question to medical treatises, (2) to avoid unwarrantable generalization from a single case under observation.

While conforming with these limitations, it has seemed that a record of the case, giving such concrete details of the appearance, the progress and the peculiarities of the disease as it was studied in our laboratory, might leave deductions and generalizations to await the discovery of new cases.

We shall pursue the following general plan in presenting the subject:

(1) Circumstances attending the first appearance of the phenomenon in the laboratory.
(2) Description of details leading to given diagnosis.
(3) Urticaria Factitia.
(4) Characterization of Miss M.
(5) Introspections furnished by Miss M.
(6) Conclusion.

(1) As a part of the course in General Pschology, our students perform a series of [1]elementary experiments, and the laboratory records show that several hundred students have, within the past few years, performed substantially the same experiments. A few weeks ago, while supervising the work of an experiment on the tactual localization of a point, some results were obtained which stand unique among our laboratory reports. For the experiment in question, the students are arranged in teams of two each, one student acting as experimenter and the other as subject. The subject's ability to locate a point by touch, is determined by the accuracy with which he can put his pencil upon a spot on his

[1]Seashore, Elementary Experiments in Psychology. Ch. VI, Exp. I.

forearm which the experimenter has lightly touched while the subject's eyes are closed. Fifteen trials are suggested and the points of stimulus and location are transferred to a diagram in the student's notebook for comparison and study.

Such being the general plan of the specific experiment, one of the experimenters was greatly surprised and somewhat disconcerted to note that at every point of his team-mate's arm which the pencil touched, there soon appeared a pronounced welt or wheal.

The experiment had been in progress several minutes before my attention was called to these results. Ten or more wheals, standing up like discs and resembling insect stings figured the area which had been selected for purposes of the experiment. With care not to make the case any more conspicuous than necessary, a few simple facts were determined at this time: (1) The pressure of stimulus and location had been uniformly and normally light, (2) the subject, whom we may designate as Miss M., was aware of this sensitiveness to touch but had never regarded it as unusual. (Later, however, Miss M. asserted that as a young girl she was the recipient of much sympathy because of the unusual ridges or marks which were left on her body after moderate parental chastisement.) (3) The subject was not aware of any physiological conditions which had been or which might be regarded as a sufficient explanation of these wheals. (4) There was not itching or special irritation in the affected spots. Beyond these introductory questions, no further efforts were made in the general laboratory exercise to determine more definitely the origin and development of the wheals.

(2) The progress of this case was followed in several succeeding experiments, under conditions favorable to the discovery of further details through tests and by the information furnished by the subject itself. At no time was Miss M. prejudiced by an undue estimate of the abnormality or gravity of the case. Her attitude was that of an interested observer in the experiments which were made.

At the first meeting in the laboratory, several days after the discovery of the disorder, careful observations were made (1) to corroborate the earlier results by making the markings recur upon light tactual stimulus, (2) to note accurately the length of time which elapsed between the stimulus and the appearance of the wheals, (3) to determine the duration of the wheals and ridges, (4) to note more specifically any peculiarities in size, form, elevation of the wheals due to the character of the instrument used in giving the stimulus or to changes in the pressure of the stimulus.

Our findings on these points, briefly summarized from a number of stimulations on the forearm (both right and left arms, and the front or back of the arm being employed in the experiments) were as follows:

Stimulation by a dull pencil point or a round, blunt-pointed peg brought out separate wheals for each point touched, and these wheals appeared within three minutes after the stimulus. They reached their maximum vividness between five and ten minutes after the stimulation. These wheals measured from 3mm. to 5mm. in diameter varying in size with the fineness of the point used in stimulation. For example, a fine point gently pressing the skin brought out a beadlike disc, while pressure from the flat end of a lead pencil produced a blotch with the same general characteristics as the wheals.

A number of later experiments confirmed our findings as to the interval between stimulation and the appearance of the figures on the arm. The wheals remained visible from half an hour to an hour and a half, gradually sinking back into the normal smoothness and color of the surrounding skin. Frequently a red blotch or line would be the last visible trace of the wheals. The size of the individual wheals varied with the character of the instrument used, and the form was still further modified when the corner of a card was drawn across the skin. In such a test the reaction took the form of a welt or ridge resembling fine beading and having a conspicuous elevation perceptible to the touch, as the fingers were drawn across it. The wheals and the ridges thus produced at the will of the experimenter involved merely the contact to insure their appearance day after day, and with equal clearness whether the experiment were tried early in the morning or late in the afternoon. Miss M.'s ability to duplicate the results in subsequent tests showed that the reactions were not due to any temporary physiological condition. This fact was further confirmed by Miss M.'s own testimony of having long been familiar with this quality of sensitiveness to tactual impressions.

Different parts of the body were not equally sensitive to the same degree of stimulation. There was very little difference between the distinctness of the wheals on the front and on the back of the arm. Any slight advantage might easily have been attributed to inequality of stimulus or to the difficulty of bringing the two surfaces into comparison at the same time. However, when a test was made on the tip of the index finger, with its decided advantage of tactual sensitiveness, no wheal or welt appeared. Repeated experiments on those parts where the epidermis is tough or calloused failed to bring the results described above. Miss M.'s own report of tests performed under the same general conditions but on different parts of the body shows that the condition of sensitiveness is general, having been detected in widely separated areas of the body.

In a series of experiments, attempts were made by the writer to discover whether factors of suggestion could be made to produce or to modify the results as described above. These suggestions took a variety of forms. Verbal suggestions were made by telling the subjest to focus the attention up a proposed figure. Again a certain figure was agreed upon and then, without permitting the subject to see the tracery, a different design was given tactually. Another attempt to make the factor of suggestion as potent as possible consisted in having the subject fixate a design drawn upon paper while the experimenter executed the design close to the surface of the arm but without actual contact. None of these efforts to produce the phenomenon under examination through the subject's own attention proved in the least successful. Whatever more fundamental reasons there may have been for this failure, the writer believes that it was due in part to the subject's inability to control the attention. The means were not at hand to pursue this phase of the experiment further by the aid of hypnotic suggestions but it would seem to be quite in accord with some of the recent results of hypnotism to believe that, were the verbal suggestion made during hypnosis, the graphism would result. This so far as any positive data which the writer has, is conjectural and is not offered as a deduction from his experiments.

(3) Upon reporting the findings as outlined above to a local physician of standing, a professional diagnosis pronounced the disorder to be a form of Urticaria or Nettle Rash. This opinion has been corroborated by the writer, who finds in the descriptions of some eighteen recognized varieties of Urticaria, that the form characterized by the sudden appearance of wheals or marks (autographisms) on the surface of the body, possessed enough points in common with Miss M.'s case as to warrant her disorder being diagnosed as Urticaria Factitia. An equally diversified list of causes assigned to the different forms of Urticaria includes poisoning due to certain foods, such as mushrooms, strawberries; deleterious effects produced by drugs; the crawling of a caterpillar over the skin; certain disorders of menstruation; by nervous irritability, emotion, hysteria, etc.

Some of these causes and, hence, certain forms of Urticaria seem to be eliminated by the results of our tests with Miss M. For example, no temporary disturbance of the gastro-intestinal tract due to eating of certain foods would be likely to give reactions over such an extended period. On the same account, a temporary disorder of menstruation should be omitted from the possible causes. The apparently chronic nature of the case together with the obvious identity of our results with the autographisms in other recorded cases, lead to the diagnosis as Urticaria Factitia, and bring into strong relief those causes referred to as "nervous irritability, emotion and hysteria."

(4) Miss M. is twenty-one years of age, active in college interests outside the class-room, including social, literary and athletic engagements. She appears to be in normal good health and spirits, and in her general bearing is energetic and animated. No physical characteristics indicate any functional disorder. But not the least positive factor in determining the cause and, hence, the classification of the affection under consideration, is an acquaintance with the conspicuous traits of Miss M.'s temperament. Concrete data, furnished by Miss M.'s instructors and based upon observation dating back over several months' acquaintance, indicate the leading features of Miss M.'s nervous organization. Without exception and independently her instructors have noted her nervous instability. One profesor speaks of her erratic conduct in the preparation and recitation of lessons. Another comments upon her inability to concentrate upon matters in hand. Another has observed the frequency of distractions and irrelevancies when working with other students thoroughly absorbed in laboratory occupations. One speaks of her as being a disturbing member of his classes, etc. The writer was informed by a colleague that in the midst of a laboratory exercise in his department Miss M. suddenly burst out laughing, then in embarrassment stated that she could not assign any reason for her unusual behavior.

Indecision and resolute conviction seem to alternate in matters of slight consequence. A lack of motor control is as evident as her inability to control attention. Restlessness and supersensitiveness to surrounding impressions point toward a lack of nervous organization. Her introspective efforts are labored because of the shifting of attention.

All these data plainly show that Miss M. is of the neurotic type familiar to the medical profession. In some cases of meningitis the skin is so sensitive that a red mark will result from drawing the thumb nail across its surface. A hypersensitive condition of the skin whether it shows as a graphism or results merely in an unusual sensori-motor reaction, leads the physician to look for a type of nervous instability such as we have observed in Miss M.

(5) An epitome of Miss M.'s analysis of the conditions under which the disease manifests itself is as follows:

"I do not remember when I first noticed the marks on my skin but I believe that the condition is not of recent origin. These marks were first noticed on my forearm and above my elbow (cause tight sleeve) I cannot analyze my mental attitude on first observing the results but I supposed it was a common result of pressure. The welts show elsewhere on the body and the condition is general. The marks remain distinctly visible about half an hour. While I am nervous occasionally after a tiresome week or some special excitement, I do not know of any nervous disorder which might be regarded as conditions. I am carrying seventeen hours and all my time outside of school is full—Student Volunteer, Camp Fire, Choral Union, etc., etc.—I have no special worries. This matter (the welts) does not impress me as significant. I consider it no more extraordinary than the common cases of flushing or reddening of skin in other young people."

(6) As already implied, the findings in Miss M.'s case will be of chief interest (1) to the observer of psychological conditions, because of the unusual and abnormal type of reaction which points to a deeper nervous disorder; and, (2) to the physician who sees in the foregoing details the typical neurosis with its accompanying functional disturbance. The conditions of nervous instability which the psychologist detects in the regular laboratory exercises are serious enough to justify referring the student to a physician. He may recommend that the student's life of mental discipline and outside duties be given up temporarily for a mode of life designed to correct the conditions. The psychologist is bound to take this broader view of one of the chance by-products of his laboratory practice. We may even question the importance of the experimental means used in this case to produce the peculiar phenomena but if the phenomena point to deeper causes than the instruments used in stimulating touch spots, and these deeper causes mean much to the individual's welfare, then the psychologist's purpose has been accomplished. Whether the actual pressure was essential (as it appeared in all of our tests) or the fact, that any experimenter *was doing something*, was sufficient to focus the attention of the neurotic subject, are secondary in importance to the fact that the graphism confirmed the suspicion of nervous disorder. As noted above the writer worked on the theory that any stimulus sufficiently suggestive would produce the same results as actual pressure. It seems probable that the touch stimulus is the mode by which Miss M.'s attention can best be focussed, but that there is no

special significance to be attached to the surface phenomena more than as indicative of more fundamental disturbance.

In conclusion, mention may be made of a minor point, so far as this study is concerned, but one which is of some significance to the student of certain features of abnormal psychology. Autographism may be productive of a sort of prestige. It is quite easy to understand how in another age, or in a different environment the effect of these markings, first, upon a superstitious public and, then, upon the neurotic subject herself might be sufficient to lead to all degrees of religious extravagance and fanaticism. Mystic marks or religious symbols could start from as matter-of-fact conditions as those of our experiments and, in a crowd of suggestible worshippers, become a menace to religious and social sanity.

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