PROCEEDINGS

OF THE

Iowa Academy of Science

FOR 1922

VOLUME XXIX

THIRTY-SIXTH ANNUAL SESSION, HELD AT
DES MOINES, APRIL 28-29, 1922

PUBLISHED BY
THE STATE OF IOWA
DES MOINES

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THE TORCH PRESS
CEDAR RAPIDS
IOWA

IOWA ACADEMY OF SCIENCE

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1921-1922

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Zoology, H. M. Kelly..................................Cornell College

PAST PRESIDENTS

Osborn, Herbert	1887-1888
Todd, J. E.	1888-1889
Witter, F. M.	1889-1890
Nutting, C. C. (2 terms)	1890-1892
Pammel, L. H.	1892-1893
Andrews, L. W.	1893-1894
Norris, H. W. (1 term)	1894-1896
Hall, T. P.	1896
Franklin, W. S.	1896-1897
Macbride, T. H.	1897-1898
Hendrixson, W. S.	1898-1899
Norton, W. H.	1899-1900
Veblen, A. A.	1900-1901
Summers, H. E.	1901-1902
Fink, Bruce	1902-1904
Shimek, B.	1904-1905
Arey, M. F.	1905-1906
Bates, C. O.	1906-1907
Tilton, John L.	1907-1908
Calvin, Samuel	1908-1909
Almy, Frank F.	1909-1910
Houser, Gilbert L.	1910-1911
Begeman, L.	1911-1912
Bennett, A. A.	1912-1913
Kinney, C. N.	1913-1914
Conard, Henry S.	1914-1915
Kelly, Harry M.	1915-1916
Stewart, George W.	1916-1917
Ross, L. S.	1917-1918
Beyer, S. W.	1918-1919
Stephens, T. C.	1919-1920
Knight, Nicholas	1920-1921
Morehouse, D. W.	1921-1922

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*Arthur, J. C.....Purdue University, Lafayette, Indiana
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*Todd, J. E.....State University, Lawrence, Kansas
*Trelease, William.....State University, Urbana, Illinois
*Udden, J. A.....State University, Austin, Texas

LIFE FELLOWS

*Bartow, Edw. W.....State University, Iowa City
*Beyer, S. W.....State College, Ames
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*Lees, Jas. H.....Geological Survey, Des Moines
Lindly, John M.....Druggist, Winfield
Norton, W. H.....Cornell College, Mount Vernon
Pellett, Frank C.....American Bee Journal, Hamilton, Ill.
Ricker, Maurice.....U. S. Public Health Service, Washington, D. C.
*Ross, L. S.....Drake University, Des Moines
*Seashore, C. E.....State University, Iowa City
*Shimek, B.....State University, Iowa City
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*Boyd, Dr. Mark F...c/o L. W. Hackett, Cairo Postal, Rio de Jan., Brazil

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*Ewing, H. E. .... U. S. Nat'l Museum, Washington, D. C.
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Galpin, Sidney L. .... State College, Ames
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*Wester, C. W. .... State Teachers College, Cedar Falls
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Wilson, Ben H. .... Iowa Wesleyan College, Mount Pleasant
Wilson, Guy West .... Upper Iowa University, Fayette
Wolden, B. O. .... Wallingford
Woodrow, Jay W. .... State College, Ames
*Woodward, S. M. .... State University, Iowa City

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Miller, Cephas ....Cornell College, Mount Vernon
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Mock, Charles A. ....President Western Union College, LeMars
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Poulter, Miss Susannah ....Iowa Wesleyan College, Mount Pleasant
Prottsman, W. G. ....Neola, Iowa
Raeder, J. M. ....University of Idaho, Moscow, Idaho
Ralston, Paul ....Lacona
Reagan, Albert B. ....Cornfields, via Ganado, Arizona
Reed, Ervin E. ....Monticello
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Rouse, Glenn F. ....Washington

Rowe, Paul .... Glenwood
Rusk, W. J. .... Grinnell College, Grinnell
Schriever, Wm .... State University, Norman, Okla.
Schulz, Jno. A. .... Agri. Exp. Station, Ames
Scott, Winfield .... State Teachers College, Cedar Falls
Searight, Walter V. .... State University, Iowa City
Shaffer, Sherman .... Cornell College, Mount Vernon
Shippee, Vernon C. .... Prineville, Oreg.
Slaght, W. E. .... Cornell College, Mount Vernon
Snider, Frank J. .... Kalona
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Spiker, Chas. J. .... New Hampton
Stainbrook, Merrill A. .... State University, Iowa City
Stolt, Miss Margaret Z. .... Hawarden
Takkenberg, Henry G. .... St. Ambrose College, Davenport
Taylor, Joseph .... Wapello
Torrance, D. Merrill .... Van Horne
Treganza, J. A. .... Britt
Trieschmann, Jacob E. .... Ellsworth, Kansas
Van Horn, Max .... Iowa Wesleyan College, Mount Pleasant
Verbeck, L. M. .... Grinnell College, Grinnell
Wait, G. R. .... Carnegie Inst. Ter. Magnetism, Washington, D. C.
Watson, Emery E. .... 2004 Olive St., Cedar Falls
Weeks, Carl .... 124 Des Moines St., Des Moines
Weeks, Rev. Leroy Titus .... Emmetsburg
Wehman, H. J. .... Burlington
Wellhouse, Walter H. .... Iowa State College, Ames
Whipple, Mrs. Elizabeth Springer .... Wapello
Whittaker, J. S. .... Corydon
Willson, L. H. .... 315 Sixth St., Ames
Windenburg, Dwight .... Cornell College, Mount Vernon
Young, Paul A. .... Coe College, Cedar Rapids

TITLES OF PAPERS PRESENTED

Archaeology

Geology

Mathematics

Iowa Section, Mathematical Association of America,

Physics

Zoology

Botany

Chemistry

Iowa and Ames Sections American Chemical Society

PROCEEDINGS OF THE THIRTY-SIXTH ANNUAL SESSION OF THE IOWA ACADEMY OF SCIENCE

Drake University, Des Moines, April 28 and 29, 1922

The meetings of the thirty-sixth annual session were held at Drake University on Friday and Saturday, April 28 and 29, 1922. President Morehouse called the session to order at 1:30 p. m. on Friday in the Auditorium. After the transaction of business the president announced the following committees for the session:

Nominating, Messrs. Conard, Knight and Stewart.

Resolutions, Messrs. O. H. Smith, Jaques, Cable, Baker.

Membership, The Treasurer, the Secretary.

Conservation, Messrs. Pammel and Bennett.

Secretary's Report, Messrs. Doty, Raiford, Norris.

Necrology, Messrs. B. H. Wilson and Kay.

Auditing, Messrs Reilly and Ross.

After announcements by the local committee President Morehouse gave the Presidential Address on "The Cosmology of the Universe." The Academy then separated for the section meetings and at 6 o'clock the sections met for dinners.

At 8 o'clock the Academy convened at the Municipal Observatory to listen to the public address on "Some Aspects of Science," by President Edgar O. Lovett of Rice Institute, Houston, Texas. After the address President Holmes of Drake and the members of the University tendered a reception to the visiting scientists and opportunity was given for inspection of the Observatory and using the 9-inch telescope.

On Saturday morning the sections met for the completion of the reading of papers and at 10 o'clock the Academy gathered to hear several papers of general interest.

At 11 o'clock the President called the Academy to order for the closing business meeting. The first order of business was the reports of committees. The president called for the reading of the minutes of the meeting of the executive committee at Grinnell on October 22, 1921. These were read as were also those for the meeting of the executive committee held at 9 a.m. on Saturday, April 29, 1922. It was then moved that the action of the executive committee be endorsed and approved by this body. A rising vote was called for and the motion was carried unanimously.

Invitations for the next meeting were received from Cornell, Grinnell and Penn Colleges and from the Tri-State Science Club of Oskaloosa, and Doctor Pammel invited the Academy to meet with the State College in 1924, when he will have been with the College thirty-five years. The invitations were referred to the executive committee which later decided to meet with Cornell in 1923.

The temporary committees gave their reports and in the absence of Mr. Ben H. Wilson, Professor Jaques reported the death of Professor C. C. Norwood of Iowa Wesleyan College. The report was adopted and a memorial will be found in this volume.

Doctor Conard for the committee on nominations reported as follows:

For President, R. B. Wylie, State University.

Vice-President, Orrin H. Smith, Cornell College.

Secretary, James H. Lees, Iowa Geological Survey.

Treasurer, A. O. Thomas, State University.

It was moved and carried that the report be adopted.

The following members were elected chairmen of sections and as such are members of the executive committee:

Botany, H. S. Conard, Grinnell College.

Chemistry, Edward Bartow, State University.

Geology, S. L. Galpin, State College.

Mathematics, C. W. Emmons, Simpson College.

Physics, L. D. Weld, Coe College.

Zoölogy, H. W. Norris, Grinnell College.

After the discussion of new business the Academy adjourned.

REPORT OF THE SECRETARY

Members of the Academy:

The duties of the secretary of an organization like ours are somewhat diversified, despite an expressed opinion as to "his simple tasks," and hence I beg that in this so-called report of the secretary I may be permitted some latitude in the scope of my remarks. As one of the officers of the society who is presumably keeping the welfare of the Academy in the forefront of his thought there are several directions from which impressions come to the secretary's mind and varied channels through which he may in thought or action effect desired results. It is desirable first of all that the secretary, in common with the officers and members of the Academy, keep continually the welfare of the general body as one chief goal of attainment. Another aim of large importance is the improvement and quickening of scientific research in general, and in particular in the schools of our own state and those represented in this body. And the still broader desideratum is the bringing of the value and results of such study and research to the attention and comprehension of a public which still knows and appreciates all too little of the import of the work we are doing. In fact, to what degree do we ourselves appreciate the general signification of the work of our fellow investigators? How far is the mathematician cognizant of the universal value of chemical research? To what extent does the psychologist appreciate the personal application of the studies of a botanist? Of course the geologist must enlist all sciences to aid in his advance — from the highest heavens to the profoundest depths — and therefore he must needs realize the value of all scientific endeavor and achievement.

Closely connected with research in pure science is its application to subserve the needs of the public which is perpetually clamoring for new means of bettering its physical and mental condition. Research for research's sake is fascinating and worthy of appreciation, but research for the uplift of humanity is more worthy still. During the year there appeared in one of the technical journals an advertisement which impressed this thought so strongly that I have taken the liberty of reproducing it in part here. It read as follows:

HOW DO HOT THINGS COOL?

"The blacksmith draws a white-hot bar from the forge. It begins at once to cool. How does it lose its heat? Some is radiated, as heat is radiated by the sun; but some of it is carried away by the surrounding air. Now suppose the bar to be only one-half the diameter; in that case it loses heat only half as fast. Smaller bars lose in proportion. It would seem that this proportion should hold, however much the scale is reduced. But does it? Does a fine glowing wire lose heat in proportion to its diminished size?

The research laboratories of the General Electric Company began a purely scientific investigation to ascertain just how fast a glowing wire loses heat. It was found that for small bodies the old simple law did not hold at all. A hot wire .010 inch diameter dissipates heat only about 12 per cent more rapidly than a wire .005 inch diameter instead of twice as fast as might be expected.

The new fact does not appear very important, yet it helped bring about a revolution in lighting."

The statement then describes in detail the method of using a helix of fine tungsten wire in a gaseous medium by means of which "a new lamp was created which at the same cost gave more and better light." In conclusion the advertisement says:

"Thus pure research, conducted primarily to find out how hot things cool, led to the invention of the gas-filled lamp of to-day — the cheapest, most efficient illuminant thus far produced.

"Sooner or later research in pure science enriches the world with discoveries that can be practically applied. For this reason the research laboratories devote much time to the study of purely scientific problems."

It may be argued that there is a selfish motive behind the pure research in this case, but may it not be conceded that beyond the utilitarian incentive there is also a humanitarian wish to elevate and improve living conditions. Thus it may be in all research. That accomplishes the greatest good which most helps mankind, be it in physical, mental or spiritual channels.

The work of the year has been very much like that of other years. There has been quite a large and varied correspondence — with members regarding various phases of the Academy's work, with others who are interested in our publications; and in addition, despite the fact that we have issued no volume of Proceedings during the past two pears, there has been a large number of books distributed to various parts of the world.

The problem of the publication of our Proceedings is like the proverbial poor — it is ever with us. At risk of becoming wearisome may I restate the situation? The 38th General Assembly abolished the offices of state printer and state binder and provided that all public printing should be done by contract. But it provided also that no awards should be made at prices beyond those previously paid under the old law. The war caused prices to soar and this automatically put a stop to publication until the 39th General Assembly unscrewed the lid. When that was done the Printing Board which was created by the new law proceeded with the authorization of the printing of the accumulated documents, among which were two volumes of Academy Proceedings. The contract for these two volumes was awarded the Torch Press of Cedar Rapids, and the first volume is now under way.

As soon as possible the second volume will be turned over to the printer.

The Secretary regrets that the Printing Board saw fit to limit the pages of these volumes to 400 each. This was done after the Secretary had explained to the Board the purposes of the Academy and its publications and with full knowledge of recent procedure. If the members would exert themselves to urge upon the elective members of the board — the Attorney General, the Auditor of State and the Secretary of State — the undesirability of limiting the size of our volume, it might have some effect. Let it be remembered that this is election year.

The Secretary will freely admit that much of the delay in issuing the Proceedings occurs in his own office. With the work of the Academy added to the work of the Geological Survey it is not within the limits of his time or strength to read the copy and then the proof as quickly as he would like to do. So long as the Academy must choose a secretary from those of its members who are already busy with other work the outlook for more prompt publication does not seem very hopeful. It should be said, however, that because the Survey's reports have been denied publication as have those of the Academy the situation this year is worse than usual and hence may be expected to be somewhat relieved by another year.

The Academy has experienced a healthy growth during the year. The Treasurer reports that a year ago the membership numbered 313. At the Simpson meeting there were elected five fellows and fifty-four associates of whom forty-four accepted their election. During the year twenty-two names were dropped from the roll, chiefly, I believe, because of the constitutional provision calling for such action after two years financial delinquency. This leaves a net increase of twenty-seven in our membership, bringing it to the number of 340. This number is distributed as follows: Honorary Fellows, 6; Life Fellows, 24; Fellows, 167; Associates, 143.

The present Secretary took office following the meeting for 1914. At that time there were enrolled 260 members of all classes. Today, as already indicated, the membership is 340. The program for that meeting included fifty-nine titles and was the largest presented to the Academy up to that time. The program now in your hands contains 103 titles and nine additional were received too late for publication. These figures reveal not merely the material development of the Academy in the past eight years, but, going deeper than that, they show that Iowa has an Academy of Science of which its members are sincerely proud and for which they are glad to work and for which they do work.

For the achievements already won I congratulate you. To the results yet to be accomplished I urge your attention and your thoughtful energy. What we may do is scarcely to be measured by what we have already done.

Respectfully submitted,

James H. Lees,
Secretary.

TREASURER'S REPORT

Receipts

Balance on hand April 30, 1921	$ 73.69
Income from Entrance dues	55.00
Income from Annual dues	276.00
Income from Transfer fees	25.00
From sale of Proceedings	6.00
From Life Fellows	45.00
Interest on Bonds $2.75, on deposits $13.88	16.13
Overpayments by members	4.00
A. A. A. S. dues collected	536.00
For Membership List, Vols.	7.50
Refund from A. A. A. S.	4.00
Transferred from Savings Account	85.00
	$1133.32
Check No. 34 in transit	1.00
Total	$1134.32

Disbursements

Iowa Printing Company Stationery and Inserts	$ 21.45
Programs for 35th meeting	25.15
Postage for Treasurer	19.00
Postage for Secretary	11.00
Group photos at Simpson for Secretary's Archives	2.50
J. P. Goode, Address and traveling expenses	142.82
Stenographic work, treasurer	19.13
Refund to members, overpaid	4.00
Traveling Expenses, called meeting Executive Committee, October 22, 1921	45.74
Honorarium to Secretary	75.00

Honorarium to Treasurer	25.00
To Miss Newman, distributing Proceedings	10.00
Dues remitted to A. A. A. S.	528.00
For A. A. A. S. membership lists	7.50
Deposited in Savings Account	60.00
Fifty Dollar Liberty Bond — Second Loan 4¼%	43.36
Fifty Dollar Liberty Bond — Victory Loan 4¾%	50.46
	$1090.11
Balance on hand	44.21
	$1134.32

Unpaid Dues of Less Than Two Years' Standing:

11 Fellows in arrears 1 year	$ 11.00
4 Fellows in arrears 2 years	8.00
19 Associates in arrears 1 year	19.00
9 Associates in arrears 2 years	18.00
	$ 56.00

Assets of Academy, April 29, 1922, are as Follows:

Balance in Bank	$ 44.21
Savings Account	375.00
Bond, Second Loan 4¼% — value to-day	49.91
Bond, Victory Loan 4¾% — value to-day	50.35
Accrued Interest on Savings Account, to date	5.00
Back Dues	56.00
	$ 580.47

A. O. Thomas,
Treasurer.

April 28, 1922.

REPORT OF COMMITTEE ON CONSERVATION

Your committee on conservation is pleased to note that there is a feeling that conservation is on more stable ground in the United States to-day than ever before in the history of the country. However, we wish to warn the members of the Academy that we need to be on the alert in order to protect conservation interests. Your committee begs leave to report the following:

Forestry

We consider the matter of forestry of great importance to the welfare of the country and especially to Iowa. The forests are essential to our civilization. It is therefore of great importance that adequate provision be made for the growing of forest trees, not only because of the economic use of timber, but for the protection of wild life and recreation. We recognize that Iowa is a great agricultural state, where fertile lands must produce large agricultural crops and that much of the soil can not, from an economic standpoint, be used to produce a forest crop. We also recognize that there are 3,000,000 acres of land in the state which are not producing adequate agricultural crops, and which should be made to produce something in the way of a crop suited for these lands. By planting such idle lands to a forest crop, the state will be much richer. We, therefore, urge the importance of utilizing such lands for the growing of trees. Cut over lands in the state should receive proper care so that the regrowth of good forests may start at once. We urge upon our legislature such needed legislation as will materially reduce the taxation on privately owned forest lands so that a remunerative crop can be produced; that in taxation a distinction shall be made between forest lands and other farm lands; that the taxation on such lands shall be reasonable. We commend the present tax exemption law where forests are not taxed when the same are not used for pasture purposes, and a good stand of timber is found thereon. The law, however does not meet all of the requirements of good forestry and should be amended to properly safeguard the state. The state should encourage small forest areas and for this purpose small areas might well be set aside as state forests. We urge that state owned lands subject to overflow shall be utilized for the growing of timber; that the state stop the sale of such public land and allow it to grow up with forest trees. We would urge that cities where possible establish municipal forests, especially along streams or hillsides. We realize that our largest returns ultimately will come from the public forests of the government, or in some states from state forests. We also realize that these public forests in Iowa can never be large and that it must be individual enterprise, and any state aid that can be given the private individual should be encouraged in every way. We deplore the burning of some of the woodland tracts in northeastern Iowa and there should be a law to stop this.

Erosion and Conservation of Water

Newspapers have given us only a partial idea of the devastation of floods during the last month; over 75,000 people were rendered homeless in the Mississippi valley, in spite of the fact that expensive levies have been built to protect individuals, cities and states. These floods will continue as long as our waters are rushed down the small streams and creeks and emptied into the larger streams causing them to go out of their banks. We, therefore, view with concern the straightening of streams and the building of large drainage ditches, changing the channels of the small streams, causing a rapid run-off of water which is thrown into the main channels with disastrous results to property owners farther down the stream. The water should be kept back by reforesting the hillsides and keeping the trees of the slopes in good condition, so that the water may enter the soil through the humus. During the early days in Iowa the streams were clear soon after a rain, perennial springs were numerous. Lakes, no matter of what kind, should be preserved to hold back water so that along with the water percolating through the soil of a forest this water will be made available for agricultural crops. We are opposed to spending millions of dollars for the kind of reclamation work advocated by the Mississippi Valley Association. We are an agricultural state and water is of vital importance for our welfare.

Aquatic Resources

There are something like seventy meandered lakes in the state, besides such meandered streams as the Des Moines, Cedar, Iowa, Wapsipinicon, the Missouri on the west and the Mississippi on the east. These lakes and streams abound in animal life which adds materially to the wealth of Iowa. We will seriously curtail this wealth of Iowa by shutting off the food supply of fish, wild game and muskrats by draining the lakes or destroying the sloughs of the Mississippi and Missouri. Aquatic plants, with few exceptions, cannot grow in rapid running streams, and many of these plants which furnish the food for these aquatic animals will not grow in water much more than three to four feet deep, though a few occur in eight to ten feet of water. Therefore, if we expect to retain this source of wealth, this plant life must be maintained and more shallow bodies of water must be provided. We must view with alarm some of the drainage projects of the state. This problem is connected with recreation, and is therefore a problem of conservation as well as a problem of economic production.

According to the biological station at Fairport the annual net fish production is as follows: The average annual net fish flesh production of the Fairport farm pond, measuring 0.22 acre in surface area, has been for the four years from 1918 to 1921 inclusive, 65 pounds, 6 ounces, or per acre 297 pounds 2 ounces. The maximum annual net fish flesh production has been 82 pounds, 7 ounces, or per acre, 374 pounds, 11 ounces. The maximum annual production of fish of edible size has been estimated at 20 per cent of the total net annual fish flesh production. The total annual production of fishes of the current year has varied from 6.3 to 26 per cent of the total net production, while the bass were held in the pond. After these were removed and the bluegills alone were held as the experimental fish, the per cent of the total net production of the pond based on this factor increased to 57.5 and 59.7 in the years 1920 and 1921, respectively.

Forestry and the National Government

We are opposed to the transfer of the forests and forest service from the U. S. Department of Agriculture to the Department of the Interior. The national forests have been wisely administered by the National Forest Service and should therefore remain in the U. S. Department of Agriculture. The forest is an agricultural crop which requires a long time to mature. Such problems as diseases caused by fungi and insects and the ecology all must be considered by trained experts and no other agency of the government is so well able to take care of the problem as is the U. S. Department of Agriculture. A faithful steward should be rewarded.

Wild Game Protection

We commend the last session of the legislature for legislation in protecting the quail and we would ask that the bag limit on other game be materially reduced. We are pleased to note that the migratory bird law is respected much more than it formerly was. There are still violations but it is because of the inadequacy of the force at work to stop these violations. Wild ducks and geese should have larger areas in which to breed in the state of Iowa, and therefore ponds and sloughs should be preserved and owned by the state. We commend the last legislature in passing a law pertaining to the meandered streams and lakes of Iowa as a step in the right direction. We commend the quarantine regulations of the U. S. Department of Agriculture, especially regulations No. 37, which should not be abrogated but enforced to the letter.

Historic Trees

We urge the keeping of unique, large and old trees of Iowa for scientific and historic purposes; we urge that some of these giants of the forest be used to memorialize important events in the history of the state and to perpetuate the memories of those who served in the late or previous wars. We would commend the action of our governor in issuing a proclamation for planting trees on Arbor Day and hope this custom may be continued in the state.

Flowers

Your committee feels that it is important to conserve our native wild flowers; that the state parks of Iowa shall be sanctuaries not only of wild animal life, but the wild flowers, trees and shrubs as well. The committee would like to go a step further and recommend to the citizens of Iowa that they refrain from the picking of wild flowers, especially the rarer species like the bluebell, wind and pasque flowers, columbine, moccasin flower, mandrake and many others. We would like to suggest that every community in Iowa do a little missionary work in trying to save the wild flowers. In order that the question may be brought nearer home, we would suggest that we have a day set aside as a state flower day.

Iowa Conservation Association and Federated Women's Clubs of Iowa and Wild Life School

We wish to commend the work of the Iowa Conservation Association for its activity in connection with conservation and the great work of the Federated Women's Clubs of Iowa in behalf of conservation. We are glad to note the progress of the School of Wild Life at McGregor, Iowa. These organizations reach a large number of the people of the state, and the conservation movement is greatly helped.

Signed L. H. Pammel
(T. C. Stephens, absent)
Geo. Bennett

REPORT OF THE COMMITTEE ON RESOLUTIONS

WHEREAS this thirty-sixth annual meeting of the Iowa Academy of Science, which is now drawing to a close, has been one of the most successful in the history of the Academy, BE IT RESOLVED that we extend to the president and faculty of Drake University and to the city of Des Moines our sincere appreciation of their cordial and gracious welcome, generous hospitality, and efficient provisions for the successful entertainment of this meeting.

BE IT FURTHER RESOLVED that we express our great pleasure in the masterful address of President E. O. Lovett of Rice Institute, Houston, Texas.

BE IT FURTHER RESOLVED that we recognize in the success of the meeting and in the work of the Academy in general the faithful, efficient, and intelligent efforts of our officers and executive committee and especially of our secretary and treasurer whose efforts, continued year after year, have entered so effectively and so largely into the policies of the Academy.

BE IT FURTHER RESOLVED that we commend the governor and the executive council of the state and the state conservation board for their work in conserving of our natural resources.

WHEREAS the hand of death has entered the homes of some of our members,

BE IT RESOLVED that we extend to Professor B. Shimek our deep sympathy and regret of the loss of Mrs. Shimek from his family circle.

BE IT FURTHER RESOLVED that, on the occasion of the passing of Mrs. Rockwood, we extend our heartfelt sympathy to Professor E. W. Rockwood.

O. H. Smith,
H. E. Jaques,
E. J. Cable,
J. A. Baker,
Committee.

REPORT OF COMMITTEE ON SECRETARY'S REPORT

Your committee appointed to consider the suggestions of the secretary recommend the acceptance of the report in full. We wish to commend the secretary for his endeavors to bring about the means whereby a prompt publication of the Proceedings of the Academy will be assured.

Respectfully,

H. S. Doty,
(For the Committee)

REPORT OF THE MEMBERSHIP COMMITTEE

Transferred Members. — Ainslee, G. N., Sioux City; Baldwin, F. M., Ames; Bode, I. T., Ames; Brown, F. E., Ames; Davis, George E., Ames; Emerson, F. W., Oskaloosa; Ellison, C. W., Waterloo; Gilman, Henry, Ames; Gouwens, C., Ames; Johns, Erwin W., Northfield, Minn.; Lindly, John M., Winfield; Laird, Don, Iowa City; McKelvey, J. V., Ames; Patton, Leroy, New Concord, Ohio; Sawyer, Louise, Galesburg, Ill.; Simpson, Margery, Green Castle, Indiana; Stecher, Lorle I., Iowa City; Smith, Don M., Ames; Willey, Florence, Ames; Williams, N. J., Arnolds Park; Weida, F. M., Iowa City; Wentworth, C. K., Iowa City; Wilson, B. H., Mount Pleasant; Young, Paul A., Cedar Rapids, (Coe College).

Fellows. — Carr, A. B., Indianola; Clokey, Ira W., Ames; Evans, J. E., Ames; Hart, Hornell, Iowa City; Hulbert, E. O., Iowa City; Leicht, W. F., Indianola; Popoff, Stephen, Iowa City; Theobald, John, Dubuque (Columbia College); Whiting, P. W., Iowa City; Woodrow, Jay W., Ames.

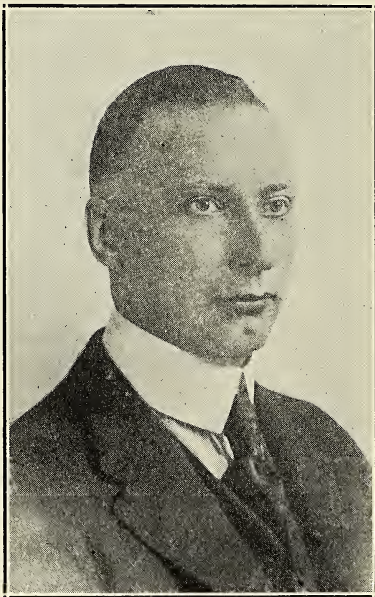
New Members. — Adams, John E., Iowa City; Baltz, James, Mount Vernon; Becker, A. G., Clermont; Bell, Ruth, Des Moines; Berry, June, Mt. Pleasant; Butcher, Fred D., Ames, Zoölogical Department; Cain, Edith, Des Moines, 2840 University Ave.; Carnahan, Marye, Mount Pleasant; Castetler, E. F., Ames; Chittum, John, Wapello; Corlette, Donald D., Mount Vernon; Cox, Benjamin B., Chicago, Ill.; Culbertson, Prof. J. B., Mount Pleasant; Damerow, Arthur, Mount Vernon; De Ryke, Willis, Iowa City; Elmer, O. H., Ames; Emmons, Prof. C. W., Indianola; Evans, Arthette R., Oak Bluffs, Mass.; Fenton, Carroll Lane, Chicago, Ill., Walker Museum; Gauet, Foster, Mount Pleasant; Giddings, Glenn, Mount Vernon; Hauber, Ulrich A., Davenport, (St. Ambrose College); Havens, Hale, Mount Vernon; Hockett, Prof. S .W., Oskaloosa, Penn College; Jensen, Lloyd, Alta; Kadesch, W. H., Cedar Falls; Lantz, Prof. C. W., Cedar Falls; Larson, H. W., Des Moines, 1607 E. Walnut St.; Leonard, Ray, Avoca; Lewis, Harry F., Mount Vernon; Littlefield, Max, Iowa City; Malone, Howard E., Keokuk; McLaughlin, H. M., Ames; Morgan, Russell, Clinton; Muncie, J. H., Ames; Olson, T. C., Alta; Over, W. H., Vermillion, South Dakota; Phillips, George, Des Moines, 1149 28th St.; Potter, George E., Iowa City; Poulter, Susannah, Mount Pleasant; Reagan, Albert B., Cornfields, Ganado, Arizona; Searight, Walter V., Iowa City; Slaght, Prof. W. E., Mount Vernon; Sternberg, J. C., Iowa City; Taylor, Joseph H., Wapello; Van Horn, Max., Mount Pleasant; Van Zandt, Fritz Nelle, Des Moines, 1344 27th St.; Wellhouse, Walter H., Ames; Windenburg, Dwight, Mount Vernon; Verbeck, L. M., Grinnell.

A. O. Thomas,
James H. Lees,
Committee.

LIST OF MEMBERS IN ATTENDANCE

Abbott, Roy, Cedar Falls; Albert, O. W. Grinnell; Almy, Frank F., Grinnell; Arey, M. F., Cedar Falls; Baker, J. Allen, Indianola; Bakke, A. L., Ames; Baldwin, F. M., Ames; Baltz, James I., Mount Vernon; Bartow, Edward, Iowa City; Begeman, L., Cedar Falls; Benedict, A. A., Ames; Bennett, George, Iowa City; Beyer, S. W., Ames; Bird, Kenneth L., Ames; Bond, Perry A., Iowa City; Brown, F. E., Ames; Brunk, Amos, Des Moines; Butler, L. W., Ames; Cable, Emmett J., Cedar Falls; Carnahan, Miss Marye, Mount Pleasant; Carr, A. B., Indianola; Castetler, E. F., Ames; Chittenden, E. W., Iowa City; Clark, Norman A., Ames; Clokey, I. A., Ames; Conard, Henry S., Grinnell; Conklin, R. E., Des Moines; Corlette, Donald D., Mount Vernon; Cratty, R. I., Ames; Crone, Neil L., Grinnell; Culbertson, J. B., Mount Pleasant; Damerow, Arthur, Mount Vernon; Davis, George, Ames; Doty, H. S., Indianola; Emmons, C. W., Indianola; Evans, J. E., Ames; Fenton, F. A., Ames; Galpin, Sidney L., Ames; Getchell, R. W., Cedar Falls; Giddings, C. W., Mount Vernon; Gilman, Henry, Ames; Gose, Bert C., Indianola; Goshorn, Arthur, Winterset; Goshorn, Mrs. Gertrude Rhodes, Winterset; Harrison, B. M., Ames; Hart, Hornell, Iowa City; Hartzell, Albert, Ames; Haven, H. A., Mount Vernon; Hayes, Anson, Ames; Heaton, Vincent E., Ames; Heitkamp, G. W., Dubuque; Hendrixson, W. S., Grinnell; Hersey, S. F., Cedar Falls; Irion, Clarence E., Ames; Jaques, H. E., Mount Pleasant; Jones, Miss Eunice, Grinnell; Kay, G. F., Iowa City; Kelly, Harry M., Mount Vernon; King, George E., Mount Pleasant; Kinney, C. N., Des Moines; Knight, Nicholas, Mount Vernon; Kunerth, Wm., Ames; Lamb, A. R., Ames; Lantz, C. W., Cedar Falls; Larson, G. A., Des Moines; Larson, H. W., Des Moines; Lawson, D. F., Waterloo; Lees, James H., Des Moines; Leicht, F. V., Indianola; Lewis, H. F., Mount Vernon; Lowman, O. E., Fayette; Lu, K. Y., Grinnell; McClennon, R. B., Grinnell; McGaw, F. M., Mount Vernon;

Martin, John N., Ames; Mason, O'Neal, Mount Vernon; Maxwell, Harold L., Ames; Meister, Charles J., Ames; Mooers, Miss M., Grinnell; Morehouse, D. W., Des Moines; Morgan, R., Mount Vernon; Norris, H. W., Grinnell; Pammel, L. H., Ames; Popoff, Stephen, Iowa City; Poulter, Miss Susannah, Mount Pleasant; Raiford, L. Charles, Iowa City; Read, O. B., Cedar Falls; Reed, Charles D., Des Moines; Reilly, John F., Iowa City; Rietz, H. L., Iowa City; Rockwood, E. W., Iowa City; Ross, L. S., Des Moines; Rowe, Paul R., Glenwood; Schultz, J. A., Ames; Sherman, L. P., Grinnell; Sieg, L. P., Iowa City; Smith, D. M., Ames; Smith, John E., Ames; Smith, Orrin H., Mount Vernon; Stanley, F. C., Oskaloosa; Stewart, G. W., Iowa City, Iowa; Stiles, H., Ames; Stromsten, Frank A., Iowa City; Suydam, V. A., Grinnell; Sylvester, Reuel H., Des Moines; Taylor, Joseph, Mount Pleasant; Thomas, A. O., Iowa City; Thompson, George E., Ames; Trowbridge, A. C., Iowa City; Verbeck, L. M., Grinnell; Wester, C. W., Cedar Falls; Whiting, P. W., Iowa City; Wifvat, Samuel J. A., Des Moines; Willson, L. H., Ames; Wilson, Ben H., Mount Pleasant; Woodrow, J. W., Ames; Wright, H. V., Ames; Wylie, R. B., Iowa City.



FRED C. WERKENTHIN

IN MEMORIAM

FRED C. WERKENTHIN

On June 13, 1922, death again entered the ranks of Iowa scientists, taking from us a young botanist of unusual promise.

Fred C. Werkenthin received his A.B. and A.M. degrees from the University of Texas in 1915. He was assistant professor of biology in the College of New Mexico and station plant pathologist, 1915-1918; associate professor of botany and assistant botanist in experiment station in New Hampshire State College, 1918-1920; instructor in botany at Iowa State College, 1920-1921, and assistant professor, 1921-1922. A short time before his death, he was elected head of the botany and bacteriology department in the University of Louisiana.

While connected with the New Mexico Agricultural College, Mr. Werkenthin published a number of papers on plant diseases and their control. He did some excellent work on the fungus diseases of Texas soils, the results of which were published in Phytopathology, Vol. 3, No. 3, 1916. At the time of his death, he had ready for publication a paper on the classification of Cucurbits and one on the history of plant breeding. Thus, within a period of seven years after graduating from the university, he had published more than a half dozen excellent papers and had been advanced to the headship of botany and bacteriology in one of the leading southern universities.

All his promotions were indicative of his merits. Like many others, he was forced to earn most of the expenses of his education. He was an incessant worker and had the ability of accomplishing much in a short time.

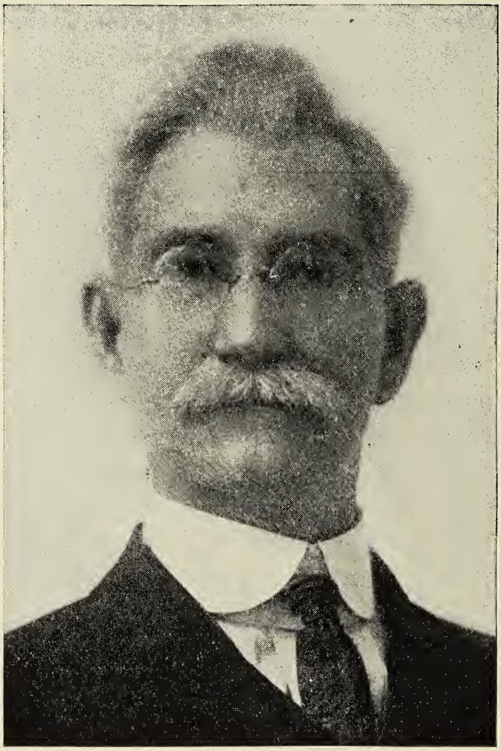
Fred was not only an excellent investigator, but he was a remarkable teacher. He was able, as few teachers are, to combine the lecture and recitation methods so efficiently as to cover the subject matter one could ordinarily cover in a lecture and yet receive about as much response from the class as ordinarily obtained in recitation. There were no passive recipients in his classes. In addition to the asset of an impressive personality he was always prepared to the smallest details for his lectures, laboratories, or any other tasks.

His students sought him as a friend and advisor and his office was at times an assembly for those wanting counsel on various matters.

As an associate, his chief motive was to help others. If there was an opportunity to do something for his fellowmen that would make this world "seem better to live in" as he himself expressed it, he always saw the opportunity and turned it to account.

He was unblemished morally and was guided by a high standard of ideals. In his death, not only has science lost a young man of great promise, but to all humanity there befalls the loss of a young man, clean and with the noblest of aims, the type of man the world so much needs.

JOHN N. MARTIN



CHALMERS COLIN NORWOOD

CHALMERS COLIN NORWOOD

1853-1922

Professor Chalmers Colin Norwood was born in the state of Alabama in 1853, of Scotch parentage. His early boyhood was spent in that state and in North Carolina, where he attended Davison College, receiving his A.B. degree from this institution in 1878, at the age of twenty-five; later he attended Johns Hopkins University as a graduate student, where he sat under the instruction of Simon Newcomb and other eminent scientists of those times, receiving his A. M. in 1882. He was professor of mathematics in the Maryland Agricultural college from 1882 until 1886, whereupon he returned to his Alma Mater, to become professor of physics and astronomy, which position he held for two years, 1886-1888. Professor Norwood then became an examiner in the Patent office at Washington, D. C., occupying this post from 1888 until 1893, at which time he was compelled to seek a western location to benefit the health of Mrs. Norwood. He removed to the west and occupied the following positions in turn, all of an educational and scientific nature: professor of mathematics and physics, Agricultural College of Utah, 1895-1897; superintendent of public schools, Evanston, Wyoming, 1897-1904; professor of physics and applied mathematics, Westminster College, 1904-1918; graduate student in physics, Columbia University, summer session, 1917; service with Hercules Powder Company, Ballistic engineering, 1918-1919; and professor of physics, Central College, Missouri, 1919-1920.

Professor Norwood entered work in the field of science in Iowa in September, 1920, when he assumed the duties of the chair of physics at Iowa Wesleyan College, Mount Pleasant, where, by his quiet unassuming manner and wonderful spirit of coöperation and helpfulness, he quickly endeared himself to both faculty and student body. Although the senior member of the faculty from the point of age, his mind remained open and he was quick in his appreciation and as keen in the assimilation of the newest discoveries and theories of science, as were his pupils for those new truths he so simply and adeptly unfolded to them from his lecture room.

At the time of his death he was engaged in an intensive study of the Einstein "Theory of Relativity." His last public utterance, aside from his class room work was a lecture on this subject delivered before a joint meeting of the physics and chemistry clubs of Iowa Wesleyan College, and it is said by those who were privileged to hear it, to have been remarkable, both for the clearness of his conception of the theory and also for his ability to explain it by the use of such simple terms and illustrations that many of the pertinent facts might be grasped by even the under-graduate student.

It may truthfully be said, that Professor Norwood sacrificed his life for science, for the immediate cause of his fatal illness was exposure brought about by a strenuous trip to Iowa City to sit in on the lecture of Dr. H. A. Lorenz, of the University of Leyden, Holland, on the subject of "Old and New Mechanics," given before the students of the Graduate College of the State University on the evening of March, 6, 1922. The trip required his being up on two consecutive nights, which exertion overtaxed his strength, the physical strain being too great for a man of his years. He returned home exhausted and suffering from an illness which quickly developed into pneumonia, and on March the 30th, 1922, he fell asleep in death as quietly as he had lived.

Although a member of the Iowa Academy of Science but a short time, he impressed all those who were privileged to know him as an earnest student and a Christian gentleman. He was conscientious in his work and faithful to every duty. His quaint, gentle mannerisms will not soon be forgotten, and though he is gone, his influence for the good of science will live on in the lives of the four generations of students, many of whom are now eminent scientists, who sat under his teachings.

In 1889 he was married to Mary Greenleaf Thuthell, and is survived by her and one daughter, Helen Alice, who was born to the union. His earthly remains were taken to Matewan, New Jersey, where they were laid to rest.

Ben Hur Wilson

PAPERS PRESENTED AT THE THIRTY-SIXTH ANNUAL MEETING

THE ADDRESS OF THE PRESIDENT

THE COSMOLOGY OF THE UNIVERSE

D. W. MOREHOUSE

Astronomy is the original science. Its scope comprehends all the physical sciences — geology, physics, chemistry — and even the natural sciences. All borrow from it, and in turn contribute to astronomical knowledge. Moreover, from the very beginning, the study of astronomy has been inseparably connected with philosophy and religious speculation. For its theme — its age-long objective — has been a true world concept. I quote: "Back of every religion, and of every philosophy or science, worthy of the name, lies a world-view, a concept in which are included all localities and all beings supposed in that religion or philosophy or science to exist. In proportion to its clearness and completeness it, in every case, groups and mentally pictures these localities and beings in certain relations to each other, and thus also in their total unity as a universe. The science which critically investigates and expounds the world-view of any people or of any system of doctrine is called cosmology."

Every race has had its cosmology, the current interpretation of which has in many cases gone far afield through the teaching of various leaders in scholarship. Almost daily new facts and new relations have been revealed by investigators, so that any deduction or concept needs for its best statement continual modification. One needs only to call to mind the metamorphosis of world concepts from the days of the ancient Babylonians to the deductions of the theory of relativity, to support this statement. The history of the struggle to gain a true concept of the solar system is familiar to all and will be passed with this single mention.

Today the attention of the astronomer is absorbed in a similar attempt to solve the cosmogony of the stellar universe. Of course we have long ago passed the Egyptian and Ptolemaic and have penetrated far into the Copernican age of siderial astronomy. Since the days of Halley, Wright, Kant, and La Place this concept has undergone continuous modification. In a masterful discussion of "The Structure of the Universe," Dr. Simon Newcomb says:

"From the philosophic standpoint a discussion of the subject which is of such weight that in the history of thought it must be assigned a place above all others is that of Kant in his *Kritik*. Here we find two opposing propositions — the thesis that the universe occupies only a finite space and is of finite duration; the antithesis that it is infinite both as regards extent in space and duration of time. Both of these opposing propositions are shown to admit of demonstration with equal force, not directly, but by methods of *reductio ad absurdum*."

I cannot agree fully with the *reductio ad absurdum* method of proof, especially in astronomical science, admittedly true for certain lines of logic. But who is to determine when a proposition regarding the nature and extent of the cosmos has been reduced to absurdity? In my opinion this depends upon the experience of the one who judges the argument. What is absurd in the scientific world today becomes a method for investigation of new truths tomorrow.

In 1720 Halley argued that "the light would diminish more rapidly than the distance between the stars increased and therefore space would not be equally illuminated if the stars were infinite in number." He further suggested that light from the stars at a great distance would not reach the earth. It would seem that Halley had in mind an infinite universe. The main argument that is constantly being used against an unlimited universe is that space would be equally and brilliantly illuminated if the stars were infinite in number. Practically all the older methods of dealing with the extent and form of the universe were based upon the principle of equal distribution of the stars (uniform density of matter) and their apparent luminosity. About the only observational data upon which to base this principle was the observed stellar density and the ratio of the number of stars of any given apparent magnitude to the number of stars in the next lower magnitude, together with the pitifully small number of stars whose distances had been determined by direct trigonometric methods.

From such inductive studies, astronomers, notably Wolf of Germany, Eddington of England, and Newcomb of America, have postulated a fairly accordant concept of the extent and structure of our stellar universe, the general characteristics of which are (1) that the stars are limited in number and not uniform in distribution; (2) that the "Milky Way" or "Great Galaxy" constitutes the major part of our system and is about thirty thousand light years in its longest diameter and something like one-sixth this distance in thickness; (3) that the solar system is not far from the center of the galactic system. According to this postulate our system is comparatively simple in structure and extremely finite in dimensions. The classes of objects visible in our telescope and generally considered as constituting the universe consist of (1) stars with their attendant system of planets, including the double and multiple systems; (2) star clusters of two main types — globular and loose clusters; (3) nebulae, of which there are four types — (a) bright, diffuse, undifferentiated masses of enormous size and wholly gaseous in character, (b) dark nebulae of remarkable form and size and associated in practically every case with bright nebulae, (c) planetary nebulae including the ring form. These are very few in number and practically all in the "Milky Way." They give a gaseous spectrum and have high radial velocities. (d) The spirals, with their peculiar space distribution, clustering about the poles of the "Milky Way." Their numbers run into the hundreds of thousands if not millions. Their spectrum resembles that of the denser clusters and bright star clouds in our galaxy. Their space velocities are enormous.

Astronomical research is as noted for its methods as it is for its results. We have seen on the instrumental side the most astounding development recorded by any science; from the sextant of Tyco Brahe through the telescope of Galileo to the one-hundred-inch Hooker; from the spectroscope of Huggins to the spectroheliograph of Hale; from the micrometer of Hershell to the interferometer of Michelson. On the theoretical side the list of notable names is too long to mention more than the extreme limits, commencing possibly with Olbers and expanding into a great galaxy of present-day men. Indeed, very recently there has been developed a new branch of science known as Statistical Astronomy. As Theoretical Astronomy attacked the problems of the solar system, so statistical astronomy bids more than fair to solve the question of the extent and form of our siderial universe. Kapteyn in Europe and Russell in America are probably the pioneers of this new astronomy. Within the last ten years Dr. Russell has demonstrated a remarkable progression of absolute magnitude with spectral type and suggested the strong possibility of the existence of so-called giant and dwarf stars. Dr. Walter S. Adams of the Mount Wilson observatory has discovered a similar relation between the relative intensities of certain sets of spectral lines in stars of known distances and their absolute magnitude. We have here then a method which will determine the distances of the stars by means of their spectra and apparent magnitude, though depending fundamentally on direct measurements for its scale. Dr. H. H. Turner of the Greenwich observatory, commenting upon the accordance of the trigonometric parallaxes as measured by Dr. S. A. Mitchell at the Leander McCormick observatory with the spectroscopic parallaxes as determined by Dr. W. S. Adams at Mount Wilson, said: "It gives good assurance that Dr. Adams' working curves for inferring parallaxes which were necessarily formed by a series of approximations (trial and error), are approaching final shape, if indeed they have not already attained it, and I will venture to add a word of admiration for the great advance in our knowledge of the distance of the stars rendered conspicuous by this most beautiful accordance of the two methods."

With these methods and the ever-increasing mass of data made possible by our modern observatories, we have a system of measuring distance beyond the most daring dream of celestial mechanics. Dr. H. D. Curtis, director of the Allegheny observatory has examined about five thousand separate parallax results from which he has selected one thousand six hundred strictly modern values for one thousand one hundred stars, and plotted their absolute magnitude against spectral type, the results of which investigation will be shown on the screen. Through his extensive study of stellar clusters Dr. Shapley, director of the Harvard College Observatory, has shown remarkable correlations between the members of star clusters and like members in the solar neighborhood, which has extended our knowledge of the star clusters and groups of stars to unbelievable limits.

For example, in a series of papers entitled "Studies Based on the Colors and Magnitudes in Stellar Clusters" he finds that a wide range of color is present in star clusters, but that change of color with brightness is hardly perceptible, that magnitudes of the blue stars seem to indicate the remoteness of the star clusters and also that they are of great dimensions. He further deduces that cluster stars are very probably giants in luminosity and accordingly the distance of the groups must be of the order of fifteen thousand light years. The wide dispersion in magnitude of both blue and red stars indicates a similarly great distance for the neighboring galactic clouds. He suggests that the extent of the stellar clouds in the line of sight is relatively very great. In fact, the depth may be as great as or greater than the distance of the nearer boundary.

In the bulletin of the National Research Council, May, 1921, the same author says: "We know some of these important correlations with greater certainty in the star clusters than in the solar neighborhood. We now have the spectra of many individual stars, the colors and spectral type of variables and something also of the absolute luminosity of the brightest stars of the clusters from the appearance of the spectra. Is it surprising therefore that we venture to determine the distance of this cluster "Messier 13" and similar systems with more confidence than was possible when none of these facts was known or even seriously considered in cosmic speculation?"

In a report on "The Physical Members of the Pleiades Group," L. O. Bulletin No. 333, Mr. Robert Trumbler who has given extensive study to this cluster through the application of these modern criteria, says: "With respect to the distribution of the stars among the different spectral types, the relation between luminosity, spectral type and color, the proportion of double stars, etc., this cluster resembles our stellar system on the average, with the exception however that yellow and red giants are completely missing in the Pleiades and that the stellar density is about ten times greater than in the immediate neighborhood of our sun."

As a result of these statistical studies we find that the stars differ greatly in absolute luminosity and absolute magnitude. By absolute magnitude is meant the apparent magnitude of the stars if they were all placed at the same distance, that is, at a distance corresponding to a parallax of one-tenth of a second of arc or thirty-two and six-tenths light years. This relation of absolute magnitude to spectral type shows that our own sun is a typical star of about the fifth absolute magnitude and neither a giant nor a dwarf, but is classed as a "G" type star.

Today astronomers are divided, as to the extent and form of our stellar system, into two camps. One, whose leader is Dr. Shapley, conceives of our stellar system as practically unlimited in extent and similar in arrangement to star clusters. To quote again from Dr. Shapley's paper, "One consequence of accepting the theory that clusters outline the form and extent of the galactic system is that the sun is found to be very distant from the middle of the galaxy. It appears that we are not far from the center of a large local cluster or cloud, but that cloud is at least fifteen thousand light years from the center of the "Milky Way." Answering the suggestion made by Newcomb in *The Structure of the Universe* that the appearance of the "Milky Way" is due to the fact that we are situated in its center, Dr. Shapley[1] suggests that we have been misled due to our restricted methods of measuring distances and by chance position of the sun near the center of the subordinate system, into thinking that we are in the midst of things. In much the same way the ancient man was misled by the rotation of the earth, with its consequent apparent daily motion of our heavenly bodies around the earth, into believing that even this little planet was the center of the universe and that his earthly gods created and governed the whole.

If I were summarizing the world concept of adherents of this school, I would say that our stellar system (the galaxy) is a cloud or star cluster of about three hundred thousand light years in its longest diameter and about one-tenth of this distance in the shortest, which is passing through a spiral nebula about at right angles to its plane. This was probably first definitely postulated by Dr. Comstock of the University of Wisconsin. I quote him: "There is here presented the concept of a definite group of stars moving through a much more widely extended chaos, as the best working hypothesis at present attainable with reference to our stellar system." The globular clusters are typical galaxies or remote systems and the spiral nebulae are not island universes but are purely nebulous in character and probably a part of our own system. The other camp of astronomers reject the practically unlimited dimensions assigned to our stellar system and support what is known as the Island Universe theory. The unconformity of the characteristics assigned to the spirals forms the principal basis for the hypothesis. Their distribution (clustered at the poles of the galaxy) is extremely difficult to account for in any theory of stellar evolution. Why should we find no spirals in the plane of the galaxy if they are part of our own system? By what peculiar law of nature do they all recede from the galactic plane, Andromeda excepted? If they are surrounded by rings of absorbing material as the dark markings on typical spirals seem to indicate, their absence in the plane of the "Milky Way" is simply accounted for on the theory that they are obscured by our system. The extreme difference in their sizes is difficult to understand if they are all within approximately the same distance from our system. If, on the other hand, they show a great variety of distances, say from about twenty thousand light years for the Andromeda spiral to say a hundred million light years for the smallest ones which can barely be detected as spirals on photographs taken by our most powerful telescopes, then their diversity of apparent diameter is easily accounted for. Their spectra, too, are most easily explained on the basis of external galaxies, if we assume that Dr. Fath's results on the integrated spectrum of the "Milky Way" is taken as criterion. The further fact that *novæ* or new stars have never been found outside our galaxy except in spirals, gives strong support to the hypothesis of external systems. Of course the extreme distances postulated above would demand that the novæ should be of very high order of absolute magnitude. But they would compare in this particular very favorably with known novæ in our own system. The most baffling argument against the theory that the spirals are island universes is found in their proper motions. If Slipher's measurements at Flagstaf and Van Maanen's at Mt. Wilson on the rotation of spirals are verified by subsequent observations in other systems, it would seem absolutely necessary to abandon the Island Universe theory. At the close of his admirable article, Dr. Shapley says: "But even if spirals fail as galactic systems, there may be elsewhere in space stellar systems equal to or greater than ours, as yet unrecognized and possibly quite beyond the power of existing optical devices and present measuring scales."

No discussion of this subject, however inadequate, should be concluded without some recognition of Einstein's "Theory of Relativity." It, at least, escapes the criticism of being an hypothesis created "ad hoc." Schleck points out that the general theory of relativity has the inestimable advantage of giving us an unmistakable answer, whereas the previous Newtonian theory left us in total uncertainty, and could only rescue us from forming a highly undesirable picture of the universe by making new and unconfirmed hypotheses.

According to Einstein, if we suppose the matter of the universe to be distributed with absolute uniformity, space is spherical in structure, but if we consider the density of distribution as the mean, it is quasi-spherical. Now, while a sphere is bounded by its surface, spherical space is unbounded, but not a part of infinite space, that is: it is finite. We therefore have finite yet unbounded space and we should be able to determine its limits. Einstein gives us the formula. V (volume) equals 7 times 10 raised to the 41st power, divided by the square root of p cubed (where p is the mean density of matter). The postulate that star clusters are universes would seem not to be at variance with relativity. It might be urged that the universe has no plural and that to think of island universes is to fall into the old fallacy of Euclidian space. But Einstein shows that in the Euclidian universe the average. density of matter is necessarily zero. Interpreting then, the structure of the universe by the general theory of relativity, all the difficulties of the Newtonian theory are overcome, leaving us free to indulge in a world picture as unbounded as we please, yet complete and finite. There is no danger that it will ever become destroyed, because no energy or matter can dissipate into infinity since space is not infinite. The infinity of the cosmos is thus rejected without arbitrary setting of boundaries. As Schleck in a bit of ecstacy phrases it: "By combination of physical, mathematical and philosophic thought, genius has made it possible to answer by means of exact methods questions concerning the universe which seemed doomed forever to remain the objects of vague speculation."

THE OBSERVATORY,
DRAKE UNIVERSITY.

THE NEW ALBIN INSCRIBED TABLET

ELLISON ORR

During the summer of 1915, workmen, in excavating for a cellar under the residence of Mr. August Welper, of New Albin, Iowa, discovered a catlinite (pipe stone) tablet with pictographs inscribed on both obverse and reverse sides, and the purpose of this paper is to set out briefly the data connected therewith.

New Albin is built on an extensive terrace of sand and gravel, outwash from the glacier of the Wisconsin Ice Sheet — lying along the bluffs on the Iowa side of the Mississippi river, and extending from the state line between Iowa and Minnesota on the north, down the river to the mouth of the Oneota or Little Iowa River on the south. The terrace has a length of about one and one-half miles and an average width of approximately one-half mile.

This terrace or "Bench," as it is locally called, has an elevation above the present flood plain of the river of from 40 to 50 feet and is simply an immense sand-bar of the old river, now covered with a foot or two of black sandy loam, and with heavy deposits of loess along and drifted against the foot of the bluffs.

It is an ideal town site, and evidently appealed to the Indian as such as well as to his white successors.

While the digging for the Welper cellar was being done, one side caved in, and when the earth and sand was cleared away the tablet was found in it.

It was impossible to tell at just what depth it originally lay, but from where it was found in the cave-in, with reference to the surface soil, the workmen concluded it originally lay about three feet below the surface.

No bones, charcoal, pottery or other relics of any kind were found with it, which would lead to the conclusion that it might have been cached there for safe keeping and that its owner had died or possibly had been killed or driven away in war and all knowledge of its location lost.

Similar cases are the cache of a celt and fine spud found in 1911 in a bank beside the road near the May residence on the O'Reagan "Bench" on the Oneota, and that of a couple of pairs of arrow-shaft smoothers and a number of mortars, grinding stones, celts, etc., found a half mile southwest of New Albin, by Mr. R. H. Thompson.

Copper beads and other trinkets have been found from time to time by the workmen in the gravel pits in the north part of the town, and just over the line in Minnesota, on the terrace, are two mounds now nearly obliterated. Hill, Brower and Winchell in Aborigines of Minnesota say that there were nine more to the south of these in Iowa, where is now the railroad gravel pit.

On the top of the high bluff a little north of the village, and over the line in Minnesota, is a group of four tumuli or conical burial mounds, and to the southwest of these on a terrace on the north side of the Winnebago Creek, is a large group containing forty — all of the conical type. About one mile southwest of the village but still on the terrace, there was formerly a circular earthwork now obliterated by cultivation.

The south end of the terrace where it abuts on the flood plain of the Oneota, consists of four salient points and three re-entrants, the most easterly of which extends as a drainage valley up to the junction of the Iowa River and state line roads, and up the east branch of which the Chicago, Milwaukee and St. Paul Railway ascends to the level of the top of the terrace.

On the most westerly salient, near the extreme point is a mound about twenty feet in diameter and two feet high, which tradition says is the burial place of an Indian chief named Four-eyes. Mrs. Hausman, a daughter of Mr. Hayes who first settled on the land, and who later built a large and comfortable residence, since burned down, close beside this mound, says that an old Indian woman told her parents that, when a child, she saw the burial and that a hole was dug and in it was placed the chief's dead horse with him astride, dressed in all his finery, and that the earth was then heaped around and over the horse and man.

On the next point to the east are Indian graves but no mounds. On the third is a mound, while somewhere to the north of these points, in the fields, was located the circular earthwork mentioned before.

No doubt the New Albin terrace like those of the Oneota Valley has been occupied for centuries as camp or village sites by, at times, comparatively numerous populations of the Aborigines. Resulting from these occupancies are the very numerous burials, the covered up debris of camps, and the earthworks — mound, fortifications, and totemic.

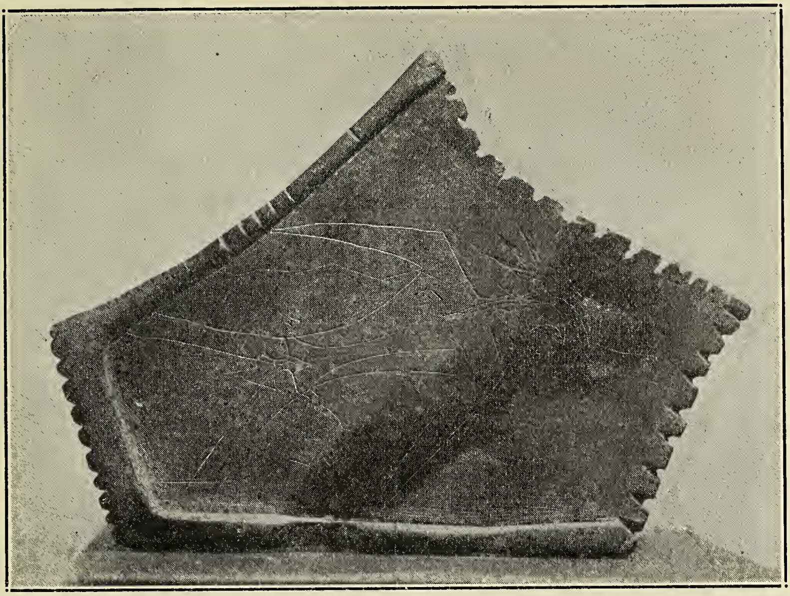


Fig. 1. Obverse side of New Albin tablet.

The tablet is approximately pentagonal in shape. The shortest side is the base for the pictographs. The two lateral sides, the longest, are of nearly equal length. The two top sides are of unequal lengths and both shorter than the laterals, one being a curve. The respective lengths, beginning with the base and then the right-hand side, are 3¼, 7¼, 4, 6, and 6¾ inches. The greatest length is 9⅞ inches, the greatest width is 7¾ inches.

The obverse face has been countersunk leaving a rim from ¼ to ½ an inch wide at the bottom and on the lateral sides, and about ⅛ inch in height. On the shorter of the top sides nine tally notches have been cut, apparently by flint; on the longer curving side, thirteen; and on the base, ten. Five have been cut into the top of the rim on the left side near the center, with one by itself nearer the top.

The pictograph on the obverse side probably represents a god or devil having the body and limbs of a man with the head of a bird, facing the left. From the head a zigzag line, probably intended for a bolt of lightning, runs diagonally downward to near the center of the left-hand rim.

The center figure on the reverse side is much more deeply incised than any other on the tablet and may be a representation of a flower or wand. On each side of this is a lozenge-shaped

Fig. 2. Reverse side of New Albin tablet.

figure resembling a spear head or knife. These three figures reach from the base half way to the top and fill the space from side to side. Above them and running crossways of the tablet, with the base to the right, is more faintly traced what looks like a schoolboy's picture of a lighthouse.

Other lines on both sides were undoubtedly purposely put there by the engraver, but with two exceptions they do not form an outline picture of any object. One of these is a small cross within and near the top of the flower pictograph, the other at the right of and near the loins of the god, may be intended for a frog.

Photographs of both sides of the tablet are attached.

WAUKON.

DECORATIVE MARKINGS ON SOME FRAGMENTS OF INDIAN POTTERY FROM MILLS COUNTY, IOWA

PAUL R. ROWE

Among the articles of Indian workmanship in the writer's possession are several hundred fragments of soft dark pottery. All may be well described as dark gray, porous and more or less sandy. Only one specimen is distinctly red. The thickness of the different pieces varies from one-eighth to one-half an inch. To judge by the curvature of the pieces the whole pots must have ranged from a quart to four or five gallons in capacity. Almost all of these potsherds were picked out of the wash along the beds of Pony creek and some smaller runs near Glenwood, Iowa. A few were found in fields or along highways. Most of the boys living near these streams will tell of finding similar fragments, but none of having seen a complete pot.

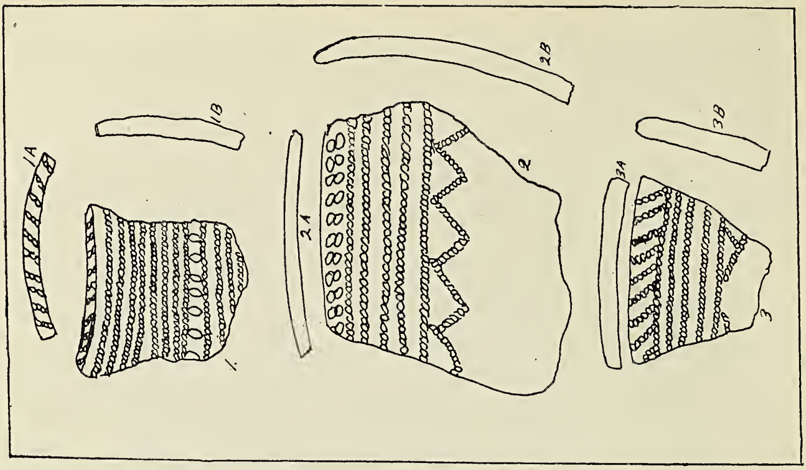
All drawings shown are one-half the exact size of the piece or edge of the piece portrayed, and the markings are as correct as the writer's drawing ability permits.

Figure 1, Plate I, is the most highly decorated piece found. The horizontal lines look as if a twisted strand of grass or cord had been pressed into the pot while it was still soft. Figure 1A shows the curve of the edge of the pot and Figure 1B that of the side. No other specimen of this design has been noted.

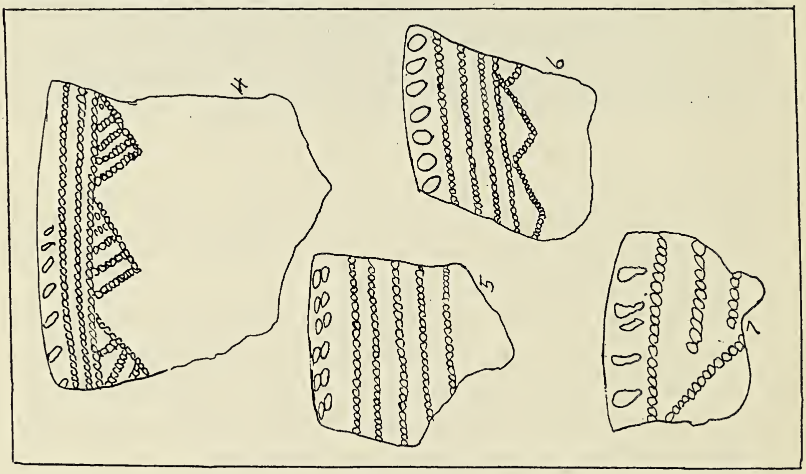
The markings on Figures 2 to 7 are of similar character although of different design. Of the design of Figure 2 I have seven pieces of at least three pots. Figure 3 is only a slight variation of one pot. I have two distinct specimens of the type of Figure 4, Plate II. Figures 5 and 7 are of one pot each while Figure 6 is descriptive of four specimens of as many pots. Figures 8 and 9, Plate III, and Figure 11, Plate IV, depend for their decorative effect on the design of the lines instead of the object with which the lines were made. They are of a smoother, harder material than many other pieces. May they not have been made by a more advanced people?

The original of Figure 10, Plate III, is thick and sandy. The five figures seem to have been made by pressing the head of a bullrush into the clay and the three protuberances by punching a

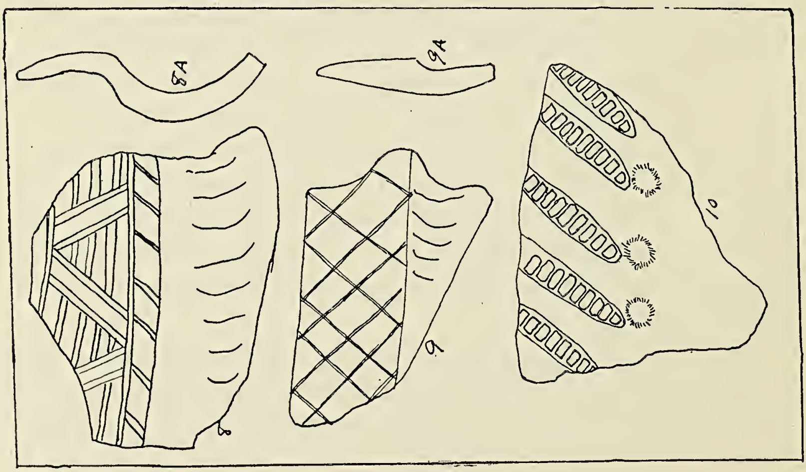
IOWA ACADEMY OF SCIENCE PLATE I



IOWA ACADEMY OF SCIENCE PLATE. II



IOWA ACADEMY OF SCIENCE PLATE III



hole half way through from the inside. My three similar specimens probably represent two pots. Figure 12, Plate IV, represents the only specimen I have with an ear. The rim is plain and turns outward about half an inch. The group of eleven pieces represented by Figure 19, Plate VII, and Figure 28, Plate VIII, should probably be classed here. All show a plain or escalloped edge turned out. Ten pots are discernible.

Eighteen fragments with no decorations at all on the pot edge have differences enough in thickness and material to indicate fifteen pots.

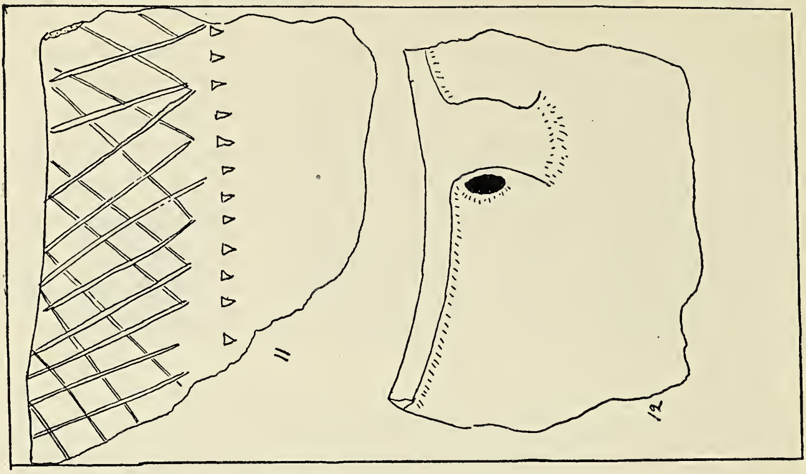
Figures 13 and 14, Plate V, are of another distinctive class. They look as though they had been moulded in a basket of woven grass. In Figure 13 lines as of twisted straw run diagonally down the piece. The vertical line of marks resembles gouges of a pointed stick. The protuberances on both may well have been made by punching a blunt stick part way through. Nine pieces of as many pots show these protuberances with variations in the ground work. One of them has lines above the punchings running at right angles to those below. Two other specimens of different curvature have similar ground lines running horizontally and two have lines running vertically, none of which have the punch marks.

Plate VI shows three specimens from the sides of pots but with distinctive markings. Figure 18, Plate VII, is of a plain pot with punch marks inward, but not entirely through. It is one of three specimens which indicate two pots. Three fragments of different undecorated pots, and my one red piece, which has diagonal ground lines, have a single hole near the edge as though for a bail.

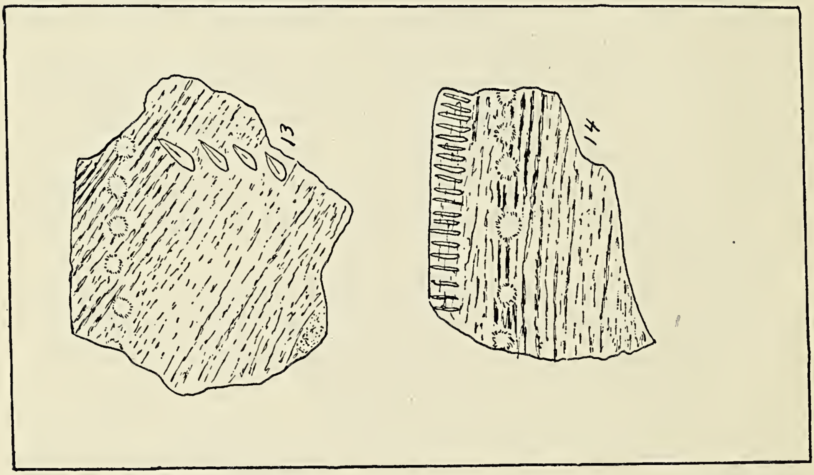
Figures 20, 21, and 22 are of pieces decorated with the end of a small woman's finger or finger nail. In all I have nine specimens of as many pots so decorated. Note the thickened rim of Figure 21 as shown in Figure 21A. Figure 30 shows some thickening and is flared out. It represents three pots.

Figures 23 and 26 represent the most numerous type in my collection. They have markings on the edge like those made by the pressure of a round twig. The twenty-eight pieces so marked belong to about twenty-five pots. These pots differ more widely in size than any other class. Of this class I have three pieces of one pot that fit together giving an outside surface roughly eight inches square. Figure 24 shows an out-turned edge like

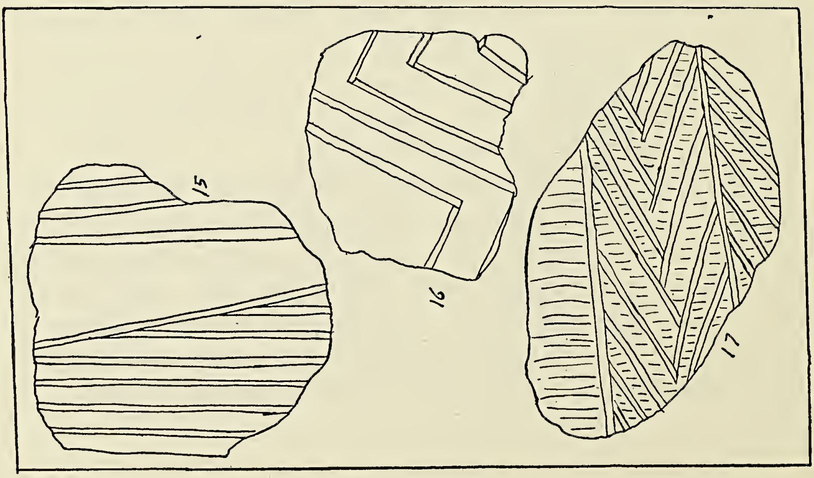
Iowa Academy of Science — Plate IV



Iowa Academy of Science — Plate V



Iowa Academy of Science — Plate VI



those shown in Figures 19 and 28 but its edge is cross marked with some sharp instrument such as a knife. The figures on pots 25, 27 and 29 were gouged as with a broken stick. Those in figure 27 are more distinct than in the specimen.

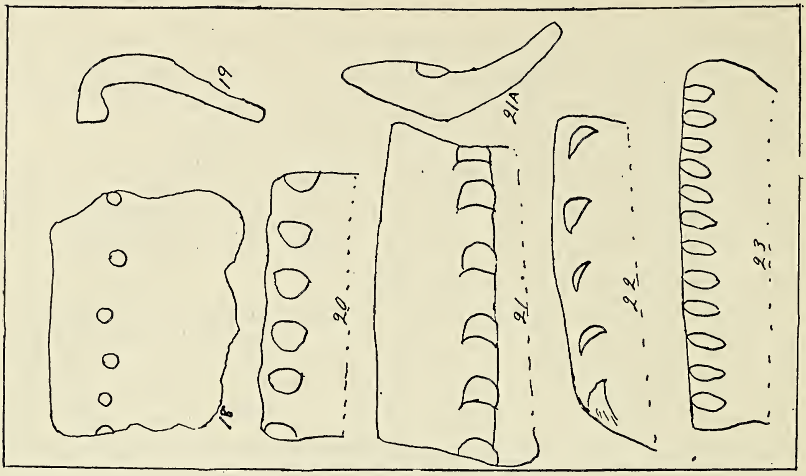
The one hundred and twenty specimens referred to in this article comprise about one-third of the bulk of my collection. The rest have no markings by which to judge whence they came. I have never so much as counted them.

Figure 1 shows a rough section of a mound I dug into September 2, 1921. It is situated on the ridge west of Mr. Boyce's house on Pony creek about one hundred yards south of a larger mound. It may be described as nearly circular, about eighteen inches or two feet high and twenty feet in diameter; with a sort of moat four to six inches deep and six to eight feet wide almost surrounding it. A black hickory about seven inches in diameter stands on the inner edge of the moat at the northeast. A similar shell bark grows at the east, and a somewhat smaller scrub oak on the east brow of the mound. The whole area is well grown to weeds and deep with last year's leaves.

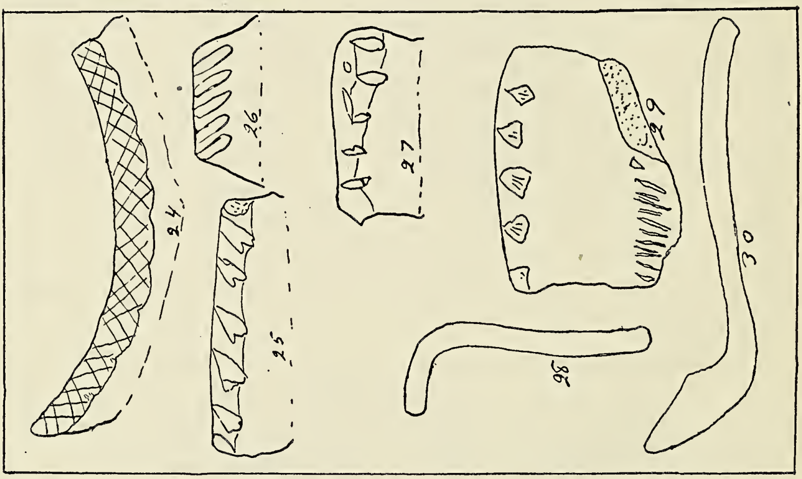
Toward the east edge the earth was solid and hard to dig although the top foot seemed to have been moved. In the middle digging was easier and the earth was streaked with yellow clay. At a depth of about one foot I began to find charred, crumbling bones that seemed to be of limbs and skulls of men. No vertebrae were noted in the mound. From fifteen inches deep to twenty inches deep in the middle of the mound the clay was red from burning and the bones almost as close as they could be piled. Is this evidence of murder or human sacrifice by some Indian tribe?

The first bones struck seemed to be two leg bones and the top plates of a skull as in the sign of death. These were blackened but not so badly burned. South of these were piles of absolutely mixed bones thoroughly burned. Around them were bones as of feet and fingers, bits of jaws and the crown of a human molar. I attempted to scratch this tooth thinking it might be metal and it fell to pieces like any thoroughly burned bone.

I tried to dig out some bones with my knife but they were so soft that the knife cut them up as badly as the shovel. Most of the larger bones had been broken before being burned. Those about the edges and below twenty inches in depth were not so badly burned and were quite solid although brittle. The deposits



Iowa Academy of Science Plate VIII



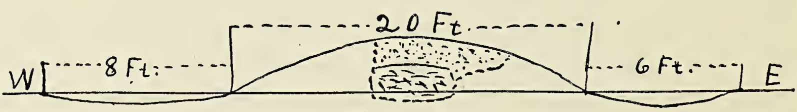


Figure 1

did not go deeper than twenty-eight inches. Below that the ground seemed to be undisturbed loess. No trace of either stone or metal was found about the mound.

Early in September, 1921, Clifford Kates and I dug into a mound on the hilltop southeast of the Kates' house. There had been so much rain that the ground elsewhere was wet over three feet deep. Across the center of the mound we dug a trench two and one-half feet wide and about fourteen feet long. Here at a depth of one foot we found a very hard dry clay that looked as if it was made partly of ashes. So hard was it that we could hardly dig through it. We found in it nothing to prove it of Indian origin. After digging through twenty inches of the hard pan we came to the common loess soil of the hilltops in this section. At the east end of the mound in a hole two and one-half feet deep we found none of the hard soil and very little elsewhere.

GLENWOOD.

TILL-LIKE DEPOSITS SOUTH OF KANSAS RIVER IN DOUGLAS COUNTY, KANSAS

WALTER H. SCHOEWE

The line marking the position of the maximum advance of the Kansan ice sheet in northeastern Kansas has been established by investigators at various places as lying either north or south of Kansas or Kaw river. The earlier maps,[1] figure 1, show the drift border as being south of the river and extending at least as far south as 38° 50′ north latitude. Of the more recent work that done by Todd [2] not only represents the latest but also the most thorough. This investigator locates the edge of the Kansan ice sheet as lying north of the Kaw river valley from a point midway between Lecompton and Lawrence to Kansas City, Kansas. See heavy continuous line, figure 1. This line separating the glaciated from the unglaciated area in Kansas is essentially the one adopted by the Kansas Geological Survey and published on its more recent maps.[3]

The presence of erratics and exposures of what appeared to be till was first called to the writer's notice some time ago while he was passing hurriedly through the country in a car. The presence of the familiar red quartzites so numerous around Lawrence aroused no special surprise as these are indicated in the literature of the region. Not so, however, with the till-like exposures, especially as no typical till was known to exist at least within ten miles north of Lawrence. The nearest outcrop to Kansas river is in the vicinity of Linwood and Lenape.[4] Opportunity presented itself later for a somewhat more detailed investigation of several of these deposits. The exposures, which are all in Douglas county

1 Hay, Robert, Geological and Topographical Map of Kansas: Geology and Mineral Resources of Kansas, Eighth Biennial Report of the State Board of Agriculture, 1891-'92.

Chamberlin, T. C., and Salisbury, R. D., Preliminary Paper on the Upper Mississippi Valley, Plate XXI, Diagrammatic Map of Drift Currents Adjacent to the Driftless Area: U. S. Geol. Survey 6th Ann. Rept., 1885.

2 Todd, J. E., Kansas During the Ice Age: Trans. Kansas Acad. Sci., Vol. 28, pp. 33-47, 1917.

3 Moore, R. C., Oil and Gas Resources of Kansas, Part II, Geology of Kansas, Outline Map showing distribution of the Quaternary deposits of Kansas, Plate XIII, p. 92: Bull. 6, Kansas Geological Survey, 1920.

4 Todd, J. E., Kansas During the Ice Age: Trans. Kansas Acad. Sci., Vol. 28, p. 35, 44, 1917.

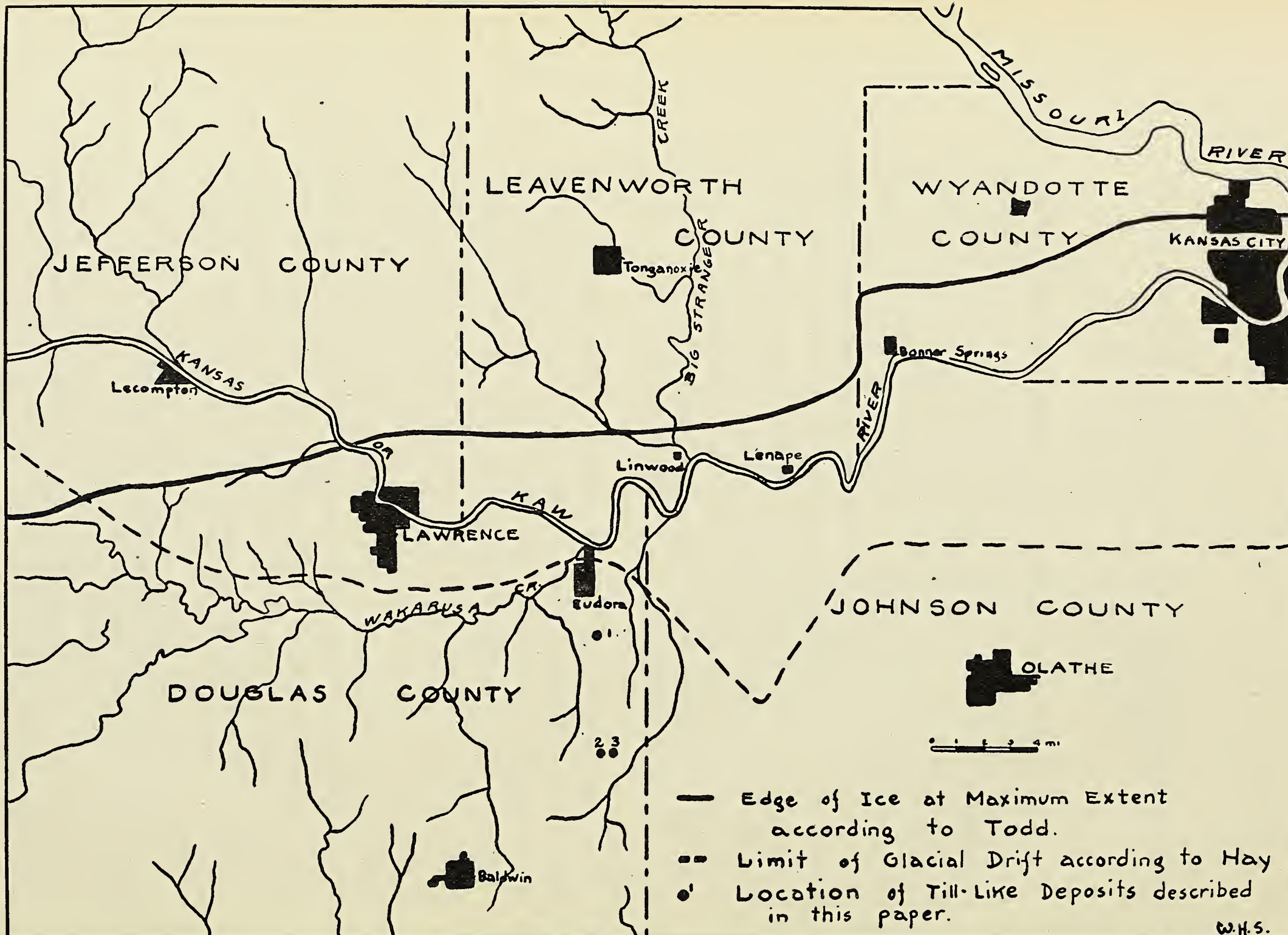


FIG. 1. MAP SHOWING LOCATION OF TILL-LIKE DEPOSITS AND OF THE KANSAN DRIFT

and from three to seven miles south of Eudora, are interpreted by the writer as being till.

The three chief outcrops, all of which are in road cuts, are located as follows:

1. SW. cor. NW. ¼ sec. 21. R. 21 E., T. 13 S.
2. SW. cor. sec. 9. R. 21. E., T. 14 S.
3. ½ mile east of exposure 2.

The material at these places is exposed in road cuts from 100 to 200 feet long and three feet deep. In all cases the drift is composed of a brown more or less sandy to sticky clayey material thoroughly leached and containing numerous pebbles and boulders. Some stratification is at places in evidence. The coarser materials consist chiefly of red quartzites, well decayed granites, brown to white cherts, gneisses, schists and sandstones. In size, the pebbles average less than one-half inch in diameter. The larger boulders, which are more numerous at exposure 2, measure over one foot in diameter and consist for the most part of red Sioux quartzites.

In all cases the till is exposed on gentle slopes leading down to young valleys. A loesslike silt covers the till-like materials in most places and in some instances small pebbles of quartzite, chert and quartz are included in the overlying cover. The immediate country is relatively flat with few shallow valleys cut in it. Because of this topography exposures are very few and in most cases nothing but the siltlike material appears at the surface.

INTERPRETATIONS OF THE DEPOSITS

To account for the presence of these deposits several interpretations may be presented:

1. The material is in situ having been deposited by the Kansan ice sheet which advanced farther south than is indicated by the position of the mapped glacial border according to Todd.
2. The material is in situ having been deposited by a tongue of the main ice mass rather than by the ice sheet itself.
3. The material is not in situ having been brought to its present position by debris-laden icebergs floating on a lake or in the current of a stream, or having been deposited as outwash.

View 1. Country south of Kansas river glaciated. — According to this hypothesis, the Kansan ice sheet crossed the valley of Kansas river and advanced southward at least as far as the two southernmost outcrops. The deposits, therefore, represent till in situ. Whether the entire ice mass crossed the valley, it is difficult to determine with the knowledge at hand. Insufficient exposures and lack of thorough investigation up to the present time make it impossible to come to definite conclusions. To the writer it seems not at all unlikely that the region south of the Kaw valley has been glaciated. The topography is flat, the slopes are gentle, hence exposures are few. What lies below the general siltlike covering has not been determined. Like the Iowan ice sheet, the edge of the Kansan undoubtedly was thin and more or less sluggish as the till where it is known north of Kaw river is relatively thin and patchy, having been made more attenuated by post-Kansan erosion.[5] According to Todd "Only scattered boulders can now be found, where till patches may have once been a few feet in thickness."[6]

In view of the fact that the till in Kansas is in general thin and patchy, the topography is flat and the exposures are few, it is not unreasonable to believe that very careful and detailed research may favor the hypothesis that the Kansan ice sheet extended farther south than the Kaw valley.

View 2. Lobate extension of the Kansan ice sheet south of Linwood and Lenape. — The outcrops of till do not necessarily imply that the entire glacier invaded the region south of the Kaw valley. The deposits can readily be accounted for by the deposition of a glacier lobe which pushed its way farther to the south than did the main mass of ice. As indicated by Todd "There is some evidence that the ice sheet in Kansas was more or less lobular in form, at least after it passed over the divide into the Kansas valley. One lobe passed down . . . the Big Stranger to Linwood and Lenape."[7] It is apparent from the map, figure 1, that the exposures of the glacial materials are in almost direct north and south alignment with Big Stranger creek and the town of Linwood. May it not be that the lobe referred to above extended farther to the south than suggested by Todd? The position of the outcrops in relation to Big Stranger creek and Linwood certainly is very suggestive.

Before finally accepting the view set forth, more detailed search would be necessary as the apparent alignment of the outcrops with the Linwood-Lenape lobe may be due to accidental discovery of the exposures of the deposits rather than to actual conditions. Further research may reveal other till-like deposits south of the Kaw.

5 Loc. cit. p. 35.
6 Loc. cit. p. 35.
7 Loc. cit. p. 44.

View 3. Debris-laden ice bergs and outwash.—The finding of erratics still farther south than the described till-like exposures and the recording of erratic pebbles as far south as 38° north latitude [8] may be suggestive of glacio-fluvial or marginal lake conditions. Todd has located, mapped and described several marginal glacial lakes and several drift-filled channels, one of which is southeast of Lawrence.[9]

The till-like character of the deposits tends to argue against their being outwash materials. It is possible, although not probable, that the deposits owe their position to the melting and depositing of debris-laden ice bergs which floated either on a marginal lake or else in the current of a glacial stream. That ice rafted boulders are common is known to all glacial geologists. Till-like deposits having a similar mode of origin are questionable or at least none are on record as far as the writer's knowledge is concerned.

CONCLUSIONS

Although no definite conclusions regarding the origin of the described deposits can be made at the present time, the writer is inclined to favor equally views 1 and 2. It is obvious that in such a region as this, located in the zone of maximum extension of an ice sheet, invaded by the next to the oldest ice invasion, the Kansan, subjected to a very long period of weathering and erosion, and cut up at its most critical places by a wide valley, evidences of past glaciation must necessarily be greatly obscured. Only by the most detailed investigation can the exact position of the Kansan ice sheet and the history of the region be worked out. It is to the endless zeal and scientific spirit of the pioneer explorer, Professor Todd of the State University of Kansas, that we owe much of our present knowledge of the Pleistocene of Northeastern Kansas.

Department of Geology,
State University of Kansas.

8 Mudge, B. F., Geology of Kansas: Kansas State Board of Agriculture. Fourth Agricultural Report and Census, p. 109, 1875.

Chamberlin, T. C., and Salisbury, R. D., Preliminary Paper on the Upper Mississippi Valley: U. S. G. S., 6th Ann. Rep't., p. 314, 1885.

9 Loc. cit. p. 41, and map 1.

SOME BLACK RIVER BRACHIOPODS FROM THE MISSISSIPPI VALLEY

CARROLL LANE FENTON AND MILDRED ADAMS FENTON

This study originated in the attempt to identify a number of Rhynchotremas and Zygospiras from the Plattin and Decorah formations of Ste. Genevieve county, Mo. Comparisons were made with sets from several other localities in the Mississippi valley, and thus considerable additional material was examined, involving not only Black River horizons, but the Kimmswick and Maquoketa as well. The results of the study may be summarized in three conclusions:

1. It has become customary to apply the terms *Rhynchotrema inequivalve* and *Zygospira recurvirostris* indiscriminately, to specimens from numerous horizons and localities.
2. *Rhynchotrema inequivalve* was not recognizably described and illustrated by Castelnau, and later authors have used the name without redescribing the original types.
3. Among the forms of the genera *Rhynchotrema* and *Zygospira* commonly referred to the two species here named there are several heretofore undescribed species and varieties.

In the following pages are descriptions and illustrations of such of these forms as have come into the hands of the authors.

RHYNCHOTREMA KENTUCKIENSE sp. nov.

Plate I, figs. 4-5; 18-22

Shell of medium or smaller than medium size, wider than long, and with postero-lateral margins curved and without noticeable flattening. Dimensions of three specimens, the first of which is the holotype: length, 12.6 mm., 12.8 mm., and 10.1 mm.; width, 14.9 mm., 15.7 mm., and 10.5 mm.; thickness, 11.2 mm., 10.4 mm., and 5.7 mm.; width of sinus, 7.7 mm., 8.5 mm., and 5.1 mm.

Pedicle valve convex in the umbonal region; flattened on the lateral slopes. In young specimens the slopes reach the margins without an increase in convexity; in adults such as the holotype the convexity is very abrupt, being accomplished by numerous strong, lamellose, concentric growth-lines. Beak acutely angular, produced 1 to 2 mm. beyond that of the opposite valve, and but slightly recurved; delthyrium large, triangular, and partly occupied by the beak of the brachial valve. Mesial sinus originates 3 to 5 mm. anterior to the beak, and is occupied by two to four strong, simple plications, the average number being three.

Brachial valve more convex than the pedicle in adults; approximately equal in young. Postero-lateral slopes regularly curved without vertical flattening; antero-lateral slopes of adult specimens abruptly convex, with numerous growth-lines. Mesial fold broad and flattened in young specimens; in adults such as the holotype it is high and rounded. In all specimens examined the fold bears four plications, regardless of aberations on the sinus. The surface of both valves is marked by fourteen to eighteen strong, simple, angular plications which are separated by narrow, angular furrows. Near the anterior margin, in adult specimens, there are abundant strong, lamellose, concentric growth-lines, which cause a pronounced anterior flattening.

This species is probably the one which Nettleroth figures as *R. inaequivalva* (Cast.). It is associated with *R. mercerense* of this paper, but differs from that species in form and proportion, particularly in that the young *R. kentuckiense* never attains the cuneiform shape, the postero-lateral flattening, and the high blade-like plications that characterize *R. mercerense.*

Formation and Localities: Black river, Danville, Burgis, Paris, and Curdsville, Kentucky.

Holotype, No. 27,445; paratypes, No. 27,446, Walker Museum.

RHYNCHOTREMA KENTUCKIENSE VARIANS, var. nov.

Plate I, figs. 1-5

Shell smaller than medium, longer than wide, subovate to subtriangular in outline, with postero-lateral margins slightly flattened vertically. Dimensions of two specimens, the first of which is the holotype: Length, 10.1 mm., and 11.2 mm.; width, 11.7 mm. and 12.1 mm.; thickness, 7.8 mm. and 8 mm.; width of sinus, 6 mm. and 6.6 mm.

Pedicle valve shallow, convex in the unbonal region, but flattened on the slopes; beak prominent, slightly incurved and produced 1 to 1.5 mm. beyond that of the opposite valve. Mesial sinus originates about 3 mm. anterior to the beak, and bears three simple, angular plications, which are finer and more crowded than those of the slopes. Postero-lateral slopes with a slight vertical flattening and obscuring of the plications.

Brachial valve more convex than the pedicle; beak abruptly incurved into the delthyrium; postero-lateral slopes flattened to correspond to those of the opposite valve. Mesial fold high and sharply defined, bearing four strong, crowded, angular plications. Total number of plications on each valve ranges from thirteen to sixteen, the commonest being fourteen. Anterior portions of both valves marked by numerous lamellose growth-lines.

The variety seems to be an intermediate between *R. kentuckiense* and *R. mercerense* of this paper. Its affinity to the former is shown in the rounded postero-lateral margin, the tendency toward subovate shape, particularly in the young, the high proportion of width to length in young (very near that of *R. kentuckiense*), and in the lamellose growth-lines. The relationship to the latter is found in the postero-lateral flattening, the crowding of plications on fold and sinus, and in the great height and angularity of the plications.

Formation and Localities: Kimmswick Limestone, near Batchtown, Ill., and Sulphur Springs, Mo.

Holotype, No. 27,451, Walker Museum.

RHYNCHOTREMA MERCERENSE sp. nov.

Plate II, figs. 17-21.

Shell of less than medium size; in the young specimens, longer than wide and acutely subtriangular; in the adults, wider than long, gibbous, and broadly subtriangular. Postero-lateral margins straight and vertically flattened in young specimens; slightly curved and convex in adults. Dimensions of cotypes: Length, 9.9 mm. and 12.9 mm.; width 8.7 mm. and 13.1 mm.; thickness 6.2 mm. and 10.6 mm.; width of sinus 5.1 mm. and 8.3 mm.

Pedicle valve moderately convex in the umbonal region; lateral slopes flattened. Beak sharp, slightly incurved, and projected beyond that of the brachial valve. Mesial sinus originates 4 to 5 mm. anterior to the beak; in the young it forms a narrow, shallow depression which curves gently to the anterior margin; in the adults the curve is more abrupt. In the adult cotype the depth of the sinus at the anterior margin is 4.6 mm.

Brachial valve more convex than the pedicle, with the postero-lateral slopes flattened vertically, meeting a similar flattened space on the opposite valve, the whole forming a very pronounced vertical area in which the plications are either greatly reduced or are lacking. In the young specimens this area is very much more pronounced than in the adults, in which there is a tendency to develop a convexity of the lateral slopes and a curvature of the postero-lateral margin. Mesial fold, which begins at the beak as a slight depression, becomes elevated at about 4 mm. from the beak; in the young it is low and flat; in the mature, very prominent and rounded. Surface of both valves marked by eleven to seventeen strong, acutely angular plications, those near the fold and sinus being extremely high and sharp. The three (in one case, four) plications of the sinus, and four of the fold are finer than those of the slopes. Anterior slopes of both valves much more abrupt in the young than in the adults.

The resemblances and differences between this species and *R. kentuckiense,* with which it appears to be associated, are discussed in connection with that species. They are, as may be seen by a comparison of the figures showing the young of both, more pronounced among the young than among the adults.

Formations and Localities: Black River, Mercer County, Ky.; Curdsville (?), Curdsville, Kentucky.

Cotypes, No. 27,449, Walker Museum.

RHYNCHOTREMA MINNESOTENSE (SARD.)

Plate I, figs. 15-17.

1891. Rhynchonella Minnesotensis Sardeson, Bull. Minn. Acad. Nat. Sci., 3, p. 333, pl. 4, figs. 21-23.

1893. Rhynchotrema inequivalvis Winchell and Schuchert (part), Geol. Minn., 3, pt. 1, p. 459, pl. 34, figs. 9-11; 15-23.

Shell small, broadly subovate, wider than long; postero-lateral margin curved, without flattened area. Dimensions of two mature specimens and one young: Length, 10.8 mm., 10 mm., and 7.3 mm.; width 12.6 mm., 11.4 mm., and 7.9 mm.; thickness 8.6 mm., 7.9 mm., and 3.3 mm.; width of sinus 7.1 mm., 5.7 mm., and ___ mm.

Pedicle valve uniformly convex in the young; moderately so in the adults, with a considerable flattening anterior to the umbo. Beak sharp, slightly incurved, produced beyond that of the opposite valve; sinus originates 4 to 5 mm. from the beak and continues to the anterior margin as a broad, shallow depression occupied by four to eight strong, angular plications.

Brachial valve more convex than the pedicle, depressed in the umbonal region and abruptly downcurved in the anterior. Mesial fold originates 5 to 6 mm. anterior to the beak; it is a broad, low elevation bearing one more plication than does the sinus. Surface of both valves marked by fifteen to twenty-five simple, subangular plications, with no growth lines in the specimens examined.

This species was described by Sardeson from the upper Platteville ("Trenton") of Minnesota; Winchell and Schuchert fail to distinguish it from *"Rhynchotrema inequivalvis"* and probably refer to it forms that do not properly belong there. The collections in Walker Museum contain sets from the Platteville at Minneapolis and at Ellsworth, Wisconsin, the latter having been identified by Mr. Sardeson, and a single pedicle valve from the Decorah Shale at Ste. Genevieve, Missouri. The Ellsworth specimens, from which are selected the plesiotypes, are narrower, with fewer and coarser plications than the two Minneapolis specimens and the one from Ste. Genevieve. From *R. wisconsinense* of this paper they may be distinguished by their greater size, more numerous plications, and lack of lamellose growth lines.

Plesiotypes, No. 27,443, Walker Museum.

RHYNCHOTREMA WISCONSINENSE sp. nov.

Plate I, figs. 6-8.

Shell small, subovate, wider than long, with the postero-lateral margins curved and slopes without vertical flattening. Dimensions of two specimens, the first of which is the holotype: Length, 11 mm., and 9.6 mm.; width, 12.7 mm., and 11.6 mm.; thickness, 8.6 mm., and 7.8 mm.; width of sinus, 5.8 mm., and 5.8 mm.

Pedicle valve moderately convex, with the slopes flattened. Beak sharp, prominent, slightly incurved, with the delthyrium partly occupied by the brachial beak. Mesial sinus originates 3 to 4 mm. from the beak, extending as a broad, flat-bottomed trough to the margin; it is marked by three (rarely four) strong, angular plications.

Brachial valve more convex than the pedicle; umbo slightly depressed; beak abruptly incurved. Slopes curve abruptly to the anterior margin; less so to the postero-lateral. Mesial fold high, flattened, sharply defined, its plications numbering one more than those of the sinus. Surface of both valves marked by twenty to twenty-two strong, simple, subangular plications, separated by deep, narrow furrows. Entire surface, to within 3 or 4 mm. of the beak, marked by heavy, concentric, lamellose growth lines, which are particularly abundant near the anterior margin. The species is distinguished by these lines, its pronouncedly curved postero-lateral margin, sharply projecting pedicle beak, and its sharply angular plications.

Formation and Locality: Black River (Platteville), Ellsworth, Wisconsin.

Holotype, No. 27,444, Walker Museum.

RHYNCHOTREMA CUNEIFORME sp. nov.

Plate I, figs. 12-14.

Shell small, longer than wide, subtriangular. Postero-lateral margins nearly straight, meeting in a very acute angle at the beak; postero-lateral slopes flattened, but with the plications present. Dimensions of the holotype: Length, 10.6 mm.; width, 10 mm.; thickness, 8 mm.; width of sinus, 5.6 mm.

Pedicle valve moderately convex in the umbonal region; slightly flattened anteriorly, with an abrupt convexity near the anterior margin. The broad, shallow sinus begins about 5 mm. from the beak, and is occupied by three to four strong plications. Beak long, sharp, slightly incurved.

Brachial valve deeper and more convex than the pedicle; flattened along the postero-lateral margins, and abruptly convex anteriorly. Beak short and abruptly incurved into the delthyrium; mesial fold originates anterior to the middle of the shell and bears four or five strong plications. Surface of both valves marked by thirteen to fifteen strong, subangular plications, which are reduced in size along the postero-lateral area. Specimens from the Decorah shale are larger and more coarsely plicated than those from the Plattin.

Formations and localities: Plattin, Ste. Genevieve Co.; Decorah Shale, near Ste. Genevieve, Missouri.

Holotype, No. 25,639, Walker Museum.

RHYNCHOTREMA DECORAHENSE sp. nov.

Plate I, figs. 9-11.

Shell small, broadly subtriangular; as wide as, or wider than, long. Postero-lateral slopes without vertical flattening. Dimensions of three specimens, the third of which is the holotype: Length, 8 mm., 8.3 mm., and 9 mm.; width, 9.8 mm., 8.8 mm., and 11.2 mm.; thickness, 5.1 mm., 4.8 mm., and 5.4 mm.; width of sinus, 5.2 mm., 4.9 mm., and 5.6 mm.

Pedicle valve convex in the umbo but flattened on the slopes; beak sharp, incurved, and produced beyond that of the opposite valve. Mesial sinus broad, sharply defined, with three strong, simple, angular plications. Brachial valve more convex than the pedicle, due to its shortness, but as shallow as, or shallower than, the pedicle. Umbo slightly flattened; beak sunk into the delthyrium. Mesial fold broad, sharply defined but flattened, and bearing in all specimens examined four strong, simple, angular plications. Surface of both valves marked by fifteen to twenty plications, the average being sixteen or seventeen. Growth lines present in but one specimen, that a deformed one.

While this species seems to be characteristic of the Decorah shale in Iowa, it has not been collected in Ste. Genevieve county. Surprisingly enough, however, it occurs in its typical form in the lower portions of the Maquoketa stage in the neighborhood of Clermont, Iowa, sets being in the collections of both Walker Museum and the University of Iowa.

Holotype, No. 25,632; Paratypes, No. 25,611, Walker Museum.

RHYNCHOTREMA MISSOURIENSE sp. nov.

Plate I, figs. 22-26.

Shell small, subovate to subtriangular, as wide as or wider than long; postero-lateral slopes with slight vertical flattening. Dimensions of three specimens, the second and third of which are the cotypes: Length, 11.5 mm., 10 mm., and 9.3 mm.; width, 13.3 mm., 10.2 mm., and 9.7 mm.; thickness, 9.5 mm., 8.3 mm., and 6 mm.; width of sinus, 5.7 mm., 5.8 mm., and 5.1 mm.

Pedicle valve convex on the umbo; flattened on the lateral slopes, and abruptly convex to the margins. Beak acutely angular, incurved, and produced 1 to 1.6 mm. beyond that of the opposite valve. Mesial sinus broad, shallow, flat-bottomed, containing, in all specimens examined, three plications; it originates 4 to 5 mm. anterior to the beak, and curves with increasing abruptness toward the opposite valve.

Brachial valve more convex than the pedicle; beak short and sharply incurved into the delthyrium; region anterior to the umbo slightly flattened; antero-lateral slopes abruptly convex. Mesial fold arises about midway of the valve; is broad and flattened, bearing four plications. Postero-lateral slopes with slight vertical flattening. Surface of both valves marked by fourteen to eighteen strong, simple, subangular or rounded plications; growth lines lacking in all specimens examined.

This species resembles, in general form, both *R. minnesotense* and *R. wisconsinense.* From the former it differs in its lesser width and greater thickness, fewer plications, and lesser elevation of the fold. From the latter it may be distinguished by its lesser width, greater thickness, fewer and less angular plications, and complete lack of lamellose growth-lines. Its nearest relative seems to be *R. cuneiforme* of this paper, from which it is distinguished by shape, pronounced curvature of the pedicle beak, and more rounded plications.

Formations and Localities: Decorah, — 2½ miles west of Ste. Genevieve, Missouri; Platteville, — Minneapolis, Minnesota; (?) Plattin, — Ste. Genevieve County, Missouri..

Cotypes, No. 27,443, Walker Museum.

RHYNCHOTREMA UNIPLICATUM sp. nov.

Plate II, figs. 10-13; cf. figs. 14-16.

Shell small, subtriangular in outline, wider than long; postero-lateral margins straight, meeting at the beak in an acute angle; anterior margin almost straight. Dimensions of the cotypes: Length, 11.8 mm., and 10 mm.; width, 12 mm., and 10.4 mm.; thickness, 7.7 mm., and 5.8 mm.; width of sinus, 6.7 mm., and 5.2 mm.

Pedicle valve slightly convex in the umbonal region; lateral slopes flattened. Mesial sinus sharply defined; originates about 3 mm. from the beak, and contains one strong plication. Brachial valve more convex than the pedicle. Mesial fold, originating about 3 mm. anterior to the beak, is low but well defined, and bears two strong, rounded plications. Beak sharply incurved, projecting into the delthyrium of the produced pedicle beak. Surface of each valve marked by eleven to fourteen strong, subangular or rounded plications, and by heavy, rounded growth-lines, so very coarse as to give a nodose appearance to the plications.

This species differs from *R. kentuckiense varians* of this paper, with which it is associated, in its lesser number of plications on the fold and sinus, and in the heavy growth lines which are not lamellose. From *R. dentatum* (Hall), which also possesses a single plication in the sinus, *R. uniplicatum* differs in proportions, as well as in smaller size and less gibbous character. Moreover, in *dentatum* the plications of the fold and sinus are quite as angular as those of the slopes, while in *uniplicatum* they are distinctly broader and more rounded. As compared with Foerste's and Miller's figures of *R. dentatum arnheimense* (*R. arnheimense*), that species is larger, narrower, and characterized by a more curved anterior margin than the one here considered.

Formation and Locality: Kimmswick Limestone, — near Sulphur Springs, Mo., and Batchtown, Ill.

Cotypes, No. 27,450, Walker Museum.

ZYGOSPIRA VARIABILIS sp. nov.

Plate II, Figs. 7-9.

Shell small, elliptical; wider than long in adults but longer than wide in young. Dimensions of three typical specimens: Length, 5.2 mm., 6.5 mm., and 7.5 mm.; width, 5.6 mm., 6.9 mm., and 7.7 mm.; thickness, 2.9 mm., 3.8 mm., and 4.6 mm.

Pedicle valve pronouncedly convex in the umbo, moderately so on the slopes, and depressed or concave near the cardinal extremities. Beak prominent, sharp, incurved, and produced from 0.3 to 0.9 mm. beyond that of the brachial valve. At the crest of the low, rounded mesial fold runs a slight longitudinal depression, manifested as a deepened and very broad furrow between two of the plications. Brachial valve less convex than the pedicle; greatest convexity in the umbo; slopes flattened. Near the beak originates the broad, shallow, undefined mesial sinus, which may or may not be marked by a broadened median plication to correspond to the median furrow of the fold. Width of sinus in a specimen 6.7 mm. broad is approximately 4 mm. Surface of both valves marked by eighteen to twenty-two simple, rounded or subangular plications.

What relation this species may hold to *Z. tantilla* Bradley[1] cannot be determined. Bradley does not figure his species, nor does his description afford anything determinative; it might apply to the New York *Z. recurvirostris*. Therefore, since *Z tantilla* is neither recognizably figured nor defined, it should be abandoned.

Z. variabilis differs from the typical *Z. recurvirostris* (Hall and

[1] Bull. Mus. Comp. Zoöl., 64, p. 525.

Hall & Clarke types) by its greater size, and particularly its greater width, its lesser thickness, and more angular proportions. The plications also are considerably coarser than in the New York form.

Formations and Localities: Plattin, — South Beckett Hill, Ste. Genevieve County, Kentucky; Black River, — Frankfort and Paris, Kentucky.

Holotype; No. 25,861, Walker Museum.

ZYGOSPIRA VARIABILIS FOUNTAINENSIS var. nov.

Plate II, Figs. 1-3.

In the Decorah shale at Fountain, Minnesota, and in the Maquoketa shales near Clermont, Iowa, there is found a *Zygospira* which is clearly a slight modification of the typical *Z. variabilis* of the Plattin. The proportions are almost identical; the differences being in the plications. These are somewhat more numerous (eighteen to twenty-four to the valve) than in the typical species, and are noticeably finer and rounder. Had it not been for the occurrence of the same form in two formations so widely separated as the Decorah and the Maquoketa, this would have been interpreted as a purely environmental difference.

Cotypes, No. 27,455, Walker Museum.

ZYGOSPIRA CALHOUNENSIS sp. nov.

Plate II, Figs. 4-6.

Shell pronouncedly ovoid, longer than wide. Dimensions of three specimens: Length, 5.3 mm., 5.2 mm., and 5.8 mm.; width, 4.7 mm., 4.9 mm., and 4.6 mm.; thickness, 3.6 mm., 3.9 mm., and 4.2 mm.

Pedicle valve convex, except in the vicinity of the rounded cardinal extremities where, in the broader specimens, it is slightly concave. Beak short, pointed, and abruptly incurved; mesial fold indicated by a slight, flattened elevation. Brachial valve less convex than the pedicle; marked by a broad, shallow, mesial sinus which appears 2 or 3 mm. anterior to the beak. Surface of both valves marked by twenty to twenty-two strong, simple, rounded plications, separated by narrow furrows.

This is another species of the *Z. recurvirostris* group, and is more closely related to the typical New York form than are the two preceding ones. It may be distinguished, however, by its excessive gibbosity and very slight development of fold and sinus. In the young specimens there is a lesser development of these features, coupled with a flattening or concavity near the cardinal extremities, that indicate close relationship to, and perhaps descent from *Z. variabilis.* It seems probable that both *recurvirostris* and *calhounensis* are the descendants of a species very much like *Z. variabilis.*

Cotypes, No. 27,457, Paratypes, No. 27,458, Walker Museum.

PLATE I

Rhynchotrema kentuckiense varians var. nov.

1-3. Brachial, pedicle, and lateral views of the holotype.

Rhynchotrema wisconsinense sp. nov.

6-8. Brachial, pedicle, and lateral views of the holotype, showing the lamellae.

Rhynchotrema decorahense sp. nov.

9-11. Brachial, pedicle, and lateral views of the holotype, the last showing the great depth of the pedicle valve.

Rhynchotrema cuneiforme sp. nov.

12-14. Brachial, pedicle, and lateral views of the holotype.

Rhynchotrema minnesotense (Sard.)

15-17. Brachial, pedicle, and lateral views of a plesiotype.

Rhynchotrema kentuckiense sp. nov.

4. Brachial view of a small paratype, showing the long, pointed beak.

5. Lateral view of another paratype, showing the shallowness of both valves during the earlier stages of development.

18-19. Brachial and pedicle views of the holotype.

20. Lateral view of the holotype; cf. fig. 5.

21-22. Brachial and pedicle views of a paratype.

(All figures enlarged about 1.5 diameters)

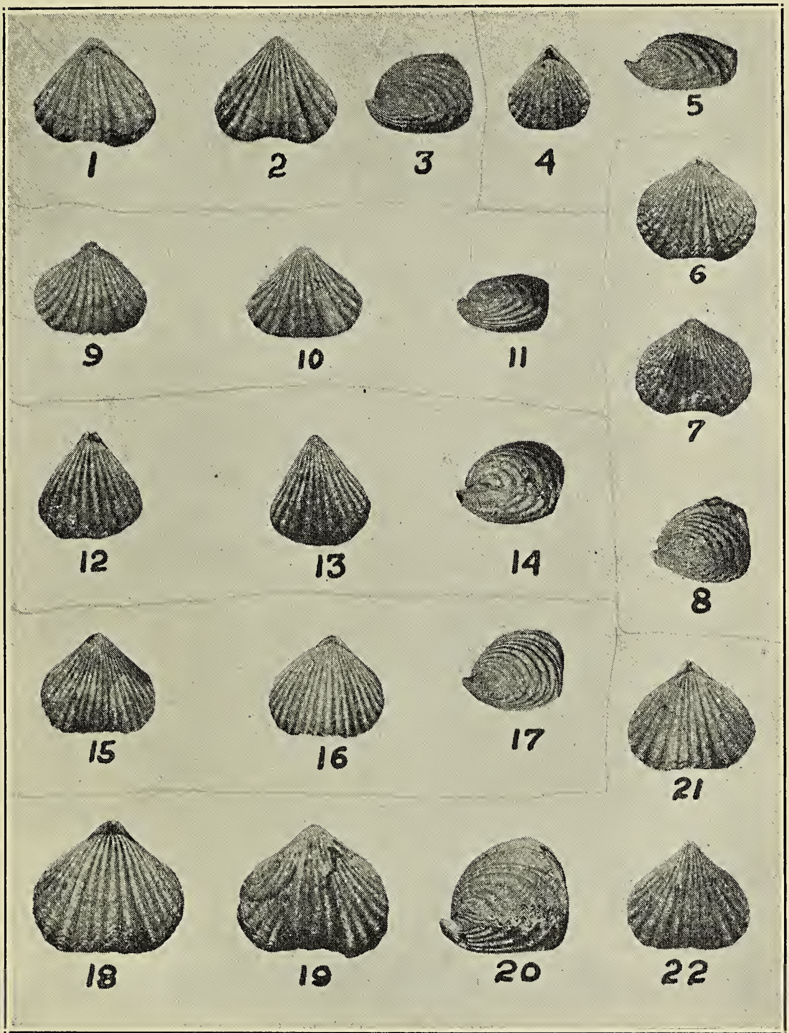

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PLATE II

Zygospira variabilis fountainensis var. nov.

1-3. Brachial, pedicle, and lateral views of a cotype, showing the even, rounded plications and median furrow (×2.5).

Zygospira calhounensis sp. nov.

4-6. Brachial, pedicle, and lateral views of a cotype, showing the differences between this species and *Z. variabilis fountainensis* (×2.5).

Zygospira variabilis sp. nov.

7-9. Brachial, pedicle, and lateral views of the holotype (×3).

7a. Pedicle view of the holotype; cf fig. 2 (×1.8).

Rhynchotrema uniplicatum sp. nov.

10-12. Brachial, pedicle, and lateral views of the oldest cotype. Note the single plication of the sinus and the nodose plications of both valves.

13. Pedicle view of a younger cotype.

Rhynchotrema dentatum (Hall)

14-16. Brachial, pedicle, and lateral views of a typical Richmond specimen, showing the differences between this species and *R. uniplicatum*.

Rhynchotrema mercerense sp. nov.

17-19. Brachial, pedicle, and lateral views of the larger of the cotypes.

20-21. Brachial and lateral views of the smaller cotype.

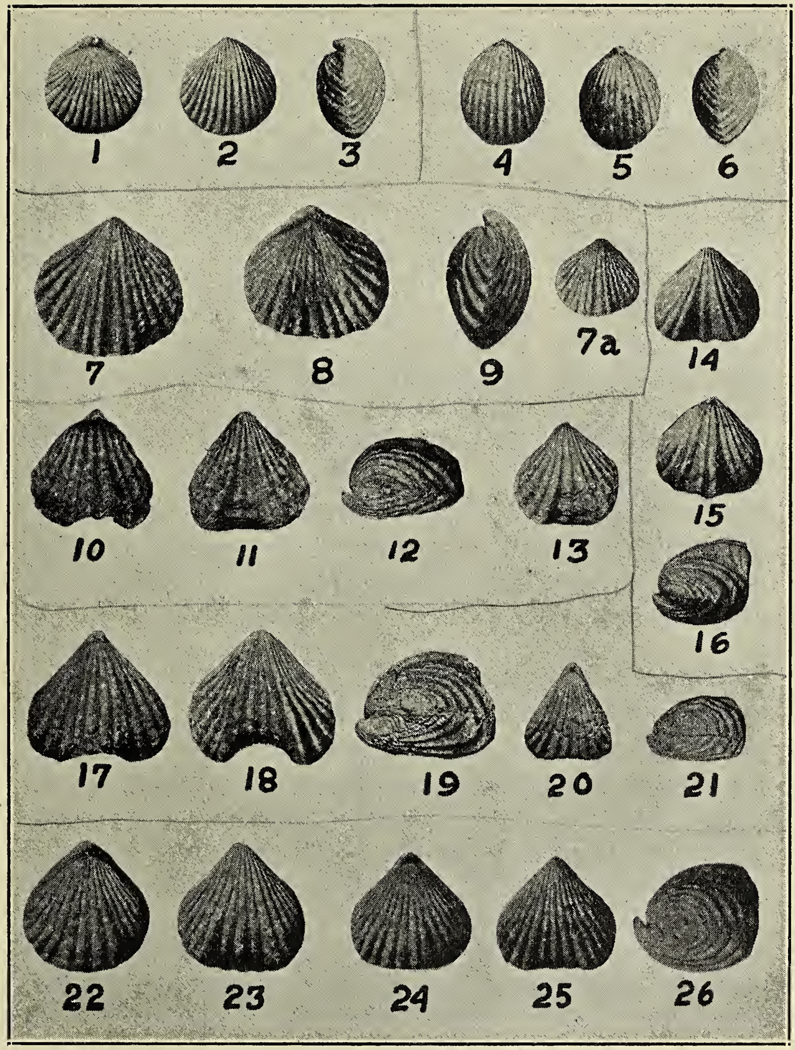
Rhynchotrema missouriense sp. nov.

22-23. Brachial and pedicle views of the larger cotype, showing the coarse, rounded plications.

26. Lateral view of the same specimen.

24-25. Brachial and pedicle views of the smaller cotype.

Unless otherwise stated, all figures are enlarged about 1.5 diameters.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SOME NEW PALEOZOIC GLASS-SPONGES FROM IOWA

A. O. THOMAS

Fossil sponges of any kind are relatively rare in the Paleozoic rocks of Iowa and especially so if we except the questionable forms generally relegated to the Receptaculitidae.

Briefly stated the record stands about as follows: in the Maquoketa beds are a few zones in which *Hindia parva* Ulrich is fairly common; in the dolomitic Hopkinton beds of the Silurian are rare examples of *Astylospongia christiani* M. and W.; in certain Devonian horizons are examples of the thick-walled, convexo-concave *Astraeospongia hamiltonensis* M. and W.; in the same system the shells of occasional brachiopods and molluscs show considerable evidence of the ravages of a tiny boring sponge belonging to the genus Clionolithes and there is record of similar depredations on Mississippian brachiopods; the Burlington limestone has furnished one Dictyosponge, *Lyrodictya burlingtonensis* Hall and a specimen of *Belemnospongia fascicularis* Ulrich; and lastly Ulrich has described a species of Lasiocladia from the Keokuk limestone.

Recurring to the Receptaculitidae, the large discs of *Receptaculites oweni* Hall, the so-called "sunflower coral" of the lead and zinc miners, are abundant in at least two zones of the Galena dolomite in the vicinity of Dubuque and at other localities where this part of the Ordovician is exposed. Of less common occurrence but associated with *R. oweni* and belonging to the group are specimens of *Ischadites iowensis* (Owen). Fragments of a Receptaculites, close to *R. occidentalis* Salter, are found in the Silurian. Another Silurian receptaculoid form is *Cerionites dactylioides* (Owen); in places the rock is crowded with representatives of this species and whatever their habits or lineage may have been they lived in dense groups whose numbers suggest prolific sponge colonies similar to those of the Tennessee Silurian.

The remarkable glass-sponge colonies of the Upper Devonian of New York and Pennsylvania are without their equivalents numerically anywhere in North America as far as known. Indeed these remote ancestors of the beautiful Venus' Flower Basket of our modern seas are but meagerly represented paleontologically outside of the New York Chemung. There are a few doubtful ancestors of Ordovician age and a derelict or two from the Silurian, one from New York and one from England. The *Cyathodictya oblonga* of this paper adds another of Silurian age. The Mississippian record is more remarkable for the wide distribution of the few forms known than for populous colonies such as inhabited Upper Devonian beds; the Burlington limestone species mentioned above was found in Iowa and up to the present paper was the only glass-sponge ever reported from the state. The Jurassic and Cretaceous have yielded some more or less obscure species. Since the Cretaceous, as well as during most of the epochs before then, the glass-sponges have occupied the deeper waters beyond the continental shelves. For the facinating history of the glass-sponges the reader is referred to an article by Doctor John M. Clarke[1] which appeared recently. For detailed descriptions and beautiful illustrations access should be had to a monograph on them by James Hall in collaboration with Doctor Clarke[2].

The occurrence of two new species, one of them belonging to a new genus, in the Paleozoic rocks of Iowa is here offered as a brief contribution to the subject. The first of these belongs to one of the more primitive stocks of the glass-sponges which Clarke assigns to the genus Cyathodictya. The other does not belong to any of the described genera but is nearest, perhaps, to the general type of Ceratodictya. Both apparently are Lyssacine hexactinellids and are placed in the family Dictyospongidae.

CYATHODICTYA OBLONGA n. s.

Plate I, Figs. 1, 4

Species based on a single elongate, obconic specimen which is attached by one side to a block of buff-colored, compact, and finely crystalline dolomite. The reticulum is preserved as fine linear impressions or casts over the entire surface. The aperture is concealed by the matrix and the body is somewhat flattened toward the upper end. The sponge expands gradually for about one-third its length above which the sides are nearly parallel until just before reaching the aperture where there is a slight but appreciable tapering. The pattern of the reticulation consists of

[1] The Great Glass-Sponge Colonies of the Devonian: their Origin, Rise, and Disappearance. Jour. Geol, vol. 28, pp. 25-37; 1920.

[2] A Memoir on the Paleozoic Reticulate Sponges constituting the Family Dictyospongidae. Albany, 1898.

a fine mesh of small oblong quadrules whose longer dimension is up and down the surface and the pattern is without variation over the exposed part of the specimen. Transversely the quadrules average about twenty-two to the centimeter while vertically the number is between eight and nine to the centimeter, hence the length of each quadrule is about two and one-half times its breadth. The transverse lines are more wavy than the vertical ones. On the expanding lower part new lines come in between the others at irregular intervals. There is no evidence of a basal tuft.

Length of specimen 125 mm., width at the midlength 34 mm., greatest thickness of the part above the matrix 14 mm.

Position and Locality: Middle Silurian or Niagaran beds, near Hopkinton, Iowa. Collected by Samuel Calvin. It is museum number 2800.

IOWASPONGIA n. g.

Large vase-shaped or fusiform sponge. Surface marked by prominent, sharp-edged, horizontal annulations separated by broadly concave interannular spaces. It has no nodes or protuberances. Aperture and tip unknown.

It is of the general type of Ceratodictya of Hall and Clarke.

IOWASPONGIA ANNULATA n. s.

Plate I, Figs. 2, 3, 5

Descriptions based on three incomplete specimens whose interiors are filled with the plastic shale of the matrix.

Body large, vase-, or spindle-shaped, approximately circular in cross-section. Upward expansion rapid in the lower part, then gradual, with evidence of becoming narrower above. Body marked by sharp and prominently elevated annulations which are farthest apart about the middle and become progressively closer together both apically and basally.

Specimen *a* is 130 mm. long, 158 mm. in greatest diameter, and 91 mm. in diameter at the lower end. It has eight annulations, the circumferences of which as well as the width of the interannular spaces gradually increase upward for the first five rings, while the remaining rings and spaces have nearly equal circumferences and widths respectively. When complete the indvidual was close to a foot in length.

Preservation is such that only a carbonaceous stain or film is left to represent the reticulum — traces of which are so faint that the character of the mesh is not clear.

Specimen *b* is 203 mm. long and 135 mm. in greatest diameter. It has been partly flattened and distorted by pressure at time of burial; parts of eight annuli are preserved; they are less prominent and farther apart than in specimen *a,* due, in part at least, to the imperfect preservation. The surface of the specimen is nearly all covered with a black carbonaceous film except for patches of iron sulphide, presumably iron pyrites; the pyrite seems partly to coat the surface as a thin film intimately mingled with the carbon or just beneath it. On the metallic surface of the pyrite may be detected very fine vertical ridges, two or three in the space of a millimeter, and obscure traces of cross lines. These may represent the reticulum.

Specimen *c* consists of a fragment of the rapidly expanding basal part of another individual. It shows parts of six annuli with long gentle lower slopes and short abrupt upper slopes. They average from crest to crest a width of nine millimeters. Fine concentric lines occur on the upper slopes of some of the rings and there are a few striae on the lower slopes at right angles to the lines on the upper slopes. These seem to represent what remains of the reticulum. The inner surface of the cavities or molds from which this and the other two specimens were taken would very likely show the pattern of the reticulum had they been saved by the collectors. The dimensions of specimen *c* are: diameter at smaller end 62 mm., at larger end 100 mm., height about 35 mm.

Position and Locality: Upper Devonian, Lime Creek shales in the blue plastic clay some thirty or forty feet below the marly horizon at the pit of the Rockford Brick and Tile Company, Rockford, Iowa. Specimens *a* and *b* were obtained at this pit by Mr. C. L. Fenton who has kindly submitted them to the writer for study. Specimen *c* was collected at the same pit at the horizon of *Lingula fragilis* by Mr. C. H. Belanski. It is University museum number 2801.

Except for some fine specimens obtained by Barrois in the Upper Devonian beds of Brittany, France, and described by Hall and Clarke in their Memoir, this is the only species reported from this horizon outside of the New York-Pennsylvania area.

Paleontological Laboratory,
State University of Iowa.

PLATE I

Figs. 1, 4. *Cyathodictya oblonga* Thomas.

Fig. 1. A part of the surface of the holotype, x 2½.

Fig. 4. A view of the holotype, natural size.

Silurian; Hopkinton, Iowa. Collected by Samuel Calvin.

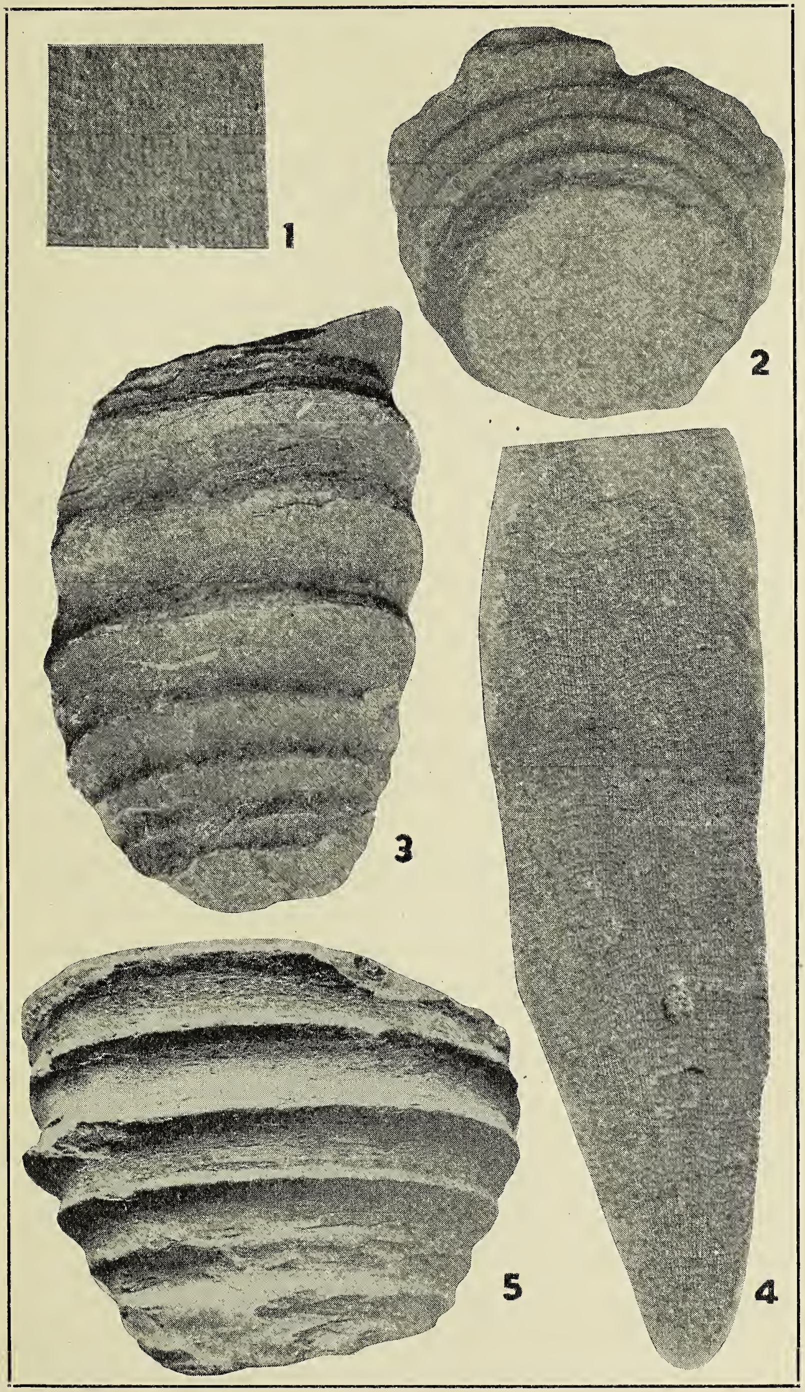
Figs. 2, 3, 5. *Iowaspongia annulata* Thomas.

Fig. 2. A view of specimen *c*, x .55, tilted to show the annulations. Note the difference between the upper and lower slopes of each ring.

Fig. 3. Specimen *b* illustrating the tapering toward the lower end and the slight narrowing upward. This individual is somewhat distorted and flattened; x about .4.

Fig. 5. Specimen *a* showing the sharp-edged annuli and the concave interannular areas. Note the gradual tapering and the progressive decrease in width between the rings; x about .5.

The three specimens are regarded as cotypes. They were collected in the plastic blue shale of the Lime Creek beds at the pit of the Rockford Brick and Tile Company, Rockford, Iowa. Specimens *a* and *b* collected by C. L. Fenton and specimen *c* by C. H. Belanski.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STATUS OF CERTAIN RHYNCHONELLID BRACHIOPODS FROM THE DEVONIAN OF IOWA

A. O. THOMAS AND M. A. STAINBROOK

At the first Annual meeting of the Iowa Academy of Science [1] at Iowa City, June 23, 1876, Professor Samuel Calvin read a paper on "New Species of Paleozoic Fossils." The Proceedings of the meeting do not give an abstract of the paper but in the American Naturalist, Vol. 11, pp. 57-58, a brief abstract says that "Prof. Samuel Calvin, of the State University of Iowa, described seven New Species of Paleozoic Fossils found mainly in Howard and Floyd counties, Iowa." One of these species was *Rhynchonella alta* which occurs in the Lime Creek shales of Floyd county, one of the two counties mentioned. It appears that Calvin distributed "a named photographed plate" [2] of these fossils but its fugitive character has been such that it has not been generally available to students. Calvin's description of the species was not published but we find paleontologists, for example, Williams,[3] Walcott,[4] and others to whom specimens had evidently been sent, accepting the name.

In the State Quarry beds, outcropping near Solon and also near North Liberty in Johnson county, Iowa, some seventy miles from the nearest Lime Creek beds, occurs a fauna rich in fish teeth,[5] broken brachiopod shells, crinoid stems and some others of less importance. The only well preserved and readily recognized brachiopod from this formation is one that is congeneric with Calvin's *R. alta* and which bears considerable superficial resemblance to it. Specimens of this State Quarry shell were distributed by Calvin and others under the name *Rhynchonella pugnus* or *Pugnax*

1 This was the first Academy of Science, 1875 to 1884. The present Academy was organized in 1887. A pamphlet printed by John P. Irish at Iowa City in 1880 gives the proceedings of the old Academy up to that year and a short abstract of some papers. See Proc. Ia. Acad. Sci., Vol I, pt. ii, p. 9, 1892. The date of the meeting at which Calvin read the paper has been given erroneously by several authors as 1877.

2 Walcott, C. D., U. S. Geol. Surv. Monog. VIII., p. 156, 1884; Whiteaves, J. F., Contrib. Can. Pal., Vol. I, pt. iii, p. 231, 1891; Schuchert, C., U. S. Geol. Surv. Bull. 87, p. 335.

3 Williams, H. S., Amer. Jour. Sci., Vol. 25, 3rd Series, p. 100, 1883.

4 Walcott, C. D., opus cit.

5 Eastman, C. R., Iowa Geol. Surv., Vol. XVIII, Dev. Fishes of Iowa.

pugnus (Martin). This name was first applied to a European species which occurs abundantly in the Lower Carboniferous (Mississippian) of the British Isles and the Continent, but less commonly in the subjacent Upper Devonian beds of the same countries. Species identified as *R. pugnus* or *P. pugnus* and varieties have been reported from several Devonian localities in North America. In the opinion of the writers these need revision.

The fact that *R. alta* and *R. pugnus* are the names heretofore attached to rather similar shells from Iowa naturally has led to some confusion. By some authors *R. alta* is made synonymous with *R. pugnus*, by others, it is regarded as a variety. Thus Walcott and later Whiteaves in the works cited above make these synonymous while Williams [6] makes *alta* a variety but actually figures *R. pugnus* from the State Quarry beds at Solon. On the other hand Hall and Clarke,[7] the authors of the genus *Pugnax*, refer both the Lime Creek and State Quarry species to *Pugnax altus* Calvin and illustrate both forms with excellent figures which bring out clearly some of the differences between the Hackberry Grove and Solon species. Schuchert [8] in his bibliography lists *R. alta* as a variety of *Pugnax pugnus* and limits it to the one locality, namely Solon. Weller [9] regards the two as similar and assigns *Pugnax altus* to both the State Quarry and the Lime Creek. But it is needless to add further examples from the literature of the obviously badly confused identification of these two quite distinct forms. Calvin clearly recognized their differences but unhappily he lacked consistency in the use of the names. In the Cerro Gordo list [10] he correctly enters the Lime Creek species as *Pugnax altus* but in the Buchanan county list [11] of the Independence shale fossils he enters a brachiopod which he considered identical with the Lime Creek species as *Rhynchonella* (*Pugnax*) *pugnus* var. *alta* and speaking of its occurrence he says, "the *Rhynchonella* (*Pugnax*) *pugnus*, found in both the Lime Creek and the Independence shales, is a small acuminate variety, quite distinct from that occurring in the State Quarry beds of Johnson county, Iowa." The distinctness of the two in Calvin's opinion is further brought out in the Johnson county report [12] where he says "the fauna of the State Quarry

6 Williams, H. S., Bull. G. S. A., Vol. I, p. 495, pl. 12, figs. 5-7, 1890.
7 Pal. N. Y., Vol. VIII, pt. ii, pp. 203, 204, pl. LX, figs. 1-5, 1894.
8 Opus cit.
9 Jour. Geol., Vol. XVII, p. 266, 1909.
10 Iowa Geol. Survey, Vol. VII, p. 165, 1897.
11 Iowa Geol. Surv., Vol. VIII, pp. 223-224, 1898.
12 Iowa Geol. Surv., Vol. VII, p. 78, 1897.

beds is unique. The deposit near Solon furnishes *Pugnax pugnus* (Martin), *Melocrinus calvini* Wachsmuth and Springer, and a very peculiar Stromatoporoid, none of which is found in the other Devonian formations."

The Lime Creek specimens in the Calvin Collection at the University all bear the label "*Pugnax altus*" in Professor Calvin's handwriting. The specimens collected by him from the State Quarry beds at Solon and North Liberty are labelled "*Rhynchonella pugnus*" except one tray containing a score or more specimens from the State Quarry beds at Solon. This is labelled "*Rhynchonella alta* Calvin, Solon, Iowa." The lot is a part of one of his earlier collections made in the seventies or eighties. In no case is there a mixture of the two species in the trays.

In 1910, Weller [13] illustrated the internal characters of the rostral portion of the valves of *Pugnax pugnus* (Martin) from the Mountain Limestone of Ireland. In 1914 he placed two American Mississippian species in this genus.[14] Neither of these is *P. pugnus* and no undoubted examples of this species are thought to occur in the American Mississippian or Devonian.

In order to settle the generic status of these Iowa Devonian rhynchonellids the junior author undertook the task of grinding away the beaks gradually and of making drawings of the brachial supports at intervals. The series of drawings are here presented. From them an ideal restoration of the brachidium and other internal characters can be made out and it is apparent that our species belong to the genus *Pugnoides*. A description of each of the two species follows.

PUGNOIDES ALTUS (CALVIN)

Plate I, Figs. 1 to 16.

1876. *Rhynchonella alta* Calvin. Read before the Iowa Academy of Science and a named photographic plate distributed.

Shell below medium size, acuminate, subpentagonal in outline, length and width about equal, greatest width posterior to the middle.

Pedicle valve strongly produced in front, the extended part being nearly at right angles to the plane of the valve; mesial sinus broad, beginning at a short distance in front of the umbo, and bordered laterally by high steep sides which gradually de-

[13] Bull. G. S. A., Vol. 21, p. 508.
[14] Ill. Geol. Surv., Monog. I, pp. 202-205.

crease in height anteriorly and become suppressed before reaching the margin; in most specimens the sinus narrows gradually to the front, becoming rather acuminate in extreme specimens. Postero-lateral angles prominent — viewed brachially, as in figures 1-4, there is but little slope from the beak to the angles — but viewed ventrally, as in figures 5-8, the postero-lateral edges form an obtuse angle at the beak which is pointed and incurved over that of opposite valve; pedicle opening round and small. Posterior part of valve smooth; near the midlength of the sinus there arise two (rarely three) plications which become stronger anteriorly, whose courses are subparallel and which meet those of the opposite valve in such a way as to make the anterior part of the linguiform extension sharply denticulate. Just in front of each postero-lateral angle and near the margin of the valve are two short angular plications. Internally the dental lamellae are short and the valve lacks a median ridge.

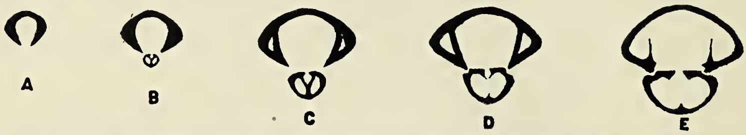


Fig. 1. A series of five cross-sections of the rostral part of the shell of *Pugnoides altus* showing the dental lamellae of the pedicle valve and the median septum, crural cavity, and crura of the brachial valve (x2½).

Brachial valve high, midline gently curving; the sides of the valve slope rapidly to the margins; in a side view the outline of the valve is sub-triangular; the high mesial region is accentuated on the front half by the presence of a sharp angular plication on each side of which is another plication equally angular but less strong. On the postero-lateral areas arise two or three low plications which are directed sharply outward to the posterior margin where they alternate with the shorter plications of the pedicle valve. Surface of valve smooth. Internally is a well developed septum which is divided to form a short crural cavity.

Position and localities: Lime Creek shales; very common at Bird Hill; also found at the exposures west of Rockford, and at Hackberry Grove. A single specimen of smaller size and with somewhat different arrangement of the plications is in the Calvin Collection from the Independence shale at Independence. Two specimens, one larger than any found in the Lime Creek beds, have been collected at exposure No. 3, of the Independence shale near Brandon. These have four plications on the fold.

PUGNOIDES SOLON THOMAS AND STAINBROOK

Plate I, Figs. 17 to 32.

1921. *Pugnoides solon* T. and S. Science, New Series, Vol. LIV, p. 308.

A strong shell of somewhat less than medium size, pentagonal in outline, wider than long, greatest width near the midlength.

Pedicle valve produced in front into a broad extension which is deflected until at right angles to the plane of the valve; the deflected part is wider than long and is of nearly the same width throughout. Mesial sinus very broad and scarcely defined until a short distance above the deflected portion; at the geniculation the sinus is flanked by the sharply elevated but short bounding plications. Anteriorly the sinus bears two, three, or four plications (rarely one or five), the greater number of shells have three; these are barely evident posterior to the deflected part. On the sides of the valve, near the margin, are three or four short, strongly elevated plications which give the sides a denticulated appearance. Beak closely incurved over that of the opposite valve; foramen small, terminal.

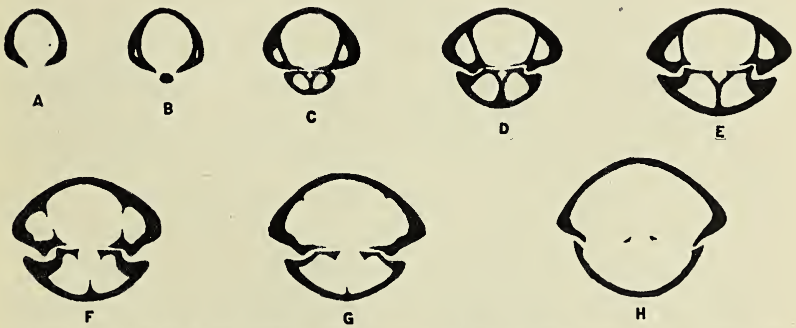


Fig. 2. A series of eight cross-sections of the rostral part of the shell of *Pugnoides solon* showing the dental lamellae of the pedicle valve and the median septum, crural cavity, and the crura of the brachial valve (x2½).

Brachial valve broadly convex from the umbo to the front margin; sides sloping gradually, their surfaces convex; fold broad, flattened anteriorly and marked by two to five, (rarely six), short, somewhat angular, but stout plications which terminate in a strongly serrate edge. Lateral slopes marked by three or four plications which arise about halfway between the beak and the margin; they are more rounded than those on the lateral slopes of the opposite valve.

Valves smooth except as noted; partly exfoliated shells under a strong lens show fine crowded radial lines and in some cases equally fine concentric lines. Internally the critical features of the genus are brought out in the series of sections here illustrated.

The species differs from *P. altus* in its generally coarser, broader, and less acuminate appearance; in the variable number of plications on the fold and sinus; and in the shorter and more rectangular deflected extension of the pedicle valve; and in having on the whole less angular plications.

Position and Localities: Limited to the State Quarry limestone at the old State Quarry near North Liberty and at various small outcrops to the west and south of Solon in Johnson county, Iowa.

PLATE I

Figs. 1-16. *Pugnoides altus* (Calvin)

1-4. Brachial view of four typical specimens; number 1 has four plications on the fold, three is the usual number.

5-8. Pedicle view of four specimens. Note the short plications on the lateral slopes.

9-12. Four specimens showing the tapering, linguiform extension of the pedicle valve.

13, 16. Two specimens viewed from the side showing the trigonal shape and the incurved beaks.

14, 15. Two examples viewed posteriorly; note the sharply angular plications on anterior part of the fold.

Figs. 17-32. *Pugnoides solon.* Thomas and Stainbrook.

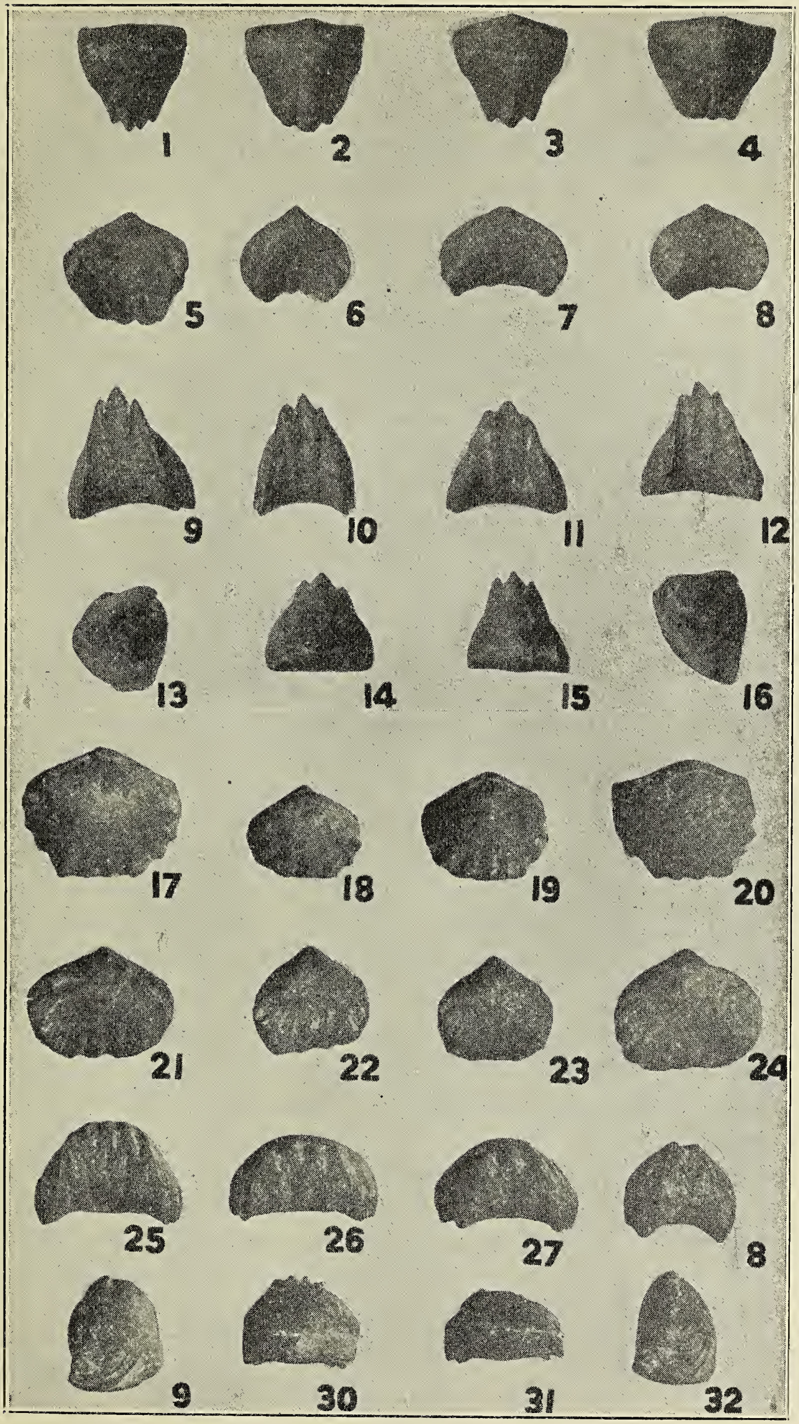
17-20. Brachial view of four specimens showing the shape of the shell and the stout, short plications.

21-24. Pedicle view of four specimens.

25-28. Anterior view of four individuals showing the thickness of the shell, the zigzag front margin, and the variable number of plications on the fold and sinus. Number 28 has but one in the sinus.

29, 32. Lateral view of two specimens showing the plications of the lateral slopes.

30, 31. Posterior view of two examples showing the thickness of the shell, the plications on the fold, and the elevated ends of the lateral plications of the pedicle valve.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LARAMIAN HIATUS AROUND THE SOUTHERN ROCKIES

CHARLES KEYES

For a long time after the vast coal fields which extend around the southern extremity of the Rocky Mountains in southern Colorado and northern New Mexico, came under close surveillance of stratigrapher their deposition was regarded as having taken place during the closing epoch of the Cretacic Period. The great thickness of the associated strata were paralleled with the enormously thick Laramie coal-bearing beds of Wyoming and Montana. On this point a voluminous literature appeared to be in general agreement.

When, in 1902, it was my privilege first to enter the New Mexcan coal-fields under the ægis of Railroads then building, I soon began to suspect and then to entertain doubts as to the correctness of the reference of the entire great rock section to the Laramie coal series. Casual examination of fossils collected and identified indicated that the principal coal-yielding strata were really well down in the Cretaceous column. A considerable part of the upper portion of the vertical section was in like manner determined to be certainly very much younger. At the coal camp of Hagan, to the westward, at the eastern base of the Sandia Range, the Cretacic rocks were displayed in full detail. Above the top of a published section [1] the beds were made out to be Tertiary in age. They enclosed a fine petrified forest.

When a little later in the season, with this clue to work from, the Raton and Trinidad coal-fields were made the subject of special investigation for the direct purpose of narrowing the limits of new prospecting as much as possible, the horizon separating the Cretacic strata from the supposed Tertiary beds was soon divined. An erosional unconformity was found to be well marked by a thick, local conglomerate, but the level proved to be in some localities much lower in the section than was anticipated. In places the basal conglomerate reached so low as the Trinidad sandstone, a notable guide horizon just above the top of the Pierre shales.

[1] Eng. and Mining Jour., Vol. LXXVII, p. 670, 1904.

Following the reports of the earlier Governmental Surveys the entire coal-bearing section was of the same age as the original Laramie beds. But the evidence brought forth demonstrated that while the section was, in its lower part, Cretaceous in age, in its upper part it was certainly of Tertiary age. The notable unconformity plane midway in the section demanded particular attention. More important than the determination of whether either part of the section was to be correlated with the typical Laramie of Wyoming was the evaluation of the depositional equivalent of the unconformity plane.

In the Raton region the stratigraphic position of the great sandstone, known as the Trinidad sandstone, was readily determined. This thick stratum manifestly rested directly upon the Pierre shales. The latter, called the La Jara shales on the farther side of the Rocky Mountains, were more than 1000 feet in thickness, and represented the uppermost member of the Coloradan series. The Trinidad sandstone, or the Pina Vititos sandstone as it is termed to the westward, and the 300 to 400 feet of coal-bearing shales beneath the plane of unconformity were all that were left of the enormously thick Montanan series. The erosion plane was an important one.

Since, as indicated by abundant plant remains, the upper 1500 feet of the section was Early Tertiary in age, it was quite evident that the unconformity plane represented a very long interval of time. Fully one-half of the great Cretaceous succession was missing. If it ever existed in the region, and it doubtless did, it had been entirely removed by erosion. If ever any Laramie beds were present they too, in like manner, had been swept away.

Out of the 4000 feet of vertical section once believed to represent the Laramie formation not a single foot could now be so regarded. The vast Laramie pile of sediments elsewhere clearly had no depositional representation here. Stratigraphically the Laramian horizon was merely the horizon of the unconformity plane. But the latter possibly represented a time interval even longer than that in which typical Laramian sediments were laid down. Lately W. T. Lee [2] came to the same conclusion. In the Raton region the tremendously thick Laramie section elsewhere was represented by a complete void. It was a Laramie hiatus. Deposition took place in other parts of the country; subaerial erosion in this.

2 U. S. Geol. Surv., Prof. Pap. No. 101, p. 56, 1917.

There is, however, a larger aspect of the Laramian unconformity plane which should be noted. It is a critical expression of that great sedimental revolution which closed the Mesozoic era on this continent. The grand effects of this crustal movement were apparently not alone epeirogenic in their nature, but they were locally orogenic also. New Rocky Mountains came into existence; although at a still subsequent date the area thus elevated was again leveled to the level of the sea. When sedimentation was renewed in the region it was Tertiary deposition, perhaps earlier than any Eocene deposit that we know elsewhere.

The old Laramian planation surface is one of wide extent. It is also well displayed on the west side of the present Rocky Mountains uplift, in the High Plateaus of eastern Utah. In magnitude and importance it seems in every way comparable to the vast Comanchan peneplain, since it extended over all the southern Rocky Mountain tract. It appears to match the great Miocene peneplanation which the same region afterwards suffered. Its record forms one of the most prolix chapters in Rocky Mountain history.

The Laramian hiatus recalls to mind our own Arkansan hiatus at the base of our Iowa Coal Measures. Like our Iowa interval enormously thick deposits are represented elsewhere. Perhaps our own Coal Measures gave clue to the solution of the Laramian problem which for more than half a century so completely baffled all mining men and geologists. Laramian events are manifestly very much more important than has been commonly supposed.

HORIZONTAL MOVEMENT IN OBLIQUE FAULTING OF INCLINED STRATA

CHARLES KEYES

In the White Basin of southern Nevada, where extensive borax deposits were discovered a few years ago, the depression is formed by a huge drop-fault block, in which the displacement is more than 1000 feet and there appears a curious set of oblique faults which meet the major side-fault at an angle of 45 degrees. The strata being inclined about 30 degrees renders the direction of movement conspicuous. This is horizontal.

These oblique faults do not seem to form straight lines but are slightly convergent. At first glance they appear to be expressions of relief from tortional stresses. But the tract under consideration is a part of the Muddy Mountains lately determined to be not a typical exemplification of Basin Range structure but a huge thrust-block. Mountain thrusts are commonly regarded as low-angled faults, the plane of rupture being nearly horizontal.

On a ground plat the faults under notice are disposed obliquely to the main fault bounding White Basin, which is seven miles removed from the line where the thrust reaches sky, in the steep face of the Muddy Mountains. While the movement of the minor faults is horizontal the plane of motion is vertical and at right angles to the strike of the thrust. It seems probable, therefore, that these minor faults are not to be attuned to the White Basin fault, but are in reality expressions of movement not heretofore recognized. If they are actually a necessary and ordinary result of thrusting the fact is important in fixing the date of the thrusting, for they cut the boraciferous beds which are doubtless Miocene in age.

TAXONOMIC RANK OF PENNSYLVANIAN GROUPINGS

CHARLES KEYES

When the title Pennsylvanian was first proposed for the upper subdivision of the general Carbonic section of America it was with the express purpose of designating the widely known Coal Measures by a specific geographic name, and of implying a time value to the succession represented. In an unreasonable proneness of that day amounting almost to mania, of multiplying geographic and geologic terms and of giving new geographic titles to old lithologic units future contingencies of geologic taxonomy were entirely lost sight of, and the possibilities of some more refined nomenclature at no distant date were not taken into account.

As thus suggested Pennsylvanian was intended to be a time-term equivalent of a rock series and its use in this manner was supposed especially to emphasize the naturalness and the necessity of a dual nomenclature which its author had then recently also strongly advocated. But there proved to be no urgent demand for duplicate sets of names, particularly when on every hand it was clearly recognized that a single set sufficed. The idea was received coldly. What a provincial rock series really needed was special definition in which the time element should find no place. The Coal Measures were found to be a rock sequence much too ponderous to be cramped into provincial bounds.

So ill-fitting was the new geographic title, taxonomically, that instead of clearly delimiting a terranal succession for all time, and becoming a world-wide time unit its proposition and use served only to throw the classification of the Coal Measures into utmost confusion. Taxonomic clarity was impossible. Being merely a place-name affixed to an old and not less indefinite section it carried with it all the objections possessed by the older designation without providing any new or advantageous attributes. It soon developed that it was without delimitation one whit clearer than that held by the older name the place of which it was intended to take.

Raised later by some writers to high dignity with Periodic rank, and by others reduced to inconsequental serial position, it was really neither. A time signification of Periodic proportions was not possible because it would have to be applied in world-wide sense. For the present, at least, and perhaps for all time, the term cannot be expected to hold time valuation. With a provincial serial rank it leaves no room for real series; and there are many. An intermediary "group" is not only unnecessary, but burdensome, and serves no useful purpose. In our Continental interior, for example, there are no less than five rock series which, already well established, must eventually be accepted as valid. All are to be resolved out of the Coal Measures, or so-called Pennsylvanian section.

In the larger sense the time-value of the Pennsylvanian is much too long; in the lesser sense it is much too short. According to most approved canons of modern nomenclature the title seems to have no taxonomic claims. In view of all of these circumstances the old name still has useful mission; the later term none. It is today one of the chief drawbacks to taxonomic progress in this country, for the principle is far-reaching. Until the term is dropped from our system of nomenclature the diastrophic aspects of Coal Measures stratigraphy are likely to be continually misinterpreted and true advancement made impossible.

PYRITE IN COAL

J. M. LINDLY

A general discussion of this subject is not intended in this article, only the consideration of a deposit of pyrite in coal of a very unusual nature.

Some time in the earlier part of the year of 1922, as I was putting coal into the furnace of our place of business in Winfield, I found imbedded in a large lump of coal an object that very closely resembled a stone ax of prehistoric times.

The coal that we were using at this time had been procured form the Home Lumber Company, one of our local dealers, who had received the coal from some mine east or southeast of East St. Louis, Illinois, probably located about forty or fifty miles from the latter city. This coal was in large pieces. One of these pieces was a little too large to carry to the door of the furnace. I gave it a tap with the sledge. Instead of its breaking into several small pieces, it separated into two almost equal pieces, and in the heart of this large piece or lump of coal lay what appeared to be a stone ax.

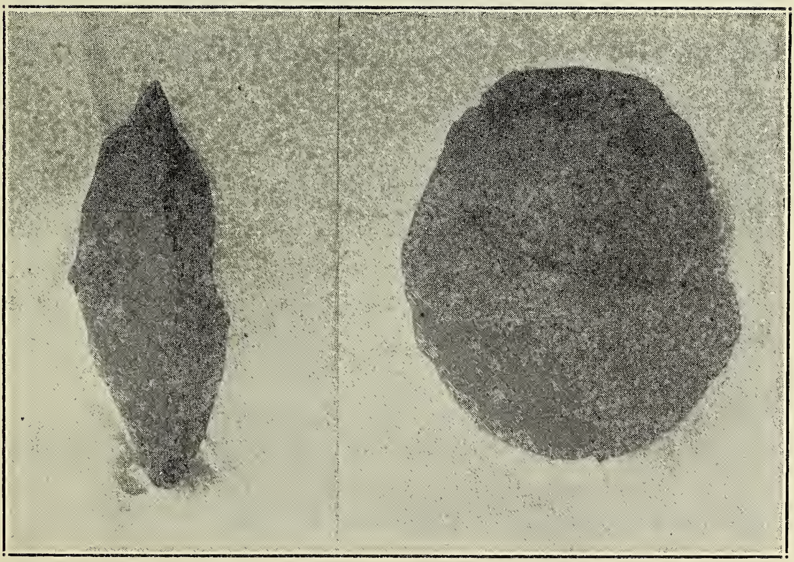

Fig. 1. Left view, edge of "ax." Right view, face of "ax."

This stone ax was seven inches long, six and a half inches wide, and two inches thick but tapering off to thin edges. Its color was light grayish brown. Its specific gravity was about 3.55 which is less than iron pyrite. What was it? It was submitted to the inspection of a few of the instructors of the State University, who expressed the opinion that it was iron pyrite but they had never seen anything just like it. Whilst it could not be a stone ax and belong to the Carboniferous age, its resemblance in outline to a stone ax is so very noticeable, I have not allowed it to be broken so as to disclose the appearance of its interior. One is sometimes prompted to suspect that it may be

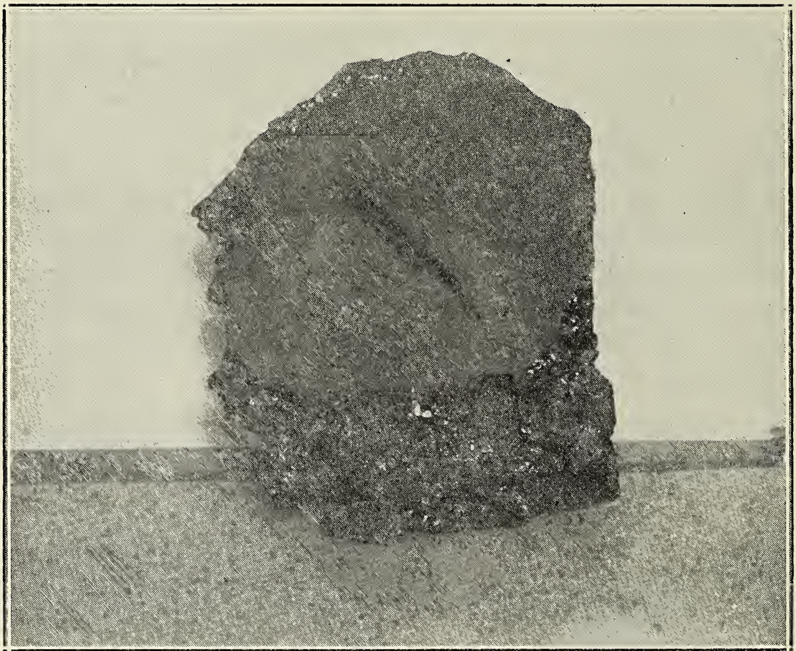

Fig. 2. Interior view of lump of coal showing where "ax" was found.

a lump of clay which had been compressed into small compass by great pressure; yet its edges in a few small places disclose the characteristic brassy color of pyrite.

The lump of coal containing this "stone ax" weighed twenty-nine and a half pounds. The "ax" weighed four and three-fourths pounds. This lump of coal was almost a cube, each face measuring about ten inches in length and breadth.

I showed this specimen to the drayman who had delivered the coal, who brought me a similar specimen, a little larger, but more

Fig. 3. The other half of lump of coal showing where "ax" was found.

irregular in outline, which shows the characteristic appearance of pyrite quite plainly. This other specimen weighed seven pounds and eleven ounces with a specific gravity of 3.62 and measured approximately eight inches by eight inches with a maximum thickness of two and a half inches, tapering to the edges. This second specimen was not smooth on its surface. The surface of the first specimen was comparatively smooth.

Iron pyrite, or pyrites, bisulphide of iron, is widely distributed in nature, being found in the rocks of nearly every geological age. It is sometimes found in clays, in slates, and in coal measures.

This particular specimen is remarkable for its resemblance to a stone ax in outline, in smoothness, in weight, in color. It was separate and distinct from the coal, and was in no wise connected with the coal. The cleavage was complete.

This specimen of pyrite, together with the lump of coal from which it was taken, will be placed with the State University.

WINFIELD'S DEEP WELL

J. M. LINDLY

Winfield's waterworks system was installed in 1914. The supply of water was from a drilled well about sixty-five feet in depth. Its purpose was fire protection. Its installation was just in time to cut short several fires which, uncontrolled, would have been very destructive. Its cost was saved several times in this manner during the next few years.

Winfield had suffered very little from fire until the 28th of December, 1909, when several large brick buildings, comprising the largest brick block in the town, were completely destroyed by fire. A few years later, the people voted on the proposition of issuing bonds for water works, but the proposition was defeated, chiefly for the reason that the amount was considered larger than necessary and that the firm that would probably install the plant was outside of the state and practically unknown to our people. In 1914 the proposition was again submitted to a vote of the people for a smaller amount, and carried. The work was done by the Des Moines Iron and Bridge Company of Des Moines, and the plant has given very satisfactory service during the seven years since its installation.

As the number of users of town water increased, and the people began to use the water in cleaning their automobiles and on their lawns, etc., it became difficult to keep a sufficient quantity of water in the supply tank for protecting the town from fire. To meet this increased demand for water, another well was put down in 1919 to a depth of sixty-five or seventy feet. But this proved inadequate. In order to secure an abundant supply of water, it became apparent that we must have a deep well.

On the 9th day of February, 1921, the McCarthy Well Company of St. Paul, Minnesota, began to drill a deep well within a few feet of our other wells, completing the drilling work on the 23rd of April, reaching a depth of 1268 feet, in sixty-three days of 24 hours each, Sundays excluded and one day on account of a break of machinery, making an average of twenty feet a day.

The log of the well, as given by Eric J. Hoff of St. Paul, is as follows:

The first three feet measured the depth of loam or black soil.

3 to 80 feet; — 77 feet of clay which took the well down to 80 feet where rock was first found.

80 to 190 feet; — this space was occupied by hard lime rock; there were many horizontal layers or seams in this lime rock.

190 to 510 feet; — this space was occupied by 320 feet of shale; shale is a soft slate rock like soapstone.

510 to 618 feet; — this space of 108 feet was occupied by lime rock; this rock was more of a solid layer than the upper stratum of lime rock before-mentioned, and a little lighter in color.

618 to 808 feet; — this space of 190 feet was occupied by shale; this shale was more in streaks of color, running from green to brown; all shales found in this well were disposed to be sticky. In other regions where the McCarthy Well Company had worked, mostly north of this, the shales were less inclined to be sticky.

808 to 818 feet; — this was more of a hard slate than anything else.

818 to 828 feet; — a dark brown shale.

828 to 1114 feet; — this space was occupied by a lime rock of 286 feet in thickness; this lime rock was brownish in color at times; at one time in this rock, some shells were drilled up, pieces big enough that they were recognized as shells resembling clam shells.

1114 to 1128 feet; — a white sand rock, very hard and fine-grained.

1128 to 1143 feet; — a greenish colored shale, which drilled the same as the other shales.

1143 to 1180 feet; — this was another sandrock, 37 feet in thickness, white in color, coarser grained than the above mentioned white sand, and water-bearing. This was the St. Peter sandstone, which is always white and coarse, one of the water-bearing strata of the earth in this region, and considered by drillers as the source of a never-failing supply of water.

1180 to 1268 feet; — this was a lime rock which was penetrated to a depth of 88 feet. Here the drilling ceased. The depth of the well is 1268 feet. This rock has very hard layers alternating with softer layers. There were quite a number of these layers. There seemed to be more water in this rock than in any other encountered in the drilling of this well.

The drilling of the well ceased on April 23. The test of the supply of water was begun on Friday, April 29, by pumping at the rate of 150 gallons per minute, continuing from eleven o'clock forenoon to eleven o'clock the following day, discharging over 200,000 gallons of water within the 24 hours. At the beginning of the test the water was within 73 feet of the surface of the ground. After pumping 24 hours, the water had fallen to 157 feet, a drop of 84 feet. This was considered a very satisfactory test, showing an abundant supply of water, and far in excess of our daily needs.

The first casing or pipe was put down 83 feet. The second pipe was down 829 feet. The first two shales were "cavy," so the pipes prevented caving. Below this it was solid enough.

Our water tank holds 50,000 gallons, and the new pump keeps it full by only three or four hours pumping in every 24 hours. The pump is operated by electric power.

In referring to the deep wells of some of our neighbors, it is noticed that the St. Peter sandstone was reached at a depth of a little over 1100 feet in the wells at the State Hospital for the Insane at Mt. Pleasant, distant about seventeen miles from Winfield; at about the same depth at Washington; and at nearly 1000 feet at Burlington. This famous sandstone was reached at Winfield at 1143 feet, but it is not as thick here as in these other localities. Its thickness at Winfield is 37 feet, at Burlington 120 feet, at Mt. Pleasant 136 feet, and at Washington 128 feet.

The depth of these wells is 1268 feet at Winfield; at Washington, City well No. 1 is 1611 feet, Well No. 2 is 1217 feet, and Well No. 3 is 1808 feet; the two wells at the State Hospital at Mt. Pleasant are 1267 and 1203 feet each.

To the reader who may not be versed in geology, it may be explained, in the language of one our state geologists, that, "The hard, regularly-bedded rocks of Iowa were formed almost exclusively under water. They were originally loose, soft sediments spread out where they now lie, in regular sheets or layers, on the bottom of ancient seas. The present sandstones were originally submarine sand banks, the shales were beds of mud, the limestones were the products of coral reefs or marine shells of various kinds, broken and ground into fragments, and the coal seams were first masses of vegetable matter accumulated in swamps or marshes, something as similar matter accumulates in modern peat bogs."

Winfield

THE STRUCTURE OF THE FORT DODGE BEDS *

JAMES H. LEES

Much has been written regarding the geologic position and the stratigraphic relations of the gypsum and associated strata which are present near Fort Dodge and many are the speculations which have been put forward to account for the peculiar conditions obtaining. Observers early discovered that the gypsum was not in

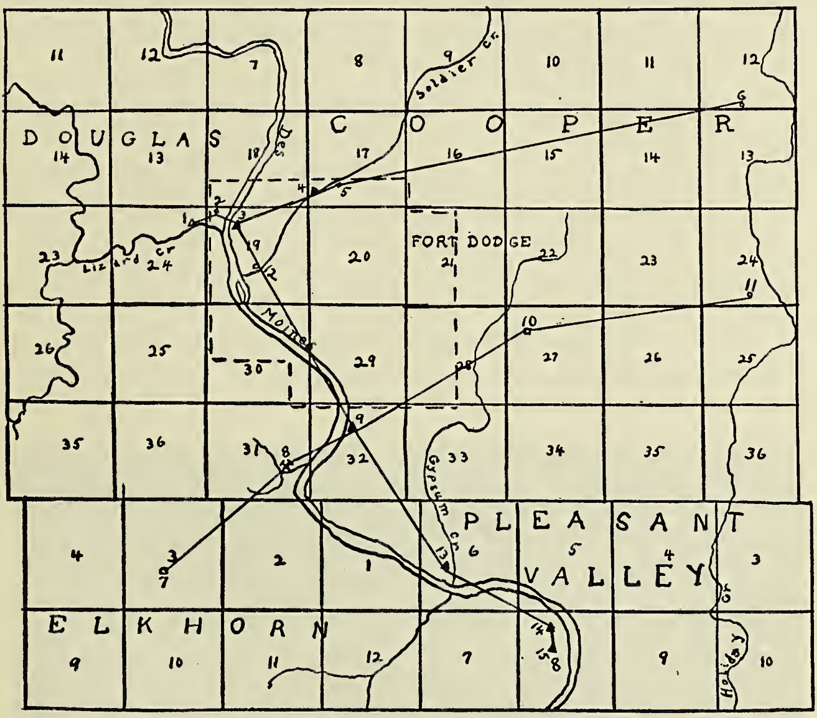

Fig. 1. Map of the Fort Dodge region showing the locations of the three series of sections in Plate II.

1. Old pit of Fort Dodge Clay Works. 2. Exposure in Hawkeye Highway. 3. Pit of Fort Dodge Brick and Tile Co. 4. Pit of Hawkeye Clay Works. 5. Exposure in Soldier creek valley. 6. Well in sec. 12, Cooper township. 7. Well at County Farm. 8. Mine of Plymouth Gypsum Co. 9. Pit of Bradshaw Clay Co. 10. Prospect holes in Sec. 27, Cooper township. 11. Well in Sec. 24, Cooper township. 12. Exposure at end of ridge between Des Moines and Soldier valleys. 13. Pit of Vincent Clay Products Co. 14. Pit of Johnson Brothers Clay Co. 15. Pit of Plymouth Clay Co.

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conformable relationship with the underlying beds and later investigators, in order to account for this situation, have enlisted various agents, even faulting in a region so little subject to diastrophism as is Iowa, having been called upon to explain such unique phenomena as may be found in the gypsum area.

The Iowa Geological Survey has always interested itself in the problems presented by the Fort Dodge beds, as the gypsum and its associated strata are called, and at three times has carried on studies in the region with the hope of reaching a solution of these problems. The writer is one of those who has studied this extremely interesting region, in connection with the preparation of a monographic report by Dr. F. A. Wilder, who was formerly connected with the Survey. The results of our field work are embodied in certain chapters of this monograph, and our conclusions may be summarized here.

The gypsum itself is almost everywhere the lowest bed of the Fort Dodge stage. In a few places a conglomerate, which evidently is related to the gypsum rather than to the beds beneath, has been found beneath the gypsum, and in some localities a thin layer of clay, perhaps residual from decay of the basal layers of gypsum, intervenes between the gypsum and the underlying shales. The basal conglomerate was described in volume XXV of these Proceedings. Overlying the gypsum there is, in most places where the beds are exposed, a stratum of red or pink sandy

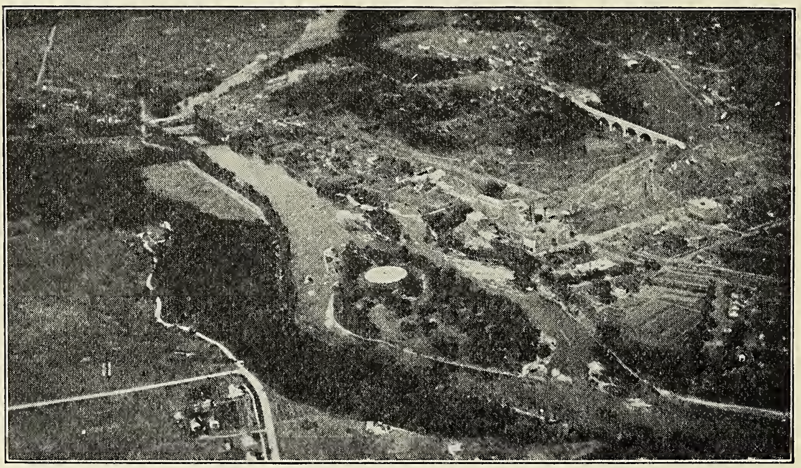


Fig. 2. Airplane view of Des Moines valley at Fort Dodge. Soldier Valley is in the upper right hand part and is crossed by the viaduct. Lizard Valley is in the upper left hand corner. — Courtesy Fort Dodge Chamber of Commerce.

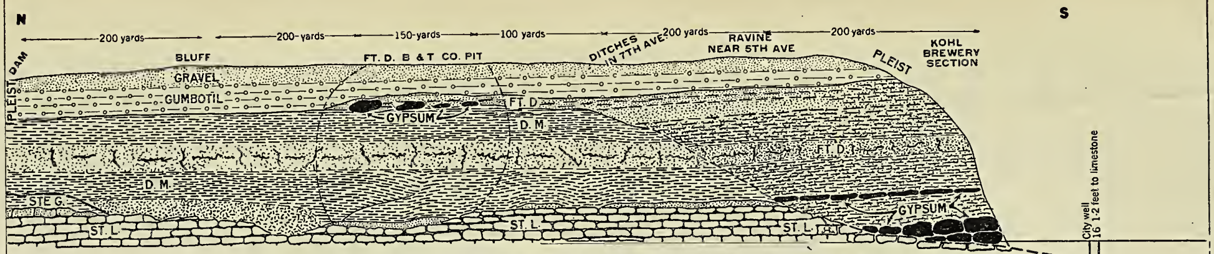
shale, with an interbedded sandstone, which is not a constant feature, however. The gypsum ranges in thickness up to a maximum of thirty feet and the overlying shales and sandstone reach a thickness of fifty feet. The conglomerate is not over two feet thick.

The remarkable feature about the Fort Dodge beds, however, is their relationship to the beds which immediately underlie them. As has been stated they are not conformable with these underlying strata. The evidence seems to show convincingly that the Fort Dodge beds were deposited in a basin of erosion cut in the strata of Des Moines and Mississippian age, which form the bed rock of this general region. In most places the gypsum lies on shales of the Des Moines series and is well above the level of Des Moines river, which may be taken as a convenient datum. The sections given in Plates I and II will show this to be the case at the exposures, and a few well records will show similar conditions elsewhere. Thus, at the County Farm the elevation is 1140 feet and the base of the gypsum is a hundred feet lower, overlying Des Moines series shales. The elevation of water in the river at Fort Dodge is about 980 feet above sea level. A mile east of Fort Dodge the elevation is about 1115 feet and the gypsum lies seventy to seventy-seven feet lower or about 1030 to 1040 feet. In the southern part of section 12, Cooper township, about four miles northeast of Fort Dodge, the surface elevation is 1120 feet and gypsum is present at a depth of eighty feet or 1040 feet above sea level. In all cases where the gypsum has been penetrated Coal Measure shales have been found just beneath it.

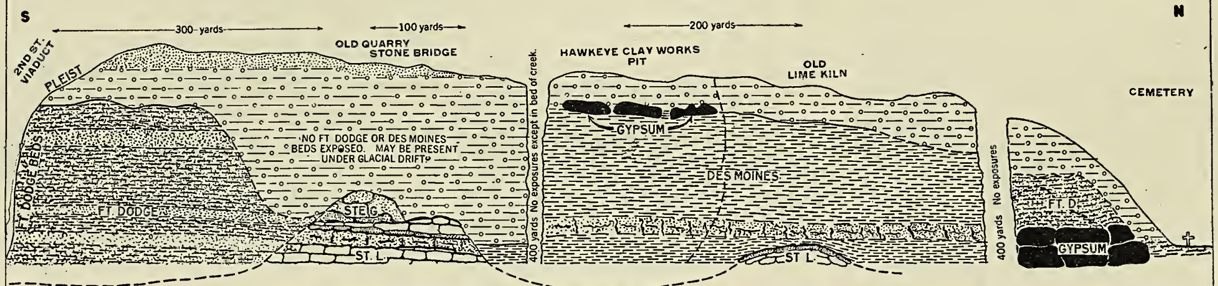
On the other hand, in some places the erosion of the aforesaid basin proceeded far enough to cut through the beds of Des Moines age and to reach the underlying limestones, marls and sandy beds of Mississippian age — the Ste. Genevieve and St. Louis strata. The surface of the Mississippian rocks on which the Des Moines beds were laid was very irregular and this fact accounts for some of the stratigraphic peculiarities which are to be seen in the gypsum area. Des Moines river flows across the region in a southeasterly direction and in the northern part has exposed the Mississippian strata. Elsewhere the Des Moines beds probably underlie the river deposits, except at a few points where the Mississippian beds extend up far enough to be uncovered. Soldier creek flows southwest and joins the river from the east in the northern part of Fort Dodge. In the lower reaches of its valley exposures of Fort Dodge beds, Des Moines shales and St. Louis and Ste. Genevieve beds alternate along the walls. It is in this valley that the gypsum may be seen at its lowest known levels. While it is found nowhere in actual contact with the Mississippian beds it lies so low in several places and its relations to the Mississippian limestones are such as to make it very probable that there is little if any vertical interval at these low points between gypsum and limestone. The sections in Plate I will show this situation quite clearly. Lizard creek empties into Des Moines river from the west about a third of a mile above the mouth of Soldier creek. Limestones, sandstones and marls of Mississippian age rise thirty to sixty feet above the water at various places along the banks of the creek and in several localities are seen to be overlain by Coal Measures shales. Above these again, at an old clay pit on the north side of the valley, gypsum may be seen in large blocks beneath the glacial drift.

Now this region about the junction of these two creeks with the main stream is a critical area in connection with the structure of the Fort Dodge beds and the fact that the Mississippian strata rise above water level at so many points and are known to be just under the valley filling at several others is perhaps the most significant fact of the local stratigraphy. It shows that erosion of the Mississippian surface had proceeded so far in pre-Pennsylvanian time that irregularities of contour amounting to seventy-five feet and perhaps as much as a hundred feet had been developed *but no faulting of the strata occurred, during either this or subsequent periods of time.*

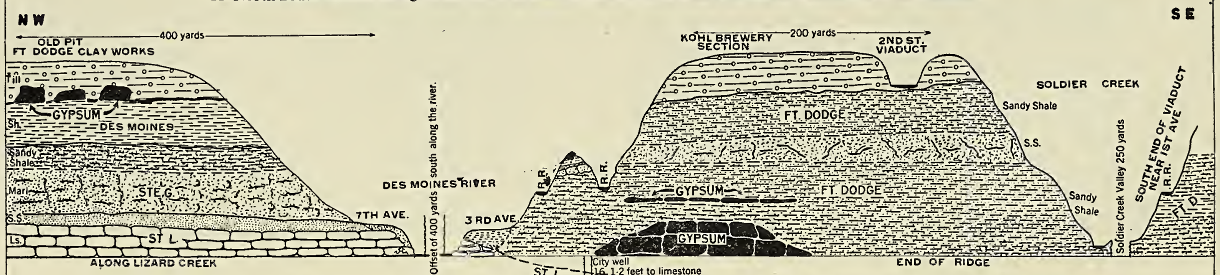
As has been stated already the Fort Dodge beds lie in a broad shallow basin eroded in the underlying strata. But into this basin there seems to have been cut a fairly deep and steep-walled valley which probably extended from northeast to southwest. After this valley and the larger depression were filled with gypsum and the overlying sandy shale and sandstone the whole region was planed down by erosion in the long post-Permian-pre-Pleistocene interval, with possibly an incursion of marine conditions during Upper Cretaceous time. During the development of the present drainage system Soldier creek has cut its valley irregularly across the old gypsum- and shale-filled basin in such a way as to expose the filling, at some points high up in its walls and underlain by Des Moines beds, at other points low down, in the deep valley, and presumably lying on Mississippian beds. This accounts for the



I North-South Section along East Wall Des Moines Valley from the Dam to Mouth of Soldier Creek



II North-South Section along West Wall of Soldier Creek Valley from 2nd Street Viaduct to the Cemetery.



III Northwest - Southeast Section down Lizard Creek Valley and across end of Ridge between Des Moines and Soldier Creek Valleys

Sections Drawn By James H Lees

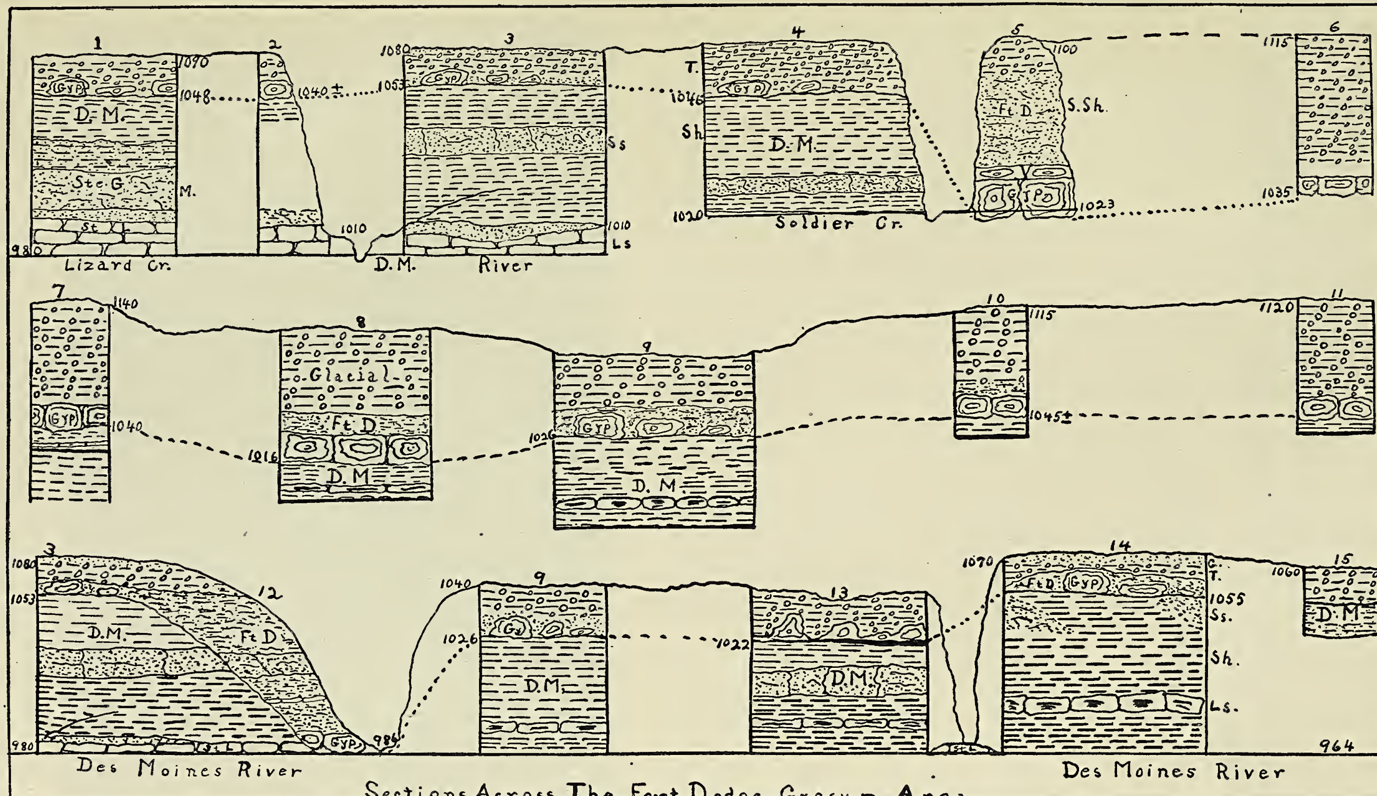
Sections along Soldier creek, Lizard creek and Des Moines valley.

wide range in altitudes at which the gypsum is found in Soldier valley. At no other place is there known such a variation, but actual examination in the field will convince anyone that there is no possibility of the existence of faults here. There can not be one along the ridge between Soldier and Des Moines valleys, for gypsum is present at similar elevations on both flanks of the ridge, namely at 1053 feet in the pit of the Fort Dodge Brick and Tile Company on the Des Moines valley wall, and at 1046 feet in the pit of the Hawkeye Clay Works on the Soldier creek side. There can not be a fault across the ridge, for then there would be bodies of gypsum at both high and low levels on both sides of the fault, no matter where it was located. And underneath, everywhere, unaffected by any faults, except those of the observers, are the St. Louis limestones.

On the west side of the river the Fort Dodge beds have been exposed at three places — on the Hawkeye Highway leading west from the city, at the pit of the Fort Dodge Clay Works on the north bank of Lizard creek and at the south pit across the creek. At the two former places the gypsum is high in the walls but at the southern locality the contact with the Des Moines beds is somewhat lower — it is nearer the deep valley which was cut into the old Permian basin. Here again the evidence is in favor of normal erosive activity and against any theory of faulting to account for the existent conditions. There is no place for faults north of the Lizard and neither is there occasion for them on the south side when general conditions are taken into account.

South of Fort Dodge there is a general though irregular rise of the gypsum plate toward its margin. The irregularity of the floor in this region is shown by the following elevations of the gypsum: Vincent clay pit, 1022 feet; about half a mile up Gypsum Hollow, 1040 feet; about a quarter of a mile farther up the Hollow, 1050 feet; at the American gypsum mill 1045 feet. On the opposite side of the river the gypsum is 1058 feet above sea level where it overlies the conglomerate in the ravine opposite Shady Oak and 1055 feet at Johnson Brothers' clay pit. The Mississippian strata also show themselves in this locality, namely in the river bed and banks opposite Johnson Brothers' plant, about a mile below Shady Oak.

It would seem then that a simple examination of the phenomena of the gypsum region should convince the fairminded observer that there has been no remarkable upheaval or convulsion of na-



Sections in the Fort Dodge gypsum area. G. Gravel; T. Glacial till; Ft. D. Fort Dodge beds; D. M. Des Moines beds; Ste. G. Ste. Genevieve beds; St. L. St. Louis beds; M. Mississippian; S. Sh. Sandy Shale; Gyp. Gypsum; Sh. Shale; Ls. Limestone; Ss. Sandstone. Figures give elevations above sea level as instrumentally determined. Small numbers refer to localities shown on map, figure 1.

ture here but simply the universal, continuous, orderly progression of erosion and deposition which during the long ages of the past prepared a suitable depository and filled it with gypsum, which they have since laid bare for the use of men and the puzzling of scientists.

Iowa Geological Survey.

DEDUCTIONS FROM THE OCCURRENCE AND CHARACTER OF TWO LARGE QUARTZOSE CONGLOMERATE BOULDERS OF UNKNOWN ORIGIN FOUND IN THE KANSAN DRIFT SHEET AT CENTERVILLE, IOWA

BEN H. WILSON

On a lawn at No. 629 West Maple Avenue, in Centerville, Iowa, are located two large quartzose conglomerate boulders which are of more than usual interest. These were removed from the glacial till during the process of excavating for the cellar under the dwelling now situated on the same lot and when found were said to be buried beneath several feet of drift material.

These boulders are of about equal mass, however, somewhat different in shape, their dimensions being approximately 2x4x5 and 2x4x6 feet respectively; and are of irregular outline. It is not often that one finds boulders of this character, of so great size as these, so far south in the drift, they being located only a few miles from the south line of the state.

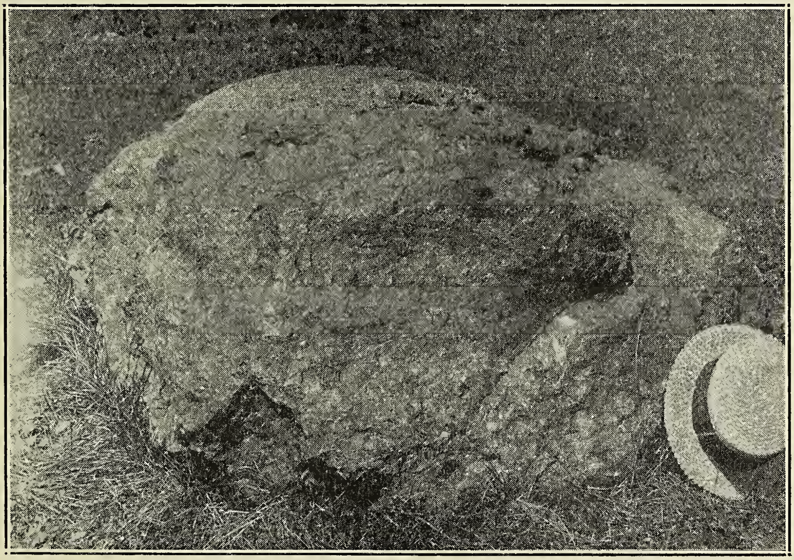


Fig. 1. Conglomeratic bowlder on lawn at 629 W. Maple Ave., Centerville, Iowa. The hat which is about twelve inches in diameter lengthwise, will serve for comparison in judging the size of the boulder.

The composition of each is identical with that of the other, both as regards the size and quality of the component pebbles, and as to the nature of the cementing material. The greater part of the pebbles are rather large ranging from one-fourth inch to three inches in diameter, and on the average are of fairly uniform shape. They are of material which is entirely siliceous in character, many being almost pure quartz, translucent cream to yellow, while others are of an opaque cherty material ranging from grey and brown to yellow, and in many cases jasper-like in appearance with marked conchoidal fracture when broken. Nearly all are well rounded, of puddingstone variety, bearing every evidence of being waterworn shore-pebbles. Very little if any angular or brecciated material is present among them.

The interstices are filled with a siliceous cementing material which is of a typically quartzitic texture throughout, quite similar in appearance to the Algonkian quartzite of Minnesota, South Dakota and Iowa, which is easily recognized and rarely mistaken by one who has studied the formation at the ledge. It possesses binding qualities which are remarkably strong and tenacious, which fact must be self-evident, as it would have been utterly impossible for conglomerate of less firm a texture to have withstood the enormous pressure and grinding power of the containing ice sheet during the process of transportation throughout such a great distance as these boulders must certainly have been carried. The more enduring granites, quartzites and their like are quite often found, having been transported from near the source of the drift sheet to its extreme outer margin, but it is quite unusual to find the more friable limestones, sandstones and conglomerates at any great distance from the place of their origin.

From the position in which these boulders were discovered it is not improbable that they were carried almost if not the entire distance as a single mass, becoming separated only in the last stages of their journey, or perhaps after they had reached their final resting place, by means of disintegrating forces possessed by the freezing processes to which they were subjected during our rigorous winters. It is possible that other fragments are present but have not yet been found, owing to the fact that no special search with this in view was made at the time of their discovery.

While the boulders themselves are entirely devoid of any evidence of stratification there can be little doubt that they originated as a basal conglomerate formed in the mid-continental seas to the north of the present borders of the state of Iowa. There can also be no question but that the conglomerates under consideration are of purely aqueous origin and were the result of coarser pebbles being imbedded in a paste of finer sand, close to the ancient shore line, which paste was eventually consolidated by the process of infiltration of silicious material into a compact quartzite mass. True quartzitic character of the matrix in boulders of this character has in the past been quite generally considered as indicative of great age, and by many it has been thought that such a characteristic precluded the probability of boulders of this type originating in the Paleozoic strata as we are familiar with the same within the confines of the great central inland basin. This is particularly true of students of geology who have not had the opportunity of doing extensive field work covering extended areas.

A train of boulders of this identical and highly similar types are to be found scattered at intervals over the surface of the Kansan and succeeding glacial drifts from north to south across our entire state and into southern Minnesota, and when found they have usually been roughly assigned to one classification and alluded to as of "Huronian age" with an air of finality, little or no consideration being given to the evidences bearing out this conclusion, other than a superficial examination showing quartzitic character of the matrix, and the appearance of veneration. Whenever any effort is made to assign them definitely, to any specific subdivision of Huronian time, which occurs but rarely, they are usually considered to belong to the lower member of the Huronian Group, known as the Sturgeon Quartzite, which according to Chamberlin is frequently conglomeratic in character.

The writer has himself personally examined specimens throughout the drift of northwest Iowa and southwest Minnesota, which contains pebbles of all sizes and of a similar material, thence passing insensibly through the coarser gravels to the finest quartzitic sandstone to quartzites, the graduation into the arenaceous group being unbroken, and can therefore upon first hand information vouch for the fact that the place of origin of the boulders in question must certainly exist above the northern limits of the state of Iowa. Like others he has glibly spoken of them as Huronian or Algonkian and confidently permitted the matter to be disposed of thusly. This lumping of all such material together indiscriminately under one classification, as Huronian, I shall presently show is erroneous, and would suggest that students of

Pleistocene geology in the future, myself included, use greater caution in assigning this and similar material to any given age, without first having well considered the subject matter from all of its various aspects.

The fact that they are found beyond the northern limits of the state eliminates the possibility of their belonging to the Paleozoic strata of Iowa; and the writer being unfamiliar with the physical character of the Paleozoic as it occurs in Minnesota and Canada cannot therefore throw any light on the question of their true age and the location of their parent ledge, other than by means of such information as may be gleaned from descriptive matter which has previously been published through the various agencies.

It may also be properly noted that these boulders possess every appearance of having been transported an exceedingly great distance, as they are of extreme hardness and in spite of that fact are well-rounded and worn, all of the edges having been ground down by the polishing influence of the ice. By way of comparison a large block of Sioux Quartzite lying a few feet away, which is about of like hardness shows little if any wear, its angles being keen and sharp as though it had just been broken from the parent ledge. Assuming that an equal or approximately equal ratio of hardness exists between these two specimens, their respective condition would indicate that the conglomerates had come from far to the north of the Algonkian area. A heavy coat of concretionary brown iron oxide is evident in splotches upon the surface of the boulders, which is also indicative of great age.

My first interest in the boulders was purely in the nature of a Pleistocene study, and after having visited them several times for the purpose of making a minute examination of the character of the component pebbles in order to be able if possible to determine by actual comparison the approximate location of the parent ledge, with the view of estimating the direction of the imaginary cross country striation made by these boulders in their Kansan journey, imagine my intense surprise on finding nestled in a little protected nook on the surface of one of them, caused by a concave place where a fracture had at one time occurred, a fine little group of clean-cut fossil casts of well developed Brachiopoda, in a small yellow jasper-like pebble. Owing to the nature of their location on the surface and the extreme hardness and brittleness of their matrix, they could not be removed without totally destroying them. I therefore made photographs and plaster casts of them

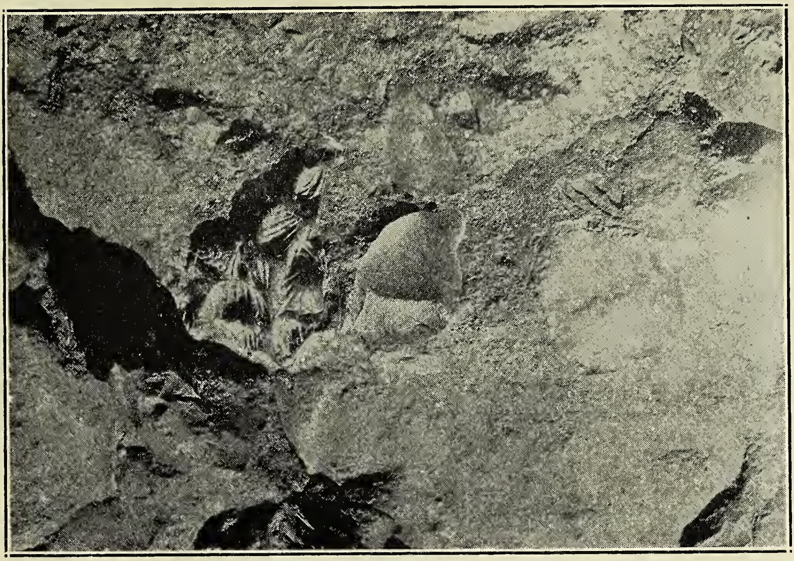


Fig. 2. Nest of brachiopod casts in upper north edge of west boulder. The plate is about two-thirds actual size. The component pebbles are distinctly shown in this picture.

(Fig. 2) for the purpose of preservation and more detailed study later on.

From the photograph it will be clearly seen that these Brachiopoda are quite similar in outward appearance to some members of the Sub-family, Rhynchonellinæ Gill. However, it has been impossible for the writer to assign them definitely to any of the species described in the literature available for this study. There remains also the possibility that we have here a new species, if not a new genus which will yet be found far in the northland, where little paleontological work has been done, up to this time. The Rhynchonellinæ group and Brachiopoda of a similar degree of development are supposed to occur about midway in the scale of brachiopodal life on the planet, and are not listed as occurring prior to the Ordovician Period.

That a conglomerate is younger than its component pebbles is a premise which needs no demonstration, therefore either of two important facts concerning the correct age of these conglomerates must be true. Final determination upon and acceptance of one theory precludes the possible correctness of the other: First, boulders of this type are not all of Huronian age, as has heretofore been supposed by many and, second, if Huronian in age, a higher type of life, as evidenced by the fossil Brachiopods of the Centerville boulders, existed in those pre-Cambrian times than has yet been observed and described. The assumption and conclusive proof of either fact is important. That life extended back into a vast period unrecorded by fossils, since the earliest fossils yet found imply a very prolonged antecedent evolution, there can be no doubt. It is not in the least improbable that some day, somewhere, someone will discover a colony of fossil remains distinctly preserved in the oldest known stratified rocks accessible to the study of man, of a higher type than has yet been conceded to exist, for among these rocks are known to occur occasional limestones and cherts, which as a class are usually products of organic life, and are thought to imply the existence of life. Perhaps we have here in Iowa resting upon materials of the youngest geological age (Pleistocene), specimens of some of the planet's earliest life, miraculously preserved and brought down to us for our observation and study.

Of whatever age they may finally be determined the boulders under consideration are worthy of further study and investigation, and if possible should be secured and removed to the campus of the State University where they may be preserved and would afford much of scientific interest. The problem of transportation alone affords much of speculative interest, for here we have material which was originally in solution, and then became imbedded in a fossiliferous stratum which was elevated, broken up by erosion and carried to the sea, where it was again imbedded in the basal conglomerate which again in turn was elevated, broken up and transported hundreds of miles, perhaps by two different glaciers. This material will again, I dare say, at some far distant future period, when our fair state shall have once more become inundated by inland oceans, be consolidated into what we like to call enduring (?) rocks only to be at some subsequent period elevated above the sea to again become a prey to that terrific monster, erosion, which is forever gnawing at the vitals of our planet.

Iowa Wesleyan College.

GEOLOGICAL ABSTRACTS

THE STATUS OF SEDIMENTATION IN IOWA

A. C. TROWBRIDGE

Iowa need not be ashamed of the part her geologists have played, either in the past history of sedimentation, or in the recently renewed American activity on this important, but too long neglected subject. There being no igneous rocks in situ within the state and practically no exposures of metamorphic rocks, all the work which has been done on the geology of the state during the years is more or less closely related with sedimentation. The more recent investigations of breccias by Professor W. H. Norton, of gumbotils by Dr. George F. Kay, of Pennsylvanian stratigraphy and structure by Dr. John L. Tilton, and of clays by Dr. Sidney L. Galpin, constitute important contributions to knowledge of sedimentary rocks and the conditions under which they are formed. At the State University there is a research course in sedimentation and a sedimentation laboratory is in process of establishment.

SCHEDULES FOR THE FIELD DESCRIPTIONS OF SEDIMENTARY ROCKS

A. C. TROWBRIDGE

An explanation of the schedules recently reported by a subcommittee of the committee on sedimentation of the National Research Council, and presentation to each of those present of mimeographed copies of the introduction to these schedules, and of printed copies of the schedules themselves. These materials were furnished the writer by Dr. M. I. Goldman, Chairman of the committee.

DEPARTMENT OF GEOLOGY,
STATE UNIVERSITY OF IOWA.

AN IOWA CAMBRIAN EURYPTERID

O. T. WALTER

Associated with dismembered parts of *Dikellocephalus minnesotensis* in the St. Lawrence limestone, at Lansing, Iowa, are parts of a very interesting Eurypterid. The carapace is sub-semicircular in outline; anterior margin well rounded; posterior margin broadly concave; sides diverging gently posteriorly and somewhat produced at the postero-lateral angles. The compound eyes are prominent, bean-shaped, situated about in the middle, and as far apart as their distance from the outer edge. Length, 8 mm., width, 13 mm. The species is named *Eurypterus thomasi* in honor of Prof. A. O. Thomas.

Department of Geology,
State University of Iowa.

ORIGIN OF LIMESTONE CONGLOMERATES

LOUISE FILLMAN

A study of the literature reveals at least eight ways in which limestone conglomerates may be formed. The following ways are noted and described in the paper: (1) derivatives from some pre-existing rock; (2) by deformation of the laminæ; (3) by pebbles derived from concretions; (4) by the secretions of limestone nodules by algae; (5) by the breaking of thin layers of limestone by storm waves; (6) by subaquatic gliding of limestone layers; (7) by lime-mud being cracked on a tidal beach; (8) by minor oscillations of the sea and the erosion of materials previously deposited.

CLASSIFICATION OF LENSES

LOUISE FILLMAN

This paper is the result of a bibliographic study of lenses, on the part of Lloyd North and the writer. In the literature some thirty-two genetic types are described. In the present paper these types are classified and described. A bibliography is appended.

Department of Geology,
State University of Iowa.

THE ROCKFORD GEODES

S. L. GALPIN

These geodes occur in Lime Creek shales. They are rather unusual in containing a number of roundish cavities rather than the customary rough opening. The cavities are lined with: 1, small rhombic calcite crystals which are bronzed with limonite; 2, occasional tabular and fanshaped aggregates of barite crystals. The mode of formation is obscure.

Department of Geology,
Iowa State College.

NOTES ON SOME MAMMALIAN REMAINS REPORTED IN IOWA DURING THE PAST YEAR

A. O. THOMAS

Road-making activity, the opening of new gravel pits and drainage ditches, and natural erosion have brought to light an unusually large number of fossil bones. A large ditch near Avoca has yielded an excellent skull of the giant beaver, *Castoroides ohioensis,* and at the same place a humerus of the great ground sloth Megalonyx. From Wayland comes a perfect tibia of the same kind of sloth and near it was found the crown of an unerupted mastodon molar. A well preserved, but worn down, tooth of the Columbian elephant was found in a gravel pit at Hartley and a part of a tusk at Bellevue. The skull of a large elk bearing a fine pair of antlers was taken from near the base of the Des Moines river bank at Irvington. The skull of a small deer from a gravel pit at Eddyville completes the list. Illustrations.

Department of Geology,
State University of Iowa.

A REDETERMINATION OF THE PRINCIPAL REFLECTING POWERS OF ISOLATED SELENIUM CRYSTALS

L. P. SIEG

Some time ago, following the publication of a paper by one of my former students, Mr. C. H. Skinner,[1] I attempted to check his results by direct experiment. The paper referred to dealt with the optical constants of isolated selenium crystals. Of these constants, the reflecting power is the only one that offers itself to an easy experimental test. It must be said that the results obtained by Skinner were obtained by indirect means, and since the equations used in reducing his results to optical constants were somewhat complicated, and rested on foundations none too sure, it was important for our own satisfaction at least, to make a direct test of their accuracy. The results of my experiments [2] confirmed me in my belief that there were two principal reflecting powers to be expected; that with the incident light plane polarized with the electric vector parallel to the crystal axis, and that with the vector perpendicular to the axis. At the time of publication, however, it was felt that the results should be looked on as merely preliminary in nature on account of the difficulty I had in setting up a satisfactory spectrophotometer for the small reflecting surfaces available.

Last fall I finally succeeded in devising a form of apparatus which proved to be highly satisfactory for the work in hand. With this apparatus I made a redetermination of the two principal reflecting powers, confirming in a general way my previous results. While the present results are not entirely free from error, they are so much more consistent than the former, that I feel considerable confidence in them. The same method of procedure is now being followed in the study of tellurium crystals.

The arrangement of the apparatus is shown in elevation in figure 1. Light of the desired wave length from the slit of the monochromatic illuminator S is made parallel by lens L_1. A portion of this beam is intercepted by mirror M_1, and then made

[1] Skinner, Phys. Rev., 9, p. 148, 1917.

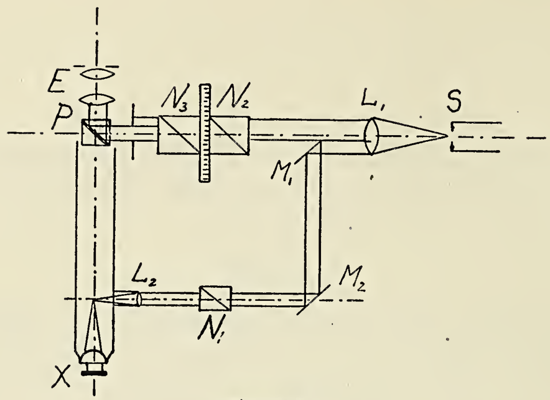


FIGURE 1.

by mirror M_2 to pass through Nicol N_1 to the opaque illuminator of the Saveur type in one of the regular metallographic microscopes of Bausch and Lomb. This plane polarized light, with the electric vector horizontal, was reflected through the objective system (usually an 8 mm. objective was employed), and fell normally upon the crystal X. In fact this is really a cone of light which falls upon the crystal, but the angle of the cone is only about 3°, and so for all practical purposes the incidence is normal. The crystal X is mounted on the stage in a special holder and can be turned without loss in centering or in maintenance of plane, so that its long axis is either parallel or perpendicular to the electric vector of the incident plane polarized light. The reflected light passes up through the tube, and forms a real image of the crystal surface on the interface of the double prism P. This image owes its intensity to the magnitude of the reflecting power of the crystal in the particular position it happens to occupy. The double prism P consists of two small right-angled prisms, one of them silvered, with the silver film cut into a grid by removing alternate narrow strips of the silver. That portion of the image passing between the strips is viewed by the eyepiece E. The upper portion of the beam from L_1 passes through the two Nicols, N_2 and N_3, illuminating the silver strips. The latter are viewed by the same eyepiece E. By adjusting the Nicol N_2 (N_3 set to make the electric vector horizontal) a match in intensity can be made for each wave length, and for each position of the crystal. With this arrangement, as far as described, only the relative reflecting powers in the two principal positions can be determined. In order to obtain the absolute reflecting powers a piece of glass,

2 Sieg, Proc. Ia. Acad. Sci., 23, p. 179, 1916.

backed with silver, is substituted for the crystal at X. The absolute reflecting power of glass backed with silver being easily found in physical tables, it becomes a simple matter to translate relative reflecting powers into absolute ones. On account of the loss in light resulting from dividing the beam, and using fairly high magnification it was not found possible to extend the results very far toward either the red or the violet end of the spectrum. Individual sets of observations were somewhat difficult to repeat with any great consistency, but by making many different settings, and using several different crystals it is felt that the mean results are correct to somewhere between 5 and 7 per cent.

The extensive original data will not be presented here. The final mean values are shown in graphical form in the curves of figure 2. The curves are largely self-explanatory. The data of Foersterling and Fréedericksz,[3] and of Pfund [4] are recorded for the

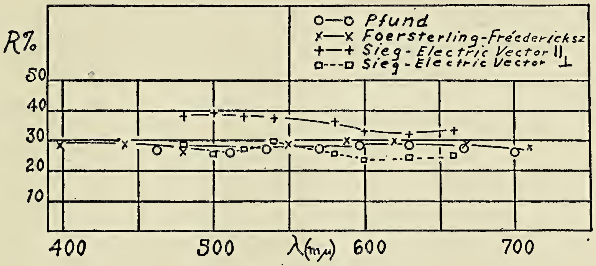


FIGURE 2.

sake of comparison of my results with the results of other observers on crystalline selenium in the form of cast, polished plates. The essential point to emphasize is that here we have double reflecting powers and that in previous work we have single reflecting powers. That former values are not exactly half way between these present double values is of no great moment. An exact mean would imply that the crystals were all lying on their sides, and haphazardly arranged. If any crystals were inclined to the reflecting surface of the plate, then the smaller reflecting power would predominate. In fact recently Grippenberg [5] has concluded that in the process of crystallization of selenium plates, most of the crystals are formed "end on" to the plane surface. This agrees well with the results shown in figure 2, as previous values are distinctly below the average positions of my results.

UNIVERSITY OF IOWA.

3 Foersterling and Fréedericksz, Ann. der Phys., 43, p. 1227, 1914.
4 Pfund, Phys. Zeit., 10, p. 340, 1909.
5 Grippenberg, Phys. Zeit., 22, p. 281, 1921.

SOLUBILITY AND POLARITY

WM. KUNERTH

Since the phenomenon of solubility is one of such common occurrence and universal familiarity, it is no wonder that a great many attempts have been made to learn the cause of it. The molecular weight of solute and solvent, the dielectric constants, the size of the molecules concerned, the surface tensions of the components, adsorption, the vapor pressure above the solution, the magnitude of Van der Waal's *a* and *b* for the components, their internal pressures as determined by a great many different methods — all these and many other avenues of approach have been used, only to be discarded again because they did not lead to a solution of the problem. Combinations of some of these factors also have been investigated in the hope that solubility might be found to depend jointly on several of these characteristics.

In 1885, Van't Hoff determined the relation existing between osmotic pressure and the amount of solute in solution. About the same time Arrhenius established a relation between electrolytic dissociation and the conductivity of an electrolyte. Two years later Raoult conducted a series of experiments which led him to establish what is known as Raoult's Law for vapor pressure, thereby connecting the amount of solute in solution with the lowering of the vapor pressure above a solution as more and more solute is added. Since that time many efforts have been made with this work as basis, to determine the cause of solubility. What property of the molecule is brought into play as it dissolves among other molecules? What forces are brought to bear upon solute and solvent in the act of solution? Are these forces always the same? And what has molecular structure to do with the process of solution?

INTERNAL PRESSURE

The method of attack upon which most stress has been laid in recent years is that of Dr. Hildebrand [1] who has relied on internal pressure as the main factor in the determination of solubility, stating that when two components have equal or nearly equal in-

1 Hildebrand, Jour. of Amer. Chem. Society, Vol. 38, p. 1452 (1916).

ternal pressures, then they will be soluble in each other in all proportions. In other words, when a molecule of solute is under the same forces when surrounded by molecules of its own kind as when it is surrounded by molecules of solvent, then solution will take place; but when these forces are altogether different, solubility will not take place. Thus he explains the immiscibility of benzene in water as being due to the great difference in the internal pressure between the two components. The miscibility of alcohol and water, he claims, is due to the similarity of the internal pressures of the two liquids but is influenced also by their polarity.

The internal pressure of any component can be determined by three or four different methods and while concordant results are not obtained, the order of arrangement is in general the same. Hildebrand has the support of Bradford who comes to the same conclusion, although his mode of approach is somewhat different.[2]

When, however, we note a number of cases, no such universal agreement as these men claim between solubility and internal pressure seems to occur, for illustrations can be found where two components have nearly the same internal pressure and yet are not soluble in each other. Again components can be found which are miscible in all proportions but their internal pressures are by no means alike. Such cases are not in harmony with the theory and hence we can not depend on this principle to solve the problem of solubility.[3]

POLARITY

Let us now consider the effect of polarity on solubility. By polarity we mean the condition or state of being polar, i.e. the molecules of a substance have the same property as magnets in the sense that they can attract other molecules of like properties. Thus if we have a polar substance, its molecules will attract each other and association will take place.

In Table I are given the solubilities in ccs. of CO_2 per cc. of the solvent listed. The results in Tables I, II, and III are due to Just[4] and were taken at 20° C. The chemical formulæ and the structural formulæ of the solvents also are given. For simplicity the H's are omitted in the structural formulæ.

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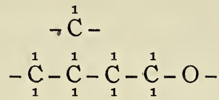
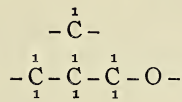
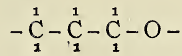
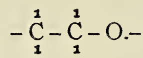
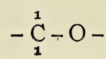
2 Bradford, Phil. Mag. 38, p. 696 (1919).

3 For a further discussion of this and related theories of solubility the reader should consult Phys. Rev. May, 1922.

4 Just, Zeit. für Phys. Chem. 37, p. 342 (1901).

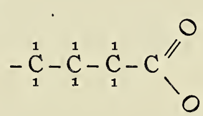
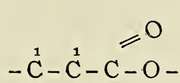
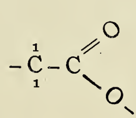
TABLE I

Sol. in ccs.		
1.83	Isoamyl Alcohol — $C_5H_{11}OH$ —	
1.85	Isobutyl Alcohol — C_4H_9OH —	
2.49	Propyl Alcohol — C_3H_7OH —	
2.70	Ethyl Alcohol — C_2H_5OH —	
3.83	Methyl Alcohol — CH_3OH —	

It may be noted here that the solubility of CO_2 in these alcohols increases as their association or polarity factor increases, for it is generally known that polarity increases as we go down the column. CO_2 is considered a polar substance and it is here shown to be more soluble in polar solvents than in non-polar solvents. The first two alcohols above tabulated are iso-compounds and hence decidedly non-polar, and it will be noticed that the solubility of CO_2 in them is low.

In Table II we have a similar list leading to the same conclusion.

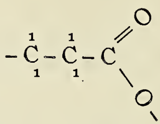
TABLE II

Sol. in ccs.		
3.47	Butyric Acid — $C_4H_8O_2$ —	
4.07	Propionic Acid — $C_3H_6O_2$ —	
4.67	Acetic Acid — $C_2H_4O_2$ —	

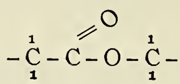
These solvents are somewhat similar in structure but we know that acetic acid is strongly polar and we also note that CO_2 is more soluble in it than in either of the other two solvents.

In the case of Propionic acid ($C_3H_6O_2$) and Methyl acetate ($C_3H_6O_2$) (two substances having identical molecular weight) we find that CO_2 has a solubility of 4.07 ccs. in the former and of 6.49 ccs. in the latter. This difference seems to be due to the greater polarity of Methyl acetate as shown by the structural formula, which gives to Methyl acetate greater symmetry and hence greater polarity.

Propionic acid —



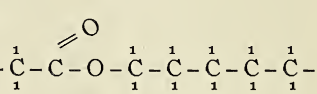
Methyl acetate —



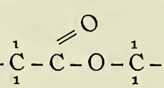
CO_2 is more soluble in Amyl chloride than in Amyl bromide, more in Ethylene chloride than in Ethylene bromide, and more in Chloro benzene than in Bromo benzene — all because the chlorides are more polar according to their structure than are the bromides.

TABLE III

4.12 Amyl acetate — $CH_3COOC_5H_{11}$ —

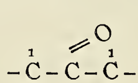


6.49 Methyl acetate — CH_3COOCH_3 —

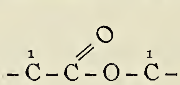


In Table III the first column represents the solubility of CO_2 in the solvent shown in the second column. Both solvents are polar but Methyl acetate has its poles closer together and hence is more strongly polar. CO_2 is more soluble in it than in Amyl acetate and this is as it should be according to this theory.

Ortho-toluidine and meta-toluidine have very nearly the same structure. They should therefore show approximately the same solubility. For the former 1.38 ccs. represents the solubility, and for the latter 1.43 ccs. of CO_2. This is in accord with the theory. Again, the solubility of CO_2 in Acetone (CH_3COCH_3) —



is 6.29 ccs. and in Methyl acetate (CH_3COOCH_3) —



it is 6.49 ccs. Both of these solvents are strongly polar and their structures are very nearly alike. We should therefore, expect the solubilities to be about the same, and both should be high.

TABLE IV

Solvent	Solubility at 20° of CO_2 A	of N_2O B	Ratio $\frac{A}{B}$
Water	0.9000	0.675	1.335
Acetone	6.98	6.03	1.155
Acetic Acid	5.23	4.85	1.078
Pyridine	3.85	3.58	1.075
Methyl Alcohol	3.57	3.32	1.07
Ethyl Alcohol	2.87	2.99	0.96
Benzaldehyde	2.98	3.15	0.95
Aniline	1.38	1.48	0.94
Amyl Acetate	4.65	5.14	0.905
Ethylene Bromide	2.27	2.81	0.808
Isoamyl Alcohol	1.91	2.47	0.773
Chloroform	3.71	5.60	0.664

In Table IV are listed the solubilities of CO_2 and N_2O in twelve different solvents as obtained by the writer. In the last column are given the ratios of the solubility of CO_2 to that of N_2O in any one solvent. N_2O is considered less polar than CO_2, and should therefore be found less soluble in polar solvents and more soluble in non-polar solvents than CO_2. Table IV bears out that contention, for those solvents which are near the top are generally considered polar while those near the bottom of the table are non-polar. This means that the ratio of the solubility of CO_2 to that of N_2O should be greater than one near the top and less than one near the bottom, as it is actually found to be.

While this theory does not pretend to explain the entire problem of solubility, it points out a method of approach which it seems has not been sufficiently emphasized thus far.

Physical Laboratory.
Iowa State College.

A COMPARISON OF INTENSITIES REQUIRED UNDER DIRECT AND UNDER INDIRECT LIGHTING SYSTEMS

WM. KUNERTH

Although artificial indirect lighting dates back twenty-five years or more, it was not very extensively patronized until after 1906 when the advent of the more efficient Mazda B lamp made its commercial use possible. At once comparisons were made between the direct and the indirect systems on various points.

It was soon recognized that when we consider the efficiency of installation only, the direct system is by far the better, efficiency of installation meaning the number of lumens obtained on the working plane for every watt of power input. In modern residences the installation efficiency is in the neighborhood of six lumens per watt, when the direct system is used; whereas when the indirect system is used the efficiency of installation is only about three lumens per watt. In a very general way the ratio of efficiencies between the two systems has been found to be about two to one. This low efficiency for the indirect system is due to the increased absorption by walls, ceiling, and glassware. The ratio has been determined repeatedly and is given here merely to recall to mind that from this point of view the direct system is to be preferred.

If we next consider the question of eye fatigue under the two systems we can do no better than to refer to the extensive series of experiments by Drs. Ferree and Rand [1] of Bryn Mawr College. They found that under conditions of natural illumination the eye is fatigued practically not at all, as is shown by the curve herewith. Under indirect lighting, however, they found that the eye is appreciably but not greatly fatigued after working for a period of three hours, and that under direct lighting the eye is excessively fatigued after working for the same period. These curves show conclusively that when eye fatigue only is considered the indirect system is to be preferred. The greater fatigue caused by the direct system is no doubt due to the great difference in intensity in different parts of the field of vision. This causes great activity in the ocular muscles and hence fatigue.

[1] Trans. I. E. S., Vols. 8-15.

The two systems have been compared in many other particulars such as shadow production, pleasantness of illumination, color of lighting, cost of fixtures, uniformity of illumination, glare, and several others; and comparison has also been made on the score of intensity required for the same kind of work. It is this problem which will be discussed in this paper.

In 1907 [2] Millar published some data, based on experiments with ten individuals, which showed that 2.7 foot-candles of direct lighting were required by these men to read newspaper print, and that 4.45 foot-candles were required to read the same print when the lighting was indirect.

In 1913 [3] T. E. Ritchie also published data on this point. He used seven persons and found that 7.3 foot-candles were required when direct lighting was used, and only 1.5 foot-candles when the lighting was indirect. In this case the print used for reading was that on the back of a slide rule.

It will be seen that the two articles referred to yield contradictory conclusions. Again, many casual observers of lighting systems give it as their opinion that less intensity is required from the one system, while others are convinced that less intensity is required by the other system.

These contradictions have opened anew the question of the relative intensities required under direct and under indirect lighting systems, and it was also the hope of the writer to ascertain why a person needs more natural light for a certain kind of work than he does of artificial light.

Accordingly, it was planned to make an experiment on a great number of individuals and under conditions such that the illumination would be decidedly diffuse in one case and exclusively direct in the other case. The room used for this experiment was 30 feet long, 18½ feet wide, and 13 feet high. The ceiling and upper half of the walls were painted white; the lower half of the wall and the floor were drab.

For the direct lighting the lamps were hung seven feet above the floor, and opaque white enameled reflectors were used As this work was done at night (actually between 7 and 8 P. M.), the window shades were raised so that light was not reflected from them but passed out through the windows. Every precaution possible was taken to have the light on the book come only from the fixtures direct.

2 Trans. I. E. S., Vol. 2, p. 590 (1907).
3 Illum. Eng., Vol. 6, p. 42 (1913).

For the indirect system silvered reflectors of the opaque bowl type were used, and thus no light passed directly from the light sources to the printed page. They were hung about two feet below the ceiling. In this case the yellow window shades were pulled down so as to augment the reflected light. Gas-filled lamps were used in both cases. The value of the current which it was necessary to put through the lamps in order to get the illumination approximately the same in the two cases was ascertained by a preliminary test. At the same time the current was so adjusted as to produce a variation in lighting intensity from one which was too low for comfortable reading to one which was too high. There were twenty-six individuals, all college seniors. The following instructions were given them.

DIRECT AND INDIRECT LIGHTING

No. _____________ Name _______________ Date ___________

Turn to a regular page of print in your text and ask yourself whether you could probably read this comfortably (without strain on your eyes), throughout the evening, when any one system and condition of lighting is used. In designating the impression of intensity of illumination on your book, use one of the following terms if possible:

Much too low
Somewhat low
Acceptable, but prefer more
Just right
Acceptable, but less would do
Somewhat high
Much too high

Brief comments on the lighting intensity will be appreciated. Keep the book on the arm of the chair and sit in a natural position while reading. On leaving the room leave this sheet on the seat of your chair. Do not change the position of your chair when once you have begun to note down observations.

DIRECT	*INDIRECT*
1	1
2	2
3	3
4	4
5	5

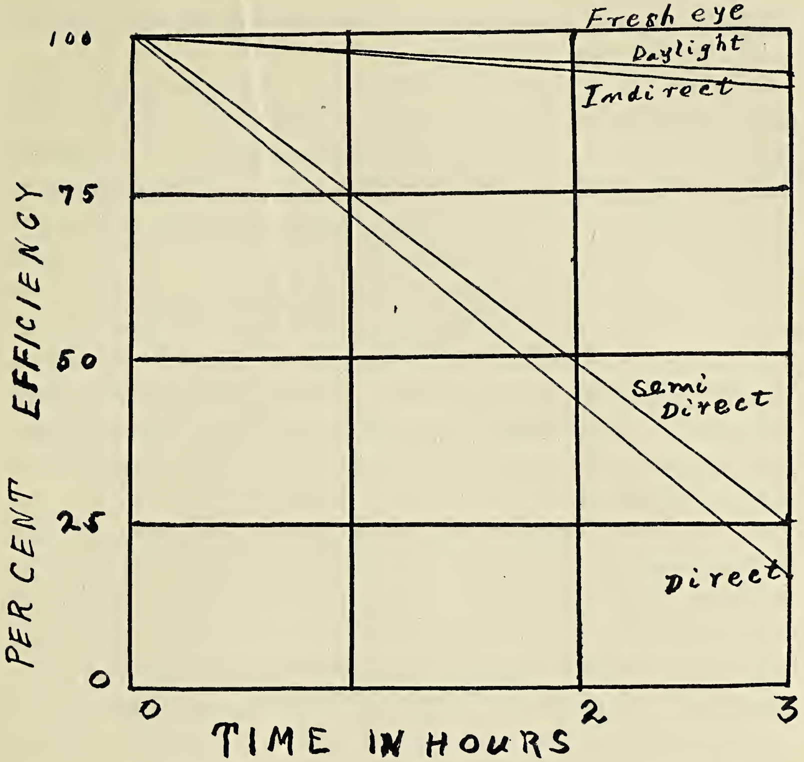
After the twenty-six individuals had been under any one condition of illumination for upward of five minutes they were asked to put down their opinion of the lighting on the basis of instructions given them. Then the current through the lamps was changed and observations again were made. In this way five different values of current were used, changes in intensity being made by irregular stages and not always in the same direction; and the individuals did not know but that any value of current might be duplicated. Then the other system was installed and the five conditions were repeated, except that the current values differed from the first set because of the difference in the efficiency of installation already noted above. During the few minutes while the change was being effected from one system to the other, the students were free to move about in the room. The arm of the chair on which the book was placed was 28 inches above the floor and sloped at an angle of 2½ degrees from the horizontal.

After the individuals had recorded their estimates of the illumination on their books under these conditions, the same conditions were repeated and the intensity in foot-candles which each individual had had on his book was measured by means of a Macbeth illuminometer. The number of foot-candles which each one considered as "just right" by the two systems is given in the table herewith. It may be noticed that a few estimates are very high, while a few others are very low.

INTENSITIES IN FOOT-CANDLES REQUIRED FOR READING ORDINARY TEXT BOOK PRINT BY TWO SYSTEMS OF LIGHTING

	Direct	Indirect		Direct	Indirect
1	2.0	2.5	15	3.0	3.0
2	7.0	5.7	16	2.3	5.0
3	3.0	2.0	17	3.0	6.5
4	2.3	2.3	18	4.0	6.7
5	1.1	1.9	19	3.0	3.0
6	1.8	4.9	20	3.0	3.0
7	2.0	6.0	21	1.0	3.7
8	5.0	6.5	22	1.5	6.0
9	5.0	3.0	23	2.0	6.0
10	3.0	5.0	24	2.3	2.3
11	2.5	4.3	25	2.3	2.5
12	3.0	2.3	26	1.7	3.0
13	3.0	4.5	Ave.	2.8	4.0
14	3.0	3.5			

Even though some required much less illumination intensity than is ordinarily considered satisfactory, it may be noted that they required less of both indirect and direct and hence the ratio



between the two, the determination of which was the chief object of this experiment, is left practically unaltered. When we drop out the abnormal intensities we get an average of 2.77 foot-candles for the direct, and 4.13 foot-candles for the indirect It may be seen, therefore, that by the indirect system we need an intensity almost 50 per cent greater than that required by the direct system for the same kind of work.

Since under the indirect lighting system everything in the field of vision is about equally illuminated, the pupil contracts much more than it does under the direct system, where much of the field is dark.

In the latter case the pupil will enlarge to allow more light to enter and will soon come to a state where a person can read print comfortably even though the actual intensity is small. It seems then that the illumination intensity required depends quite largely upon the brightness of the objects in the field of vision. If they are as bright as the objects on which we wish to focus our attention, then a high intensity is required; if, on the other hand, they are dark, the pupil will enlarge to take in a big flood of light and a smaller intensity will suffice.

The question which was at the bottom of this undertaking and which really prompted it, was, why a greater intensity of natural light is required for the same kind of work than is required of artificial light. Since natural lighting is only an extreme case of indirect lighting, it will be evident that our question is answered by the above data. It would seem reasonable that such should be the case, for with indirect or natural lighting the objects in the range of vision are illuminated and the light reflected into the eye causes a contraction of the pupil, and hence a greater intensity is required for clear vision. For the direct artificial lighting most of the light which enters the eye comes from the printed page and hence the pupil is larger and clear vision is obtained with a lower intensity.

In the direct lighting system the path of the beam of light from the source to the book is short — much shorter than for the indirect system. It follows, therefore, that the flux of light on the floor near the individual for the direct system is much less than on his book. But such is not the case for the indirect system where the path of the beam of light from the source to the book is almost the same as from the source to the floor. Thus if we had three foot-candles on the book by each system and two foot-candles on the floor by the direct system, we should probably have 2.8 foot-candles on surrounding objects by the indirect system. This latter would cause pupillary contraction and hence a greater intensity would be required for clear vision.

It may be argued that in this experiment the change of current through the lamps caused a change in color which served to affect the results; but whenever the color was at all abnormal due to the small current, the intensity was too low for comfortable reading and hence did not affect the conclusion here arrived at.

Again it may be urged that five minutes was too short a time in which to form a final opinion on a lighting system, but inasmuch as these persons had been studying illumination for three months, and since an equal period was allowed for each condition of illumination, it would seem that the conclusions here arrived at can be considered reliable.

Physics Laboratory.
Iowa State College.

THE PATH OF A RIGID ELECTRON WHICH MOVES IN A MAGNETIC FIELD OF CONSTANT STRENGTH ROTATING WITH CONSTANT ANGULAR VELOCITY

E. O. HULBURT

Abstract

Equations of motion of a rigid electron in a uniformly rotating magnetic field of constant strength rotating with a frequency $\omega/2\pi$ in the XZ plane are obtained. The reactions on the motion due to finite size, radiation from the electron and the field, and the variation of mass with velocity are neglected. If initially the velocity of the electron has components only along the X-axis or the Z-axis the path of the electron is a wavy curve inside an annular space whose axis is parallel to the Y-axis. If the initial velocity of the electron has components only along the Y-axis the path is a rather complicated type of spiral winding in the general direction of the Y-axis. It is found that a high frequency of rotation of the magnetic field, of the order of 10^6, such as may be produced by electron tube circuits, would not impart a great velocity to the electron.

STATE UNIVERSITY OF IOWA.

PHENOMENA IN GASES EXCITED BY RADIO FREQUENCY CURRENTS

E. O. HULBURT

Abstract

The spectra from hydrogen, oxygen and air excited by currents of the frequency of the order of 10^6 alternations per second produced by an oscillating fifty-watt electron tube were photographed with a grating spectrograph in the spectral region from 5000 A to 3500 A. These spectra were found to be identical with the spectra of the same gas stimulated by sixty-cycle current of the same strength as the radio frequency current.

The potentials just sufficient to set up luminosity in hydrogen and in oxygen were measured for direct and radio frequency, i.e.,

frequencies from 10^5 to 10^7, current using electrode distances from 5 to 30 mm. and gas pressures from 1 to 5 mm. of mercury. For a specified gas pressure and electrode distance the direct potential and the maximum value of the radio frequency potentials were found to be the same. In the light of this result theoretical consideration indicated that the luminosity was started by collisions of electrons, rather than of gaseous ions, with the gas molecules.

The flashes of light from hydrogen, oxygen, argon and air in turn excited by damped radio frequency current were found to be each a train of radio frequency flashes when examined by means of a rotating mirror. For hydrogen and argon the first few flashes of the radio frequency train showed a predominance of the green and blue lines of the spectrum, the later flashes of the train showed a predominance of the red lines. This was ascribed to the fact that the maximum value of the current in the first few cycles of the damped discharge was much greater than in the subsequent cycles.

State University of Iowa.

THE BROADENING OF THE BALMER LINES OF HYDROGEN WITH PRESSURE

E. O. HULBURT

Abstract

Spectrograms were taken of Hβ, Hγ and Hδ of hydrogen excited by condensed discharges for gas pressures from 2 to 135 mm. of mercury. At the highest pressure the photographic widths of the lines were nearly 100 A.U. Throughout the series of pressures the intensity of the central portions of Hβ was maintained sensibly constant. Assuming that the widening was caused by disturbance of the uniformity of the radiation due to collisions of the radiating particles (as proposed by others), the widening of the lines with pressure was calculated and found to be considerably less than that observed. This result indicated that the assumption was inadequate, and that the widening should be attributed to other causes such as the effect of the electrical fields, as investigated by Merton (Proc. Roy. Soc., 92, 322, 1915).

State University of Iowa.

NODAL DISTANCES IN ACOUSTICS

G. W. STEWART

Our elementary texts discuss the nodal planes produced by two plane waves of the same amplitude and frequency travelling in opposite directions and leave us with the impression that the distance between nodal surfaces is usually one-half of the wave length. Yet this is far from the truth. Nodal surfaces having such a distance apart exist only for plane waves, the most common case being the standing waves in pipes. The purpose of this note is to call attention to a case wherein the distance from a nodal to a loop surface can be made very short, almost as short as you please, and thus to contribute to a greater clearness of understanding.

Consider the case of a conical horn used as a receiver and closed at the vertex. The horn is approximately one-half a wave length of the resonating frequency, yet it has a node at the vertex and a loop at the open end. Now cut a tip off the vertex. There are now two loops, one at each end, and the node very close to the one at the incomplete vertex. Here then, is a nodal surface inside a conical horn which can be brought very close to a loop surface, indeed within a certainly very small fraction of a wave length. Moreover there is in the one instrument a nodal surface at two widely different distances from two loop surfaces, showing the possibility of having a distance from node to loop either less or greater than one-fourth of a wave length. A distance between nodal planes not one-half wave length can be secured by using an overtone.

To put the general statement a little more bluntly, a nodal surface is produced by opposition of phase with equality of amplitude, and traversing a distance is only one of the ways of producing the appropriate changes in phase. No limitation can be placed on the forms of apparatus which will give nodal surfaces separated at distances other than half a wave length.

Moreover, it may be added that one cannot expect that the difference in phase between two points in any kind of enclosure, room or otherwise, is determined by the wave length only.

STATE UNIVERSITY OF IOWA.

A VARIABLE SINGLE BAND ACOUSTIC FILTER

G. W. STEWART

This is a single band filter constructed by means of a straight tube or conduit with branch lines consisting of a volume and a tube connected in parallel and with the main conduit, but with an alteration at will of the opening into the main conduit. The narrowness of the single band can be modified by the modifications in the size of this hole without seriously affecting its other characteristics. The performance of the single band filter reported upon is in accord with theory mentioned.

State University of Iowa.

A NEW KIND OF TELEPHONE RECEIVER AND TRANSMITTER

C. W. HEWLETT

The Tone Generator described in these proceedings a year ago has been used successfully as a telephone transmitter and receiver. A loud speaker about eight inches in diameter has been made which will speak loudly enough to address a small gathering of people, say a hundred. The main advantage of the instrument is its faithfulness of reproduction of speech and music, the failure to do which is the chief disadvantage of all other known telephone instruments. The instrument when used as a transmitter is free from all the usual transmitter noises, and from distortion due to resonance of the diaphragm. By means of a three stage amplifier the voice currents from the transmitter have been amplified 15,000 times without the introduction of noises. With this arrangement the transmitter has been able to reproduce in a telephone receiver, ordinary conversational speech spoken at a distance of 50 feet from the transmitter. The chief phase of the problem which is being studied at present is to introduce into the loud speaker a fairly large amount of electrical power in the form of undistorted voice currents.

One marked improvement which has recently been made in the use of the instrument is to use the direct plate current of the accessory vacuum tubes to serve as the polarizing direct current for the telephone instrument.

STATE UNIVERSITY OF IOWA.

THE SCATTERING OF HOMOGENEOUS X-RAYS OF WAVE LENGTH 0.712 A° UNIT BY CARBON, LITHIUM, AND HYDROGEN

C. W. HEWLETT

The angular distribution of the scattering of the Kα radiation from a molybdenum X-ray tube by powdered graphite, diamond splints, benzene, mesitylene, and metallic lithium has been determined with an X-ray spectrometer by the ionization method. The solid substances give maxima of scattering in the places found by the photographic method, but the relative intensities of the scattering at different angles measured by the ionization method is greatly different from that estimated from the photographic method. The liquids give only one maximum of scattering, which occurs a few degrees away from the incident beam. The scattering then decreases to a minimum at 90° and then slowly increases again. The measurements have extended from 2° to 166°. In all cases the scattering approaches zero close in to the incident beam. For the solid substances mentioned the intensity of the scattering actually becomes zero within a narrow region accessible to the ionization chamber.

The total amount of scattered radiation from the scattering substances has been estimated in the following way: It has been assumed that a beam of X-rays in passing through a piece of matter is partly scattered in a series of coaxial cones, the intensity of the scattered energy being uniform between two cones of semi-apex angles θ and $\theta + d\theta$. Measurements of the intensity of the primary beam of X-rays were made, and the total scattered energy calculated from the scattering curves on the above assumption was expressed as a fraction of the primary beam. The total mass absorption coefficient of the primary beam was determined at the same time. The mass scattering coefficient, and the true mass absorption coefficient of the substance can be determined from these measurements and a knowledge of the linear dimensions and density of the scattering material. Recently a method has been developed for determining the fraction of the primary beam scattered, by continuously rotating the ionization chamber at a predetermined variable speed, which is so determined as to automatically perform the integration which was previously worked out from the scattering curve. Both methods give mass scattering and true mass absorption coefficients in good accord with J. J. Thomson's theory. The hydrogen values were calculated from the results on benzene and mesitylene.

State University of Iowa.

HALL EFFECT AND SPECIFIC RESISTANCE IN EVAPORATED FILMS OF SILVER, COPPER AND IRON

J. C. STEINBERG

Previous investigators have found the specific resistance a constant for metallic films, until the thickness becomes comparable with particle dimensions, at which thickness the resistance becomes very great. Wait[1] found the resistivity of chemically deposited silver films, whose thicknesses were greater than the above mentioned critical thickness, to be only slightly greater than that of the bulk metal. He found the Hall effect in these films, as well as in films whose thicknesses were less than the critical thickness, to be the same as that of bulk silver. On the conception that the substance in a film consists of granules not in the intimate contact obtaining in the bulk form, these results could be accounted for. Consequently it became desirable to investigate silver films obtained by an evaporation method, in order to ascertain how they differ from chemically deposited films, and how these differences affect their properties.

Evaporated films are obtained by carrying an electrically heated filament of the metal back and forth over a glass microscope slide in high vacuum. The filament when sufficiently hot ejects particles of metal which adhere to the slide, giving a hard uniform film. The surfaces of these films reflect very well without the aid of artificial polishing. No trace of structure is visible under the microscope. Hull's method of X-ray analysis shows lines similar to those in the bulk metal, from which it is inferred that the films are crystalline, the elementary crystal being of the same type as that found by Hull for the respective bulk metals. It is thought that the films possess a very fine grain.

The resistivity of evaporated films is much greater than that of the bulk metal, in the case of copper and silver about 1000 per cent. Also the critical thickness for evaporated silver films is less than that for chemically deposited silver films.

The Hall coefficient for evaporated silver and copper films is only slightly less than that for the bulk metal, whereas for evap-

1 State University of Iowa, Physics Laboratory.

orated iron its value is from 600 to 1000 per cent greater than that for pure bulk iron.

These phenomena are interpreted as a consequence of the small granules in evaporated metals, in the following way:

1. The effect of granular boundaries is to increase the resistance of a specimen.

2. The current contributing to Hall effect is decreased upon increasing the number of gaps in any cross section.

3. The Hall effect depends upon the magnetic condition of a substance, which in turn depends upon the granular dimensions.

Department of Physics.
State University of Iowa.

PHYSICS ABSTRACTS

THE ATTENUATION FACTOR IN ACOUSTIC WAVE FILTERS

H. B. PEACOCK

Abstract

A theory has been formulated by Dr. G. W. Stewart by which it is possible to determine the selective transmission in three types of specially constructed acoustic wave filters. The theoretical attenuation factor also has been worked out and shows fair agreement with experimental results. Theoretical values of the attenuation were computed for one filter of each type and, from these values, the theoretical transmission curves were determined. The types of filters were the low-frequency and high-frequency — pass, and the single band.

STATE UNIVERSITY OF IOWA.

COEFFICIENTS OF DIFFUSION OF SALT VAPORS IN THE BUNSEN FLAME

GEORGE E. DAVIS

Abstract

The coefficients of diffusion of alkali salts in the Bunsen flame have been determined by a photographic method which is a modification of the method used by H. A. Wilson. The values of the diffusion coefficients obtained for sodium, potassium, and caesium salts are roughly proportional to the reciprocals of the atomic weights of the metals. This is what we should expect from kinetic theory, if we consider the luminosity to be due to free metal atoms in the flame. Lithium salts, however, are found to have a lower coefficient of diffusion than sodium salts, and hence their metal atoms are probably free only a part of the time the vapor is in the flame.

DEPARTMENT OF PHYSICS.
IOWA STATE COLLEGE.

IOWA MICROLEPIDOPTERA

A. W. LINDSEY

After writing my last paper on the Lepidoptera of Iowa, *viz.*, "Some Iowa Records of Lepidoptera," I still had in my possession a considerable number of specimens of Tineoidea and all of the Phycitinæ which I had taken in the state. I attempted to work up this material during my last few months as curator of the Barnes collection at Decatur, Illinois, and succeeded with most of the Tineoidea. The subfamily Phycitinæ of the Pyralidæ is in such great need of careful revision that I feel safer in omitting it entirely at present, though I have identified a few species with a reasonable degree of certainty.

Since returning to Iowa I have done a small amount of field work in the vicinity of Sioux City with very interesting results. I hope to add such observations as I am able to make in the spring of 1922, and possibly the summer, to complete the material for a supplementary paper, and therefore limit the present list to the records of Tineoidea.

My good friend, Mr. R. A. Leussler, of Omaha, Nebraska, communicates to me from time to time some very remarkable captures made near that city. Is there no person in the adjacent portion of our own state who takes an interest in this order of insects? The field must be fertile, and careful collecting should add many species to our known fauna.

My list of species is as follows:

Cosmopterygidae

1. *Psacaphora terminella* West. Iowa City, one, June 3, 1917.
2. *Mompha eloisella* Clem. Sioux City, July.

Gelechiidae

3. *Metzneria lappella* Linn. Sioux City, one, July 17, 1917.
4. *Aristotelia roseosuffusella* Clem. Ames, August, abundant.
5. *Gnorimoschema gallaesolidaginis* Riley. Sioux City and Iowa City.
6. *Gnorimoschema septentrionella* Fyles. Iowa City, one, October 8, 1917.
7. *Epithectis attributella* Wlk. Sioux City, July.
8. *Arogalea cristifasciella* Cham. Sioux City, May.

9. *Phthorimaea operculella* Zell. Ames, one, August 23, 1918.
10. *Anacampsis psoraliella* Barnes and Busck. Type series of three specimens reared from *Psoralea argophylla* at Sioux City, July, 1917.
11. *Gelechia bicostomaculella* Cham. Iowa City, one, June 29, 1918.
12. *Gelechia nigrimaculella* Busck. Iowa City, July 4, 1918.
13. *Trichotaphe serrativitella* Zell. Ft. Crook, Nebraska, October. This is also in coll. Barnes from Illinois, and must occur in the very similar intervening regions in Iowa.
14. *Dichomeria ligulella* Hbn. Cou Falls, July.
14a. *Dichomeria ligulella* form *pometella* Harr. Common at Iowa City, June.
15. *Strobisia iridipennella* Clem. Iowa City, June and July.

Oecophoridae

16. *Cryptolechia tentoriferella* Clem. Iowa City, September.
17. *Psilocorsis reflexella* Clem. Cou Falls, July. Sioux City, June.
18. *Depressaria cinereocostella* Clem. Iowa City, April, Ames, August.

Blastobasidae

19. *Blastobasis plummerella* form *simplicella* Dietz. Type locality, Iowa City.
20. *Valentinia glandulella* Riley. One specimen, "Iowa."
21. *Holcocera zelleriella* form *annectella* Dietz. Iowa City is one of the type localities.
22. *Pigritia basilarella* Dietz. Part of the type series came from Iowa and one taken at Sioux City, August 23, 1916, answers Dietz's description.

Stenomidae

23. *Stenoma schlaegeri* Zell. Homestead and Sioux City, May. Iowa City, June, common.
24. *Stenoma algidella* Zeller. Iowa City, May and July. Homestead, May. Sioux City, June and July.

Ethmiidae

25. *Ethmia fuscipedella* Wlsm. Sioux City. Rare.

Aegeriidae

26. *Synanthedon acerni* Clem. This is in coll. Barnes from Quincy, Illinois, and may be expected in eastern Iowa.

27. *Synanthedon sanborni* Hy. Edw. Dickinson Co., one, August, 1915. Compared with the type by Dr. Barnes and said to be the same species.
28. *Melittia satyriniformis* Hbn. Sioux City. Undoubtedly more generally distributed than this indicates. A number of other species are known to occur in the state but my material offers no other records.

Eucosmidae

29. *Exartema permundanum* Clem. Sioux City, July. Iowa City, June and July.
30. *Exartema atrodentanum* Fern. Iowa City, July.
31. *Exartema fasciatanum* Clem. Iowa City, June.
32. *Exartema inornatanum* Clem. Sioux City, June.
33. *Exartema malanum* Fern. Iowa City, July.
34. *Exartema merrickanum* Kearf. Iowa City, June. This is a type locality. Also taken at Sioux City and Cou Falls in July.
35. *Argyroploce hebesana* Wlk. South Sioux City, Nebraska, August 30, 1916, and from many points east of Iowa.
36. *Argyroploce coruscana* Clem. Iowa City, June.
37. *Argyroploce constellatana* Zell. In coll. Barnes from localities both east and west of Iowa, and therefore probably found in the similar territory of our state.
38. *Argyroploce astrologana* Zell. Iowa City, June.
39. *Argyroploce hemidesma* Zell. Very common at Ames on *Spiraea*. Adults appeared in August.
40. *Argyroploce instrutana* Clem. Sioux City, July. Ames, August.
41. *Eucosma robinsonana* Grt. Sioux City, July.
42. *Eucosma dodecana* Zell. Sioux City, July.
43. *Eucosma sandana* Kearf. Sioux City and Dickinson county, August.
44. *Eucosma pergandeana* Fern. Sioux City, June and July. Iowa City, June.
45. *Eucosma pallidipalpana* Kearf. One, Sioux City, July 19, 1917.
46. *Eucosma comatulana* Zell. Sioux City, August.
47. *Eucosma heathiana* Kearf. Dickinson Co., August.
48. *Eucosma glomerana* Wlsm. Sioux City and Dickinson county, August.
49. *Eucosma vandana* Kearf. Sioux City, August 16, 1917.

50. *Eucosma grotiana* Kearf. Dickinson county, August.
51. *Eucosma strenuana* Wlk. Sioux City, August.
52. *Eucosma landana* Kearf. Sioux City.
53. *Eucosma carolinana* Wlsm. Sioux City, July.
54. *Eucosma giganteana* Riley. Sioux City.
55. *Eucosma otiosana* Clem. Sioux City, August.
56. *Eucosma dorsisignatana* Clem. Sarpy county, Nebraska, and Decatur, Illinois. Should occur in eastern Iowa.
57. *Eucosma tandana* Kearf. Iowa a type locality.
58. *Eucosma bilineana* Kearf. Iowa is one of the type localities.
59. *Eucosma corosana* Wlsm. Sioux City, September.
60. *Eucosma pulveratana* Wlsm. Sioux City, August.
61. *Eucosma roseoterminana* Kearf. Homestead, May. Iowa City, June.
62. *Eucosma imbridana* Fern. Sioux City and Dickinson county, August.
63. *Eucosma tenuiana* Wlsm. Iowa City, June.
64. *Eucosma vestaliana* Zell. Sioux City, June.
65. *Laspeyresia interstinctana* Clem. Iowa City, June. Dickinson county, August.
66. *Carpocapsa pomonella* Linn. Sioux City, September.

Tortricidae

67. *Adoxophyes furcatana* Wlk. Sioux City, July and August.
68. *Amorbia humerosana* Clem. Sioux City, June.
69. *Sparganothis reticulana* Clem. Iowa City, one, July 2, 1918.
70. *Sparganothis flavibasana* Fern. Iowa City, June.
71. *Sparganothis sulphureana* Clem. Sioux City, July.
72. *Pandemis limitata* Rob. Sioux City, August. Reared at Iowa City in June from *Osmunda* and Hazel.
73. *Cacoecia argyrospila* race *vividana* Dyar. Sioux City, July.
74. *Cacoecia fractivittana* Clem. Iowa City, June.
75. *Cacoecia rosaceana* Harris. Grinnell and Homestead, June. Sioux City, June to August.
76. *Tortrix quercifoliana* Fitch. One specimen reared from Hazel, Homestead, June, 1918.
77. *Tortrix lata* Rob. Sioux City and Dickinson county, August.
78. *Eulia velutinana* Wlk. Sioux City and Iowa City, May.
79. *Peronea cervinana* Fern. Sioux City, February, May, October (det. Busck).
80. *Peronea minuta* form *cinderella* Riley. Sioux City, March (det. Busck).

81. *Peronea trisignana* Rob. Iowa City, September (det. Busck).
82. *Peronea nivisellana* Wlsm. Sioux City, March (det. Busck).
83. *Peronea brewsteriana* Rob. Sioux City, February 19 (det. Busck).

Carposinidae

84. *Carposina fernaldana* Busck. Ames, August.

Heliodinidae

85. *Heliodines nyctaginella* Gibson. Reared in abundance from *Oxybaphus nyctagineus* at Ames, August, 1918. Sioux City, July.

Glyphipterygidae

86. *Brenthia pavonacella* Clem. Iowa City, June, common.
87. *Choreutis carduiella* Kearf. Iowa City, July.

Yponomeutidae

88. *Yponomeuta multipunctella* Clem. Sioux City, one, July 9, 1917.

Gracilariidae

89. *Lithocolletis ostensackenella* Fitch. Reared from Black Locust, Sioux City, August.
90. *Lithocolletis tritaeniella* Cham. Reared from Hop Hornbeam, Sioux City and Ames.
91. *Lithocolletis cincinnatiella* Cham. Iowa City, reared from White Oak.

Scythrididae

92. *Scythris impositella* Zell. Iowa City, July.
93. *Scythris eboracensis* Zell. Iowa City, July.

Lyonetiidae

94. *Bucculatrix quinquenotella* Cham. Iowa City, July.

Cossidae

95. *Prionoxystus robiniae* Peck. Iowa City.

Prodoxidae

96. *Tegeticula alba* Zell. Sioux City, June. Common in the flowers of *Yucca* on the dry hilltops.

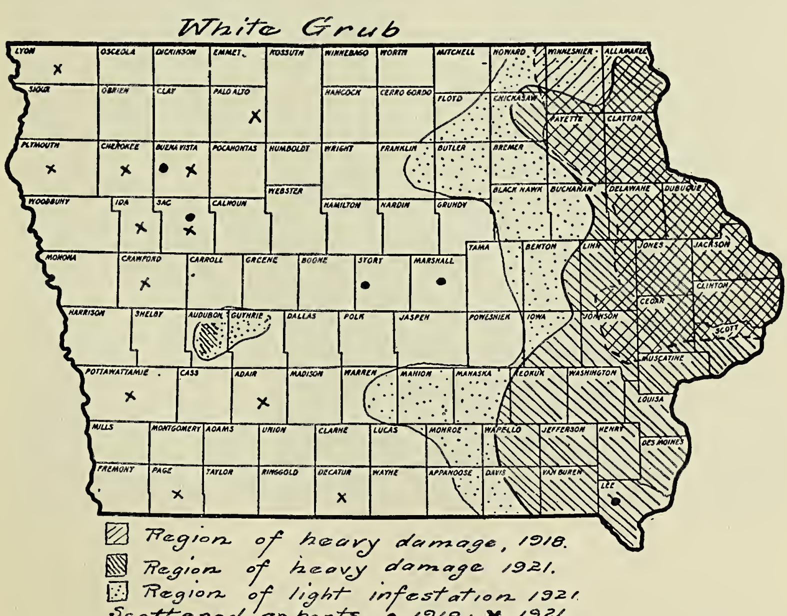
Department of Biology,
Morningside College.

BROOD A OF THE MAY BEETLES EXTENDS ITS RANGE IN IOWA

H. E. JAQUES

Among the well known insect pests with which the farmer must contend are the May beetles which in the larva stage, as white grubs, do heavy damage to the grasses, corn, potatoes, strawberries and garden crops. There are about one hundred species of May beetles known to occur in the United States all of which belong to the genus Phyllophaga. Forbes* in examining 114,493 May beetles in Illinois found 34 species, but less than half of these were sufficiently abundant to be of serious economic importance.

The more destructive species of May beetles have a three year life cycle, with the grubs doing serious damage during but one summer of the three. In any locality all stages may be found, indicating the presence of three broods which have been named broods A, B and C. Brood A, which appeared as adults in 1920 and as destructive grubs in 1921 is the largest of the three broods



and is the one which has caused most of the damage during the past fifteen years or more.

As early as the summer of 1909, brood A in numbers sufficient to do serious injury was spread over a large area in southern Wisconsin, northern Illinois, northeastern Iowa and a small corner of southeastern Minnesota. The grubs have reappeared in this territory in the summers of 1912, 1915, 1918 and 1921. In 1921 the area of damage in Iowa was much enlarged over that of previous years, and southeastern Iowa came in for a heavy share of the loss. Twelve counties untouched in a serious way in 1918 were invaded. The accompanying map shows in a comparative way the infested regions of 1918 and 1921. These data were secured through personal visits to infested regions and by correspondence with the County Agricultural Agents. Mr. Fred D. Butcher, Extension Entomologist, gave valuable information also.

In many parts of the newly infested area the injury was severe. Reports of losses range from 15 per cent of the crop to a total loss in some fields. Corn and potatoes suffered heavily but blue grass pastures seemed to be most seriously damaged. In many pastures the grubs were so abundant as to entirely cut loose the roots until the sod could be rolled up like a rug.

From Lee county came the report of grubs as thick as "75 to 150 per square foot" with a 30 to 50 per cent loss of corn and a 70 per cent loss of blue grass in some fields. Many large counts of grubs were made though no other reports showed as many grubs to a given area as this. Twenty-seven grubs were found in a post hole left open for two hours, while in a corn field twenty-two grubs were found in two hills.

The adult May beetles of this brood will appear in the spring of 1923 and it is planned to make a study of them to determine the number of species involved and their relative importance.

Biology Department,
Iowa Wesleyan College.

* University of Illinois Agricultural Experiment Station Bulletin No. 186.

A STUDY OF THE WHITE MARKED TUSSOCK MOTH

SUSANNAH POULTER

Early in the winter of 1921-22 it was observed that egg masses of the white marked tussock moth, *Hemerocampa leucostigma* Smith and Abbot were unusually abundant. Taking advantage of this opportunity it was planned to make a careful study of the life history of that interesting insect. This insect is of considerable economic importance in that the larvæ when abundant defoliate trees of various species.

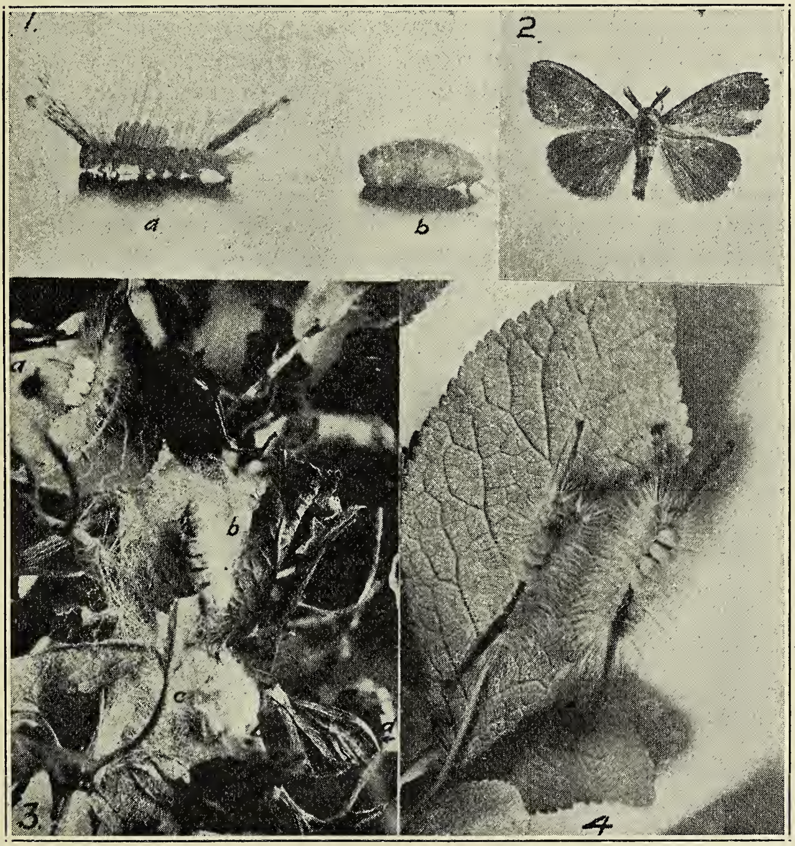


Fig. 1. The White marked Tussock Moth (*Hemerocampa leucostigma* Smith and Abbot) 1. a. Mature larva; b. adult female; 2. adult male; 3. a. Larva; b. adult female on cocoon; c. egg mass on cocoon; d. adult male. 4. Mature larvæ.

The larva is a beautiful slender hairy caterpillar about one and one-fourth inches long when fully grown. The dominating color is bright canary yellow. Four dense cream colored tufts of erect hairs on the first four abdominal segments are characteristic and give a basis for the name. A dorsal and a lateral stripe of blackish, two long black hair pencils projecting from the coral head and another from the posterior end and two brilliant red protuberances on the sixth and seventh abdominal segments lend to the decorations. The larva when dropping from one object to another spins a fine web which it can reclimb. The adult male is an ashy gray moth expanding about one and one-fourth inches. The female is light gray and is wingless, which fact offers opportunity for control measures. The body is about three-fourths of an inch long and heavy. The pupa surrounded by a hairy cocoon is attached to a tree twig, under loose pieces of bark on fences or on buildings. When placed on a twig, as is most frequent, it is usually wound in one or more leaves. The wingless female upon emerging clings to the cocoon and after mating deposits her eggs on one side of the cocoon and covers them with a white frothy coating in which stage the eggs of the second brood pass the winter. The spherical eggs are smooth except that they are covered with a lintlike mass. The color is a tawny cream. The largest diameter is slightly less than one millimeter. The eggs are almost always laid on the cocoon as already stated.

Numerous winter egg masses were collected and the eggs contained on fifty representative cocoons were carefully counted. The results were as follows:

332	382	540	481	667
469	472	500	237	415
406	461	456	302	466
516	579	454	559	422
569	674	362	460	449
534	460	526	278	507
568	402	548	527	506
602	567	688	303	341
700	438	410	708	335
504	378	328	491	573

The smallest number is seen to be 237 and the largest 708. The total number of eggs laid by the fifty moths was 23,812, making an average of 477.44.

The eggs that were collected and kept indoors began hatching the 7th of April. A large number of adults was thus reared under observation. A definite record was kept on the time of each molt for several of the larvæ as shown in the following table:

Larvæ	No. 1	No. 2	No. 3	No. 4
Hatched	May 3	May 3	May 3	May 3
First Molt	May 9	May 9	May 9	May 9
Second Molt	May 13	May 13	May 13	May 13
Third Molt	May 18	May 18	May 19	May 19
Fourth Molt	May 23	May 24	May 24	May 25
Pupation	May 30	June 2	June 2	June 2
Emergence	June 6	June 12	June 8	June 7

Larvæ	No. 5	No. 6	No. 7	No. 8
Hatched	May 3	May 3	May 17	May 13
First Molt	May 9	May 9	May 25	May 26
Second Molt	May 13	May 13	May 30	May 30
Third Molt	May 19	May 19	June 5	June 5
Fourth Molt	May 25	May 26	June 8	June 12
Pupation	June 3	June 6	Lost	Lost
Emergence	June 9	June 13		

These rather few cases revealed the length of the larval period for the first brood to be 27 to 34 days and the pupal period to be from 5 to 10 days. These figures, of course, are for indoor conditions.

On June 25 caterpillars of the second brood began hatching. The female which laid these eggs emerged June 12 and laid her eggs a few hours after emergence.

It was observed from the larvæ that matured that the males emerged a day or two before the females. The life of the adult female is very short and in this way mating was not delayed.

Many experiments in the way of offering different food plants to the caterpillars and in changing the food from time to time were carried on. Eggs were collected during the winter from the following trees: birch, maple, elm, apple, and plum.

In captivity it was found that the caterpillars fed readily on leaves of box elder, mulberry, catalpa, buckeye, horse chestnut, maple, birch, elm, lilac, apple, plum, cherry, pear, cottonwood and sycamore. They were found to eat the leaves of many herbaceous plants as readily as those of trees. Leaves of dandelion, bluegrass, low-mallow, lamb's quarter, clover, geranium, iris, lily of the valley, and plantain thus proved acceptable. The common burdock was the only food which they refused. It was also found that they could readily be transferred from one food plant to another without serious consequences.

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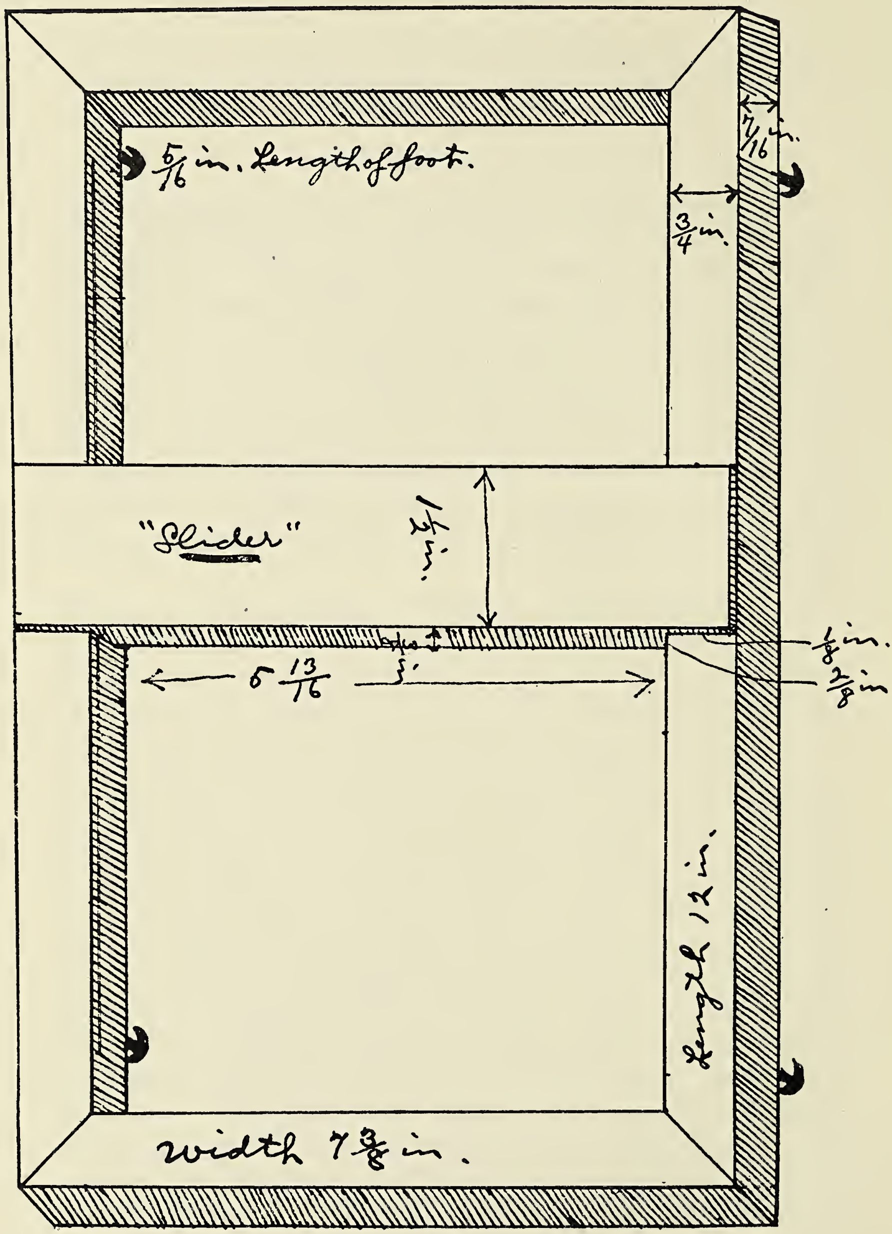
Iowa Wesleyan College.

A SCRIBOFACILOGRAPH FOR LABELING KYMOGRAPHIC TRACINGS

T. L. PATTERSON

The ordinary laboratory routine of labeling kymographic tracings involves at best a rather tedious and arduous task which consists either of holding the hand unsupported well above the carbonized paper and writing upon it with a stylus in the form of some pointed instrument, or writing over the rod of an iron stand or some other inconvenient support for the hand. Furthermore, the carbonized paper must be securely held and especially where there are drafts of air while the labeling is being done, and as a result the fingers become coated with carbon, so that notebooks, clothing, etc., which are handled or touched directly thereafter may become badly smeared and blackened with carbon.

The apparatus herein described is easily made and consists of a frame constructed of hard wood to give it weight, the strips of which are 3/4 inch by 7/16 inch which are joined together like a picture frame. The size of the frame is 12 inches by 7 3/8 inches and upon it rests an automatic slider or hand rest, 1 1/2 inches in width by 7 3/8 inches in length by 3/8 inch in thickness, the ends of which are so cut that 2/8 of the 3/8 inch thickness drops between the two sides of the frame while the remaining 1/8 inch of thickness overlaps the upper surfaces of the frame itself. This is held in place by small curved wires, one of which is introduced into each end of the under cut surface of the slider, these wires then fitting into a groove of suitable size on the inner surfaces of the long sides of the frame so that the slider may easily be pushed from end to end. The frame is so constructed, therefore, that it spans the carbonized paper, thus being elevated slightly from it by four short feet made of brass headed tacks which are driven into the under side of the frame about 2 inches from the ends respectively and projecting about 5/16 of an inch. The brass feet rest upon the edges of the paper thus holding it firm while the labeling is being done. Although this apparatus was devised especially for labeling kymographic tracings it is equally valuable for drawing


5/16 in. Length of foot.
7/16 in.
3/4 in.
"Slider"
1/2 in.
1/8 in.
2/8 in
5 13/16
Length 12 in.
width 7 3/8 in.

vertical and horizontal lines on graphs that require it, thus superseding the old rule method.

The apparatus requires no skill for its successful application and students are eager to use it in preference to any other method for labeling their kymographic tracings, since it may be not only conveniently but quickly and easily used without the disagreeable features usually accompanying this phase of physiological work.

Department of Physiology,
Detroit College of Medicine and Surgery.

EFFECTS OF STRETCH ON MUSCLE RESPONSES IN THE EARTHWORM

(*HELODRILUS CALIGINOSUS*)

B. M. HARRISON

Much investigation has been done on the physiology of the muscles of the vertebrates as compared with that of the invertebrates. Buddington[1] ('02) brings together the bibliography bearing on this problem, and shows that with increasing temperature Lumbricus muscle shows little constancy in changes of tone below 15° C and the first uniform result is a gradual loss of tone beginning at 20° C; rapid loss of tone occurring between 30° and 40°; an improvement from 42° to about 55° when rapid relaxation sets in, this changing to final heat rigor at about 65°. Eddy and Downs[2] ('21) showed that the gastrocnemius muscle of the frog when stretched by a weight of 100 grams for one-half to three hours can be completely fatigued in 85.98 per cent of the time required in the case of an unstretched muscle, when both were stimulated by the same strength induced current. Harrison and Baldwin[3] ('21) obtained definite qualitative differences in responses in earthworm muscle in concentrations of alcohols, ranging in ethyl alcohol from 40 to 1.56 vols per cent, and in propyl alcohol from 10 to 0.5 per cent. In general, the higher concentrations are toxic, the lower have no noticeable effect, while between the two extremes are concentrations of decided sensitization.

APPARATUS AND METHOD

The apparatus used in this series of experiments was the same as described in a previous paper by Harrison and Baldwin[3] ('21). A more detailed description of a part of the apparatus is given by Harrison[4] ('23). A tetanizing electric current was employed for stimulating, strengths of 6 and 8 volts were used as subsequently described. The secondary coil of the inductorium was set at 4½ centimeters from the primary, where it was maintained throughout the entire series of experiments. The kymograph was adjusted to make one revolution in one hour. The inductorium was adjusted so as to give thirty-eight to forty make and break stimuli per second. Forty to forty-five of these make and break shocks constituted the stimulus after each time interval through the entire series of experiments. The solutions in which the muscles were immersed were drained off and replaced with fresh solution after each series which ran thirty-five minutes or more, and after every second or third where each ran fifteen or twenty minutes. In each case where there was a change made in the kind of solution used, the glass tube which was to contain the muscle was thoroughly rinsed with the solution next to be used. The earthworms used in these experiments were *Helodrilus caliginosus* var. *trapezoides* (Duges). These were collected in the field, placed in jars with moist earth, and kept at room temperature, sometimes for several days before being used, with a variation of only two or three degrees from 70° F. All the experiments were performed at room temperature, the variation of which was so slight that the resulting effects on the muscle may be considered as being practically negligible. Sections of ten somites of the earthworm constituted the unit of muscular tissue used in each case and were taken from behind the clitellum as it was found that these were more easily standardized. The sections were mounted and stimulated as previously described in the paper mentioned above.

Figures 1 to 5 inclusive are records of typical experiments indicating the effects of variation in length of time of stretch upon the responses of the muscle when immersed in normal sodium chloride solution, the time varying from ten minutes to three hours. Each muscle was mounted as previously described and given thirty-five to forty stimuli with one minute intervals. Figure 1 of Plate I shows what may be considered a typical record of responses without stretching. The type of the curves is uniform, varying principally in the heights of contraction, indicating the gradual onset and progression of fatigue. The relaxation or loss of tonus begins with the initial stimulus and continues uniformly to the later part of the series where the sodium chloride is removed and .12 per cent amyl alcohol is added which immediately sensitizes the tissue to a greater height of contraction and a rise of tonus. The progressive inhibitive effects of the alcohol are shown in the last few curves of the series. In the first few curves of each of the series, 2, 3, 4, and 5, the tissue was stimulated immediately after mounting and before stretching, following this a ten gram weight was added to each for ten minutes, twenty minutes, thirty minutes and two hours, respectively. The kymograph was stopped and the electric current was shut off in each case during the stretching, after which the weights were removed and the muscle was stimulated as before. In figure 2 the contractions following the stretch with ten gram for ten minutes are practically twice as high as those preceding the stretch on the corresponding curves in figure 1 where there was no stretch. The increased height might be attributed to the recuperation during the time interval or rest, but in figure 6 where a ten minute rest occurred without any stretching the succeeding contractions were practically the same height as before, about the only change which is evident being a slight relaxation while the kymograph was stopped. It is interpreted that this increased sensitization is brought about by the stretching of the tissue. Little difference in the variation of tonus occurs, but the onset and progressive effects of fatigue are more definitely indicated than where there was no stretch. Figures 3, 4, and 5 also show this increase in sensitization due to the stretching. Figure 4 fits least well into the series, but taking all these series together the height of the contraction and the onset and progressive effects of fatigue are in proportion to the duration of the time of stretch. In the last of the series in figure 3, stimuli were introduced every twenty-five seconds which is equivalent to about twenty make and break shocks or about one-half the duration and strength of those just preceding. The corresponding contractions are proportional to the amount and duration of current used. Series 7 and 8 having twenty and thirty gram weights respectively, were stretched ten minutes each in order to attack this problem of stretch from another angle, and here again the initial sensitization and the onset and progress of fatigue are in proportion to the amount of stretch. Series 9, which was stretched for two hours with a ten gram weight in sodium chloride solution, was made to further analyze this increased sensitization property of stretched muscles. This series is directly comparable with series 5, the only variable being that instead of removing the ten gram weight after the two hours stretch it was allowed to remain and be lifted following the first three stimuli; after which it was removed and the muscle stimulated as usual. The muscle contracted only about one-fourth the height of the corresponding contractions in series 5 where the weight was removed. There is the immediate onset and progression of fatigue in the two cases which are practically the same. The height of the contractions following the removal of the weight are practically the same as the corresponding contraction in 5. It is thus evident that the amount of work done in lifting the weight is equivalent to that done in the corresponding contractions where the weight was removed. Apparently there was a certain definite amount of sensitizing material present before each of the initial contractions following the two hour stretch period, and the additional stretch due to lifting the weight liberated no appreciable additional amount. Figures 10 and 11 are continuations of series 7 and 9, respectively. In the former the muscle is only partly fatigued while in the latter the fatigue is practically complete. The sodium chloride solution was removed in each case and 0.18 per cent amyl alcohol was added, and the subsequent curves show the progressive effects of the alcohol. While these curves are not exactly comparable due to variation in the time between the introduction of the alcohol and the application of the stimulus it is quite evident from these and other experiments that the increase in sensitization by amyl alcohol in this concentration is most rapidly brought about in partly fatigued muscles.

Series 12 to 31 inclusive are records made to test the effects on the normal responses of muscles immersed, stretched and stimulated in normal sodium chloride, potassium chloride, and calcium chloride solutions. The method used in mounting and stimulating the various tissues is the same, but the length of time of stretch varies in the different series from ten minutes to three hours. The muscles are automatically stimulated with an eight volt tetanizing electric current, set to make thirty-eight to forty double vibrations each second, with intervals of twenty seconds. Each series is selected as typical among many made under the same conditions. In each solution used the most marked initial sensitization appears in tissue stretched with a ten gram weight for about one hour. Sodium chloride produced marked sensitization during the longer periods of stretch. Potassium chloride produces marked inhibition when compared with sodium, while calcium chloride brings about contracture which merges into rigor and these factors hasten proportionately comparative fatigue processes. Figure 12 is a record of a muscle when stimulated immediately after mounting and immersed in normal sodium chloride solution, without being stretched, and is a normal or standard series under these conditions. It is the same type of series as that shown in figure 1 where only six volts were used at intervals of one minute, and shows the same, in that contractions following the first ten or twelve stimuli remain practically the same, but are followed by a gradual decrease in height with the onset and progression of fatigue, and a slow relaxation or decrease of tone. Series 13, 14, 15 and 16 were made in the same way as the above, with the exception that immediately after mounting in the sodium chloride solution, each was stretched with a ten gram weight. The length of time of stretch was the only varying factor and was for ten minutes, twenty minutes, one hour and three hours, respectively. Figure 13 shows very little variation from the standard sodium chloride series. The relaxation phase is not so evident, but the evidence of fatigue is more pronounced. After a stretch of twenty minutes as shown in figure 14, the heights of the contractions are much greater and also the tonus holds up much better than in the preceding series of this group. This suggests, when compared with 12 and 13, that stretching sensitizes the muscle to greater contractions and enables it to better withstand the onset and progressive effects of fatigue. Figure 15, made after stretching one hour, shows a marked increase in the height of contraction, but fatigue begins at about the same relative time and progresses at about the same rate, and the tonus remains practically constant, all of which are important when correlated with the previous series. After three hours stretching with a ten gram weight a series is obtained as shown in figure 16. The height of contraction is not so great, the progressive effects of fatigue are more pronounced, and the loss of tone is again observed, all of which indicate that the point of maximum sensitization has been passed.

Series 17 to 21 inclusive show the effects of stretching muscles in normal potassium chloride solution, with the same weights and the same lengths of time, as those in series 12 to 16 respectively. Each series of the potassium chloride group possesses the characteristic initial contraction, followed by a series of curves indicating marked inhibition as compared with the corresponding sodium chloride series. Figure 17 shows the typical or standard series of curves when the muscle was not submitted to previous stretching. The heights of contractions, following corresponding stimuli and the resistance to the progressive effects of fatigue are much less where potassium chloride is used. In figure 18, where stretching continued for ten minutes, the relaxation following each contraction is much inhibited and the increase in tonus continues during several stimuli, followed by a gradual loss of tonus and sensitization, reaching complete exhaustion near the end. When compared with figure 17 where no stretching occurred, one also observes the increase in the initial contraction. Figures 19 and 20 record the effects of stretch in normal potassium chloride for twenty minutes and an hour and fifteen minutes, respectively, and show the same general effects as already mentioned but in a more pronounced way. Thus in series 18, 19 and 20 there is a progressive increase in the height of the initial contraction and also an increase in the duration of the maximum contractions following, which is similar to series 13, 14 and 15. This is interpreted as indicating that the depressing effects produced by the potassium chloride are more than counterbalanced by the sensitizing effects produced by stretching. Figure 21 records results of stretching for three hours and is strikingly similar to figure 18, the principal differences being the variation in the heights of the initial contractions and the tonicity during the latter parts of the experiments. The point of maximum sensitization has evidently been passed and the muscle is approaching rigor. This, in a general way, coincides with the results recorded in the sodium chloride series. Series 22 to 26 inclusive were performed to test the effects of variation in the amount of weight used, in stretching muscles when they were immersed in normal potassium chloride solution. The experiments were performed as in the previous potassium chloride series excepting that a twenty gram weight was used instead of ten grams for the same lengths of time as in the series 17 to 21, respectively. The maximum sensitization point was reached sooner, being most evident after ten to twenty minute stretch while in the potassium series where a ten gram weight was used this point was reached after about one hour and fifteen minutes stretch. The onset of fatigue is sooner and its progressive effects are more pronounced where the greater weight is used. Series 25 and 26 show results after stretching one hour and three hours, respectively. There is little response as compared with series 20 and 21, showing that a condition of practically complete fatigue is reached.

The records in series 27 to 31 inclusive are of muscles stretched in normal calcium chloride solutions for periods of time comparable to the sodium chloride series 12 to 16, and the potassium chloride series 17 to 21 and show that the initial contractures following the shorter periods of stretch are greater than in the corresponding series of the other solutions, while for the longer periods of stretch the reverse is true. The progressive effects of fatigue following the initial contractions are less marked during the earlier periods of stretch than in the corresponding potassium series, while in those of the longer periods of stretch the reverse is true. Also following the initial contraction the tonus is increased during several stimuli and maintained in a comparatively striking manner throughout each series of the calcium group.

SUMMARY

Mounts of intestine and body wall muscles of the earthworm when immersed in normal sodium chloride solution and stretched for various intervals with ten gram weights and subsequently uniformly but intermittently stimulated with a tetanizing current of known strength at successive intervals, (i. e. each minute for one-half hour) show that stretching has a sensitizing effect in the responses immediately following the treatment which is relatively proportional to the duration of the stretch up to certain limits. Noticeable relationships are found between duration of stretch and the onset of fatigue which in general seem to indicate that the greater the stretch, the greater the initial sensitization followed by rapid onset of fatigue.

Mounts stretched with different weights in normal sodium chloride, potassium chloride and calcium chloride solutions and stimulated every twenty seconds for a period of fifteen minutes show remarkable correlation between duration of stretch, intensity of stretch and the kinds of solutions used together with characteristic comparative differences in the types of curves produced. In all solutions the most marked initial sensitization appears in tissue stretched by ten gram weight for about one hour duration. Potassium chloride produces marked inhibition when compared with sodium, while calcium chloride brings about contracture which eventually merges into rigor and these factors hasten proportionately comparative fatigue processes.

These results help to substantiate a belief that stretching a muscle involves the liberation of certain amounts of energy which in turn call forth certain metabolic changes. These changes apparently produce stimulating substances, which on further transformation, by stretching yield toxic properties. Further, these inner changes can be markedly modified by environmental conditions, a point of wide significance in making physiological interpretations.

EXPLANATION OF FIGURES

The series of curves in each of these figures was selected after eight to twenty-five had been made under exactly the same conditions. Hence each is considered typical for a given set of conditions. The muscle of each of the series 1 to 11, was stimulated before stretching in order to see that everything was in proper working order. The kymograph was then stopped, the electrical wires disconnected and the desired weight applied on the longer lever arm at an equal distance from the fulcrum as the end of the short lever arm. Thus the muscle was stretched without removing it from the chamber in which it was immersed. After the proper time interval for stretching had transpired the weight was removed, the kymograph started and the necessary electrical connections made, otherwise there were no adjustments except in special cases which are subsequently explained. An eight volt tetanizing electrical current was used for stimulating.

Figure 1. This is a series of curves of the intestine and body wall of the earthworm, stimulated in normal sodium chloride solution without stretching. Observe the gradual relaxation or loss of tonus. After the fortieth stimulus the progressive effects of .12 per cent amyl alcohol are shown.

Figure 2. Typical normal curves are shown in the first few contractions followed by a stretch of ten grams for ten minutes during which time the kymograph was stopped. Observe the increased height after stretching. The amount of stimulus remains constant.

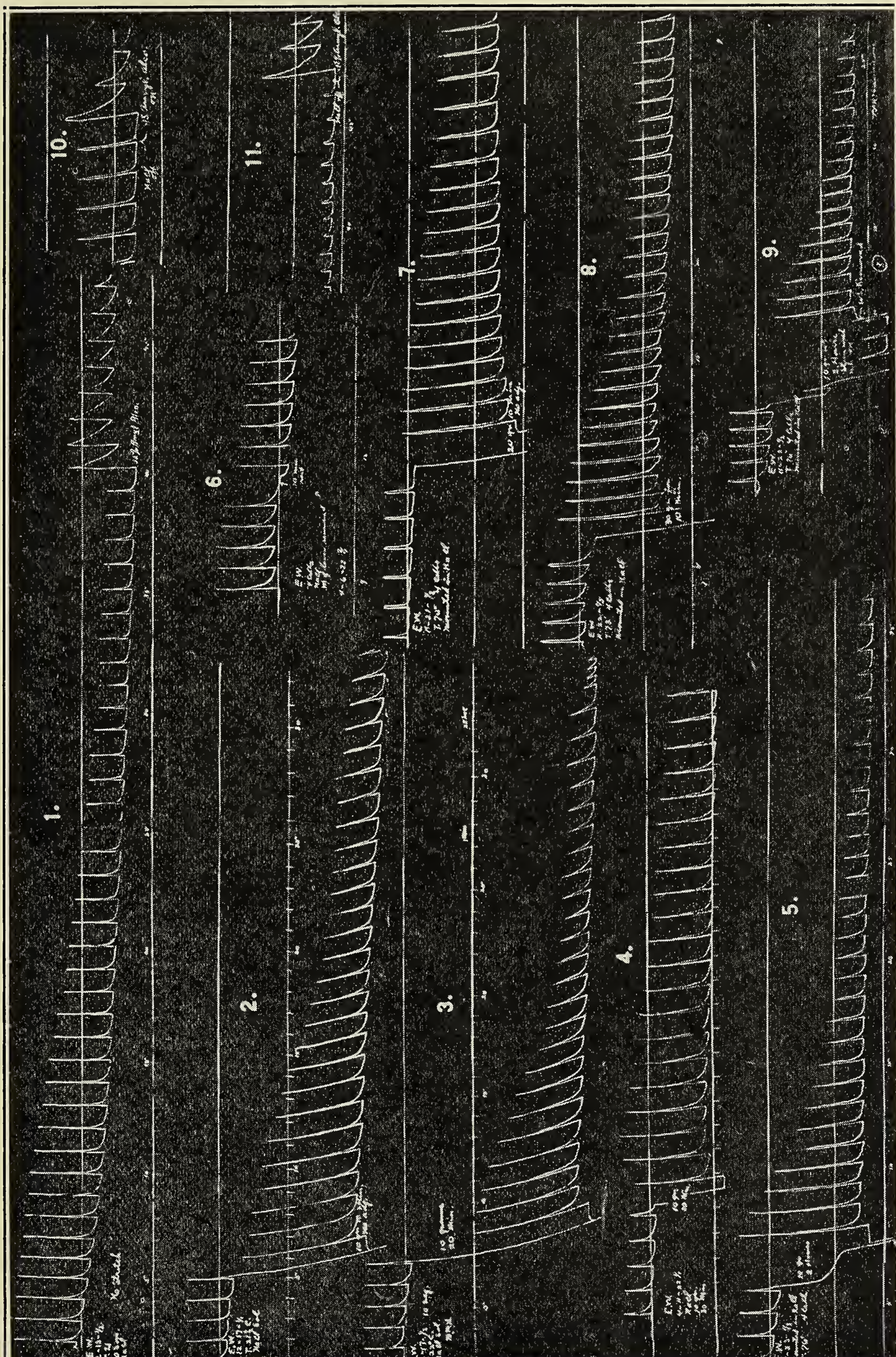
Figure 3. Curves similar to figure 2 excepting the stretch was for twice the length of time. The onset of fatigue came much more abruptly. After the thirty-second stimulus, the stimuli were made every twenty-five seconds. Observe that the extent of contraction is about one-half of the former.

Figure 4. Similar to 2 and 3 only here the length of stretch is for thirty minutes. The onset and progressive effects of fatigue are observed in a slight degree.

Figure 5. The stretching here continued for two hours but the initial contraction afterward is about the same as after the ten minute stretch. The onset and progressive effects of fatigue, however, are much more marked.

Figure 6. This series was made as a check on series number 2. After the first few contractions a rest of ten minutes occurred with no weight applied. The resulting curves when compared with those of figure 2 show that the time interval alone is not responsible for the increased contractions but, that these were due to the stretching.

Figures 7 and 8. Typical curves where muscles were stretched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with twenty and thirty grams respectively for ten minutes, which show when compared with 3 and 4 that where the minute-gram unit is constant the sensitizing effect produced is practically the same.

Figure 9. The muscle in this case was first stimulated after stretching without removing the ten gram weight, which counteracted the sensitizing properties so that when the weights were removed and the muscle was then stimulated the contractions were much lower. Compare with figure 5. The tissues used in 5 and 9 were taken from the same specimen.

Figures 10 and 11. These are continuations of figures 7 and 9, respectively, the latter being almost completely exhausted. Each was treated with 0.18 per cent amyl alcohol. The curves show its progressive effects.

The muscles in each of the series 12 to 31 were stimulated with a six volt current every twenty seconds. In figures 12 to 16, the muscles were immersed in normal sodium chloride, in 17 to 26, in normal potassium chloride and in 27 to 31 in normal calcium chloride. In each case where stretching occurred the weight was removed before the muscle was stimulated.

Figure 12. A typical normal series obtained after mounting and stimulating without stretching.

Figure 13. Similar to 12 except that the muscle was stretched with a ten gram weight for ten minutes. The onset and progressive effects of fatigue are indicated by the rapid decrease in the heights of contraction.

Figure 14. The muscle in this case was stretched with a ten gram weight for twenty minutes, and is to be compared with 12 and 13. The sensitization of the muscle is indicated by its increased and sustained contractions.

Figure 15. In this case the ten gram weight was applied for one hour. The sustained heights of the contractions which immediately followed indicate the maximum sensitization of the muscle. The tissues used in 14 and 15 were taken from the same specimen.

Figure 16. The ten gram weight was applied in this case for three hours. The rapid decrease in the height of contraction and its early depletion indicate the progressive effects of fatigue.

Figure 17. This shows a typical series when immersed in normal potassium chloride without stretching.

Figure 18. A series made from a muscle treated the same as

17 except it was stretched with a ten gram weight for ten minutes before being stimulated.

Figures 19, 20 and 21. These are series treated the same as 18 except that the ten gram weight stretched the muscles for twenty minutes, one hour and fifteen minutes, and three hours, respectively. When compared with the corresponding sodium chloride series, 14, 15 and 16, they show the inhibiting effects of potassium chloride on the contraction of the tissues.

Figures 22 and 23. The former is a record of an unstretched muscle in normal potassium chloride while the latter is comparable with it. The only difference is that in 23 a twenty gram weight was applied for ten minutes. Figures 23 and 18 are also similar, the only difference being that the former was stretched with twice the amount of weight as the latter. The greater sensitization is much more apparent where the stretch was greater.

Figures 24, 25 and 26. These series are comparable to 19, 20 and 21, respectively, differing only in being stretched with twice the amount of weight. The onset of fatigue is sooner and its progressive effects are more pronounced where the greater weight is used.

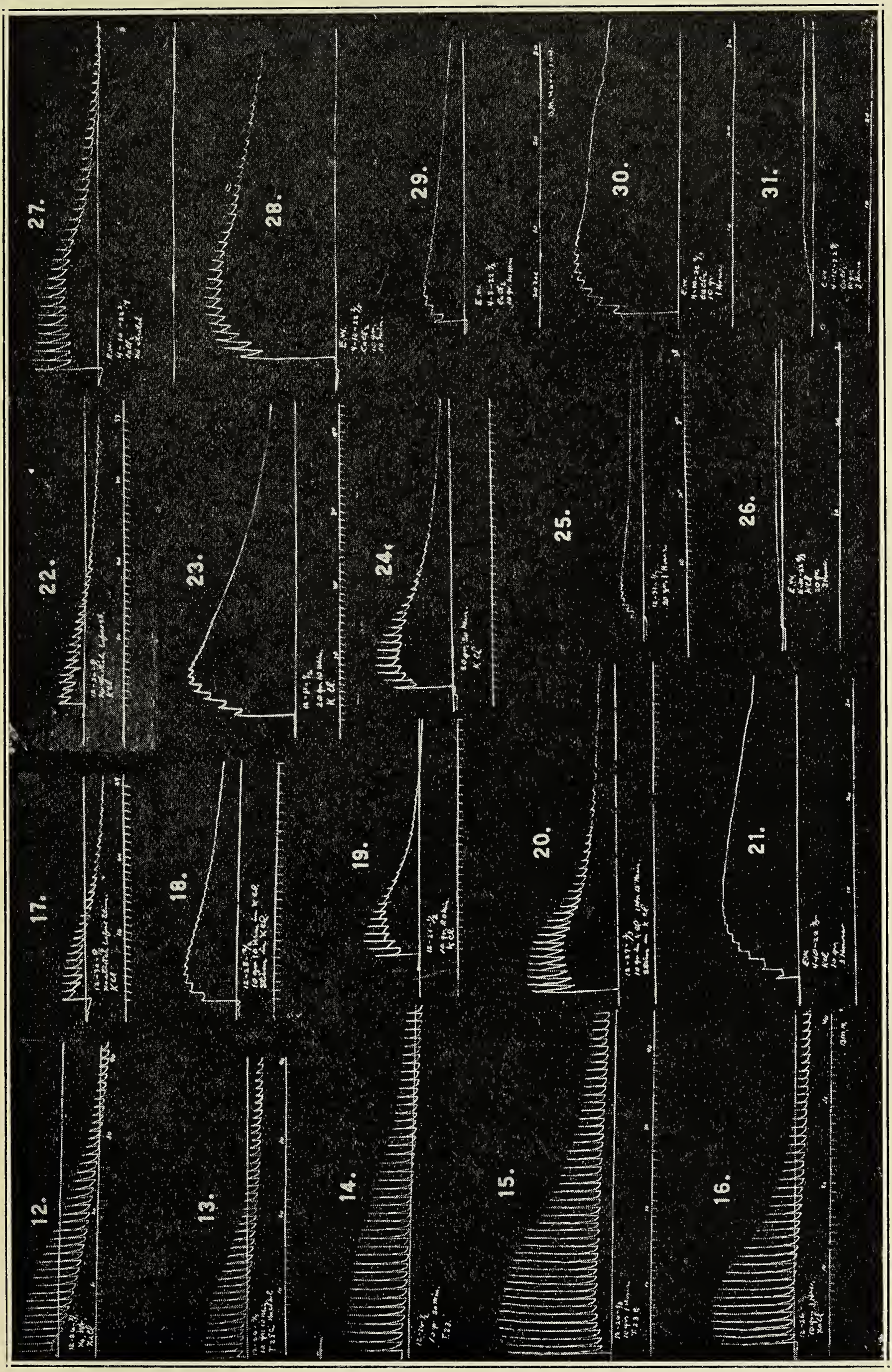
Figure 27. In this series normal calcium chloride was used and the series is comparable to 12, 17 and 22. The initial contraction is much greater, showing that the process of sensitization has taken place more quickly.

Figures 28, 29, 30 and 31. This series is similar to 27 and comparable with series 13, 14, 15 and 16, respectively, and also with 18, 19, 20 and 21, respectively. The only difference in the treatment is in the kind of solution in which the tissues were immersed.

BIBLIOGRAPHY

1. Buddington, R. A., '02, Am. Jour. Phys., Vol. VII, page 155.
2. Eddy & Downs, '21, Am. Jour. Phys., Vol. LVI, page 182.
3. Harrison, B. M., and Baldwin, F. M., Proceedings of the Iowa Academy of Science, Vol. 28.
4. Harrison, B. M., '23, Science Jan. 19, page 87.

Department of Zoology and Entomology,
Iowa State College.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OBSERVATIONS ON THE HABITS OF A TARANTULA[1] IN CAPTIVITY

ALBERT HARTZELL

On July 17, 1920, Mr. Robert Clark of Gilbert, Iowa, presented the writer with a live female tarantula which he found in a bunch of bananas in his grocery store. He believed that the specimen must have been in hiding for several weeks prior to its capture as it was not observed until the last bananas were removed. A battery jar, with sand in the bottom, in the writer's home, served as a cage for the fifteen months the creature remained in captivity.

As the tarantula refused to feed on dead insects the task of finding suitable live food became quite a problem during certain seasons when insects were scarce. Flies and grasshoppers were first introduced and disappeared in a short time owing to the starved condition of the predator. Usually the tarantula would wait until the attendant had left the vicinity of the cage before pouncing upon its victim but when driven by hunger it would boldly seize it. In one instance a large Schistocerca grasshopper was eaten completely within four minutes after it was introduced. The tarantula inserted its chelicera between the thorax and abdomen while the legs were used to prevent the grasshopper from getting away. At another time a luna moth was introduced and eaten in a few minutes. Earthworms proved so distasteful to the individual that it forced the cover from the top of its cage and made its escape. After a diligent search the creature was found crawling between the writing desk and the wall and with very little coaxing was induced to return to its cage.

In this connection the writer wishes to state that the tarantula never attempted to jump at or bite its attendants. Care was taken in handling so as to move deliberately, as nervous, hesitating motions caused it to become excited and irritable. No one was permitted to tease or annoy it.

Beginning with the first week of August, 1920, a careful study of its feeding habits was made. The notes were taken daily but are presented here in tabular form by weeks. Only insects ac-

1 Species not determined.

tually eaten are recorded. As shown in Tables I and II, crickets and grasshoppers constituted the main diet. This preference was noted early in the study and so far as possible they were supplied.

TABLE I. NUMBER OF INSECTS EATEN EACH WEEK BY TARANTULA, AMES, IOWA, 1920

Insects	August				September				October			
Crickets	7	7	6								1	
Grasshoppers	2	8	5							1	4	
Moths		1	2							1	1	
Caterpillars	2	2										
Beetles	2		2									
Flies	1	1										

On August 21, 1920, the tarantula refused to eat and became inactive at the bottom of the cage. Strands of silk forming a loosely constructed web were observed August 25. It remained in a dormant condition beneath the web until October 6, for a period of forty-six days, when it moulted. The moulting process was not observed but after the moult the specimen was much larger, more active and of a darker color. It continued to feed until the middle of October when it became inactive. During the winter the tarantula refused to eat and would move only when disturbed. The cage was kept in the house so that the temperature never reached freezing.

By the middle of March, 1921, the tarantula became active and continued feeding until May 22.

TABLE II. NUMBER OF INSECTS EATEN EACH WEEK BY TARANTULA, AMES, IOWA, 1921

Insects	May				June				July				August				September			
Crickets			5	1						2	9	6	4	6	6	8	4	5	2	3
Grasshoppers	1	1							3	2		4					2	2		3
Moths		3															2		2	
Caterpillars	1																			
Beetles																			1	1
Flies	2																			

It refused to eat for more than a month as indicated by the blank spaces in the above table. On June 3 it moulted the second time. The act of moulting was not observed. The cast skin, entangled with strands of silk, was left in perfect condition. The dorsal portion of the cephalothorax was removed in one piece and was still clinging to the claw of the right hind leg that had torn it from its place to allow the body of the individual to leave the exuvia. After this moult the specimen measured 55 mm. from the distal end of the chelicera to the tip of the abdomen and 24 mm. at the widest portion of the cephalothorax. Feeding was resumed until September 27, when it became dormant.

On several occasions the tarantula was taken from its cage and given opportunity to move about in order to observe its movements. It would invariably seek a dark place as under a leaf or behind an object, which demonstrated that it was negative phototrophic.

The possibility of an escaped tarantula finding a suitable place to spend the winter in the latitude of Iowa is rather remote. An unexpected freeze during the second week of November, 1921, unfortunately caused the death of this individual.

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OBSERVATIONS ON THE CRANIAL NERVES OF CERTAIN GANOIDS

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The forms considered are Amia and Lepidosteus (Holostei), and Polyodon and Scaphirhynchus (Chondrostei). The cranial nerves of these forms bear very obvious relations to the degree of development of certain external sense organs. That Amia and Lepidosteus are teleost-like in their nerve relations accords with the common view of their relationships in general; Polyodon and Scaphirhynchus on the other hand show in their cranial nerves elasmobranch relations.

An outstanding feature of the nervous system of Amia is the presence in the skin of the head of an enormous number of "terminal buds." These necessitate a correspondingly exaggerated nerve supply. The visceral sensory elements supplying these externally situated sense organs come from the facial, glossopharyngeal and vagus nerves. To reach their destination in the skin these nerve fibers for the most part appropriate nerve trunks and branches already existing rather than develop new pathways. The ramus palatinus VII of Amia probably carries more of these taste-bud fibers to the skin than all the other cranial nerves combined. But we know that the ramus palatinus is a visceral sensory nerve and ordinarily has no relations with the skin. In Amia the ramus palatinus reaches its cutaneous distribution through the mandibular and maxillary rami of the trigeminal nerve and the buccal, superficial ophthalmic and otic rami of the facial nerve. The supratemporal branches of the glossopharyngeal and vagus nerves, usually lateral line exclusively, also carry taste-bud fibers. These latter branches anastomosing with the ramus oticus produce that which Allis calls a "closed circuit." This condition in Amia can hardly be considered as primitive or typical, and the assumption that the trigeminal nerve fundamentally contains visceral sensory fibers is unwarranted.

In Lepidosteus there are fewer cutaneous taste-buds, consequently the ramus palatinus VII and other visceral sensory branches of the cranial nerves sending fibers to the skin are smaller. But the relations are fundamentally the same as in

Amia. The arrangement and innervation of the lateral line sense organs (canal organs and pit organs) in Amia and Lepidosteus are almost identical, allowing for the much elongated body of the latter. The gular series of pit organs in Amia is, however, lacking in Lepidosteus. The most striking difference between the cranial nerves of the two species is the total lack of a ramus mandibularis internus in the facial nerve of Lepidosteus.

In Polyodon we see an enormous development of lateral line sense organs, chiefly on the exaggerated rostrum and the elongated gill-cover. The so-called "primitive-pores" of Polyodon are certainly sense organs, and supplied by lateral line fibers of the seventh, ninth and tenth nerves, chiefly from the seventh, possibly exclusively so. Whether the primitive pores correspond to pit organs or to the ampullae of Lorenzini of the elasmobranchs the writer does not as yet have any decided opinion. The medulla oblongata of Polyodon possesses a large lateral line lobe into which enters the greater part of the lateral line elements of the seventh nerve. This lobe is an elasmobranch character and is lacking in Amia and Lepidosteus. Another elasmobranch character in Polyodon is the sharp distinction between the branches of the trigeminal and facial nerves. There is never any anastomosing between these nerves, such as is seen in Amia and Lepidosteus. Taste-buds are few and found externally only in the region of the mouth (Allis). The anterior extension of the ramus palatinus facialis is small, almost rudimentary. The rudimentary barbels are supplied by vestigial twigs from the ramus palatinus VII and the ramus maxillaris V, but no sense organs of any kind have been found on the barbels.

It would seem that there should never have been any doubt that the "primitive pores" of Polyodon are strictly comparable to the "nerve sacs" of the sturgeons. They are similar structures, parts of the lateral line system. In the true sturgeons, however, the lateral line organs are not so extensively developed as in Polyodon, and the nerve sacs are more aggregated than the primitive pores. In Scaphirhynchus (and in Acipenser, presumably) there is a great development of taste-buds. These, however, are not generally distributed in the skin, as in Amia and Lepidosteus, but occur in great abundance on the two pairs of barbels and the oral fringes. In consequence the trigeminal and facial nerves are as sharply distinct as in Polyodon, only certain peripheral parts of the ramus palatinus VII and the ramus maxillaris V uniting to supply the barbels.

General cutaneous components occur in the tenth and possibly the seventh nerves of Polyodon and Scaphirhynchus, but not in such relatively large amounts as in Amia and Polyodon.

On the basis of the origin, composition and distribution of the cranial nerves the Holostei are sharply distinct from the Chondrostei, supporting in this way the more general conclusions of comparative anatomy.

This paper is intended as a preliminary report, to be followed by a more extended account with ample illustrations, in which the related literature will be discussed, especially the agreements and disagreements with the classic accounts and discussions of the ganoid fishes by Allis.

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SOME NOTES ON *EMPOASCA FLAVESCENS* FABRICIUS

(*HOMOPTERA, CICADELLIDAE*)

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In the fall of 1910 my attention was called to the abundance of this leaf-hopper on certain trees of *Ptelea trifoliata* on the Iowa State College campus at Ames. Some notes on the insect were made that fall and also in the two years following. Practically nothing has been known concerning the life history of this insect; hence this paper. The notes are from the files of the entomological section of the Iowa Agricultural Experiment Station.

In order to obtain an authoritative identification, adults were submitted to Professor C. P. Gillette, Colorado Agricultural College, who kindly determined these as *Empoasca flavescens* Fabr.

LIFE HISTORY

Hibernation. — This insect evidently hibernates as the adult, as indicated by Forbes (1900). October 29, 1910, I found adults among dead leaves around trees that previously were badly infested. Adults were not found in the early spring at Ames; Forbes, however, records them as early as April 20, in Illinois. Hawley (1918) reports adults in May in New York state, indicating hibernation.

April 21, 1911, a twig of *Ptelea trifoliata* from a tree badly infested the year before, was placed in water in the insectary to determine whether nymphs might hatch from possible eggs in the bark. Neither eggs nor nymphs were found. It was thought that eggs may be placed in the bark, as with *Empoa rosae* on apple.

Generations. — The earliest date I have seen the insect on the hop-tree in spring is June 5. Young nymphs and a few adults were found to be rather common on that date, but no eggs. During the summer eggs were found commonly, deposited in the tissue of the leaves. July 10, all stages were present, eggs, nymphs, and adults. Considerable injury was evident. An observation July 25, 1911, seems to indicate that a new generation was then coming on. The species was present mostly in the egg stage, although an occasional adult and a few young nymphs were seen. Again September 7, 1910, all stages were present. They were abundant throughout September and on October 1 most of the insects were in the older nymphal stages. By October 24, practically only the adults were present.

These notes were taken at random and no very definite statement can be made regarding the number of generations. However, there are at least two generations in the latitude of central Iowa. Hawley (1918) reports that in New York state two generations occur, with a probable third generation in dry seasons.

Fig. 1. Surface of leaf, showing egg beneath.

The egg. — The eggs were found in the leaves of the hop-tree and their location was readily observed on the lower surface, apparently having been deposited from that side. The outline of the egg, as seen from the exterior, resembles that of the oyster shell scale, *Lepidosaphes ulmi* L. The eggs themselves are elliptico-cylindrical; white in color. A single egg exposed from the

Fig. 2. Leaf tissue cut away exposing the egg.

pouch measured .83 mm. by .18 mm. Ten egg pouches averaged .93 mm. by .27 mm.

Nymphal stages. — No descriptions were made of the nymphal stages, although these were measured. The following lengths were taken: Stage I, 1.13 mm.; II, 1.62 mm.; III, 1.98 mm.; IV, 2.4 mm.; V, 3.2 mm.

THE INJURY

The injury to the hop-trees consisted in the extraction of sap from the foliage. The upper surface of the leaves was irregularly mottled with many fine areas, paler in color than the rest of the leaf, indicating the necrosis of groups of cells within. There was no curling of the leaves as in the case of injury to apple foliage by *Empoasca mali.* The injury was similar to that caused by *Empoa rosae* to apple foliage. During every year for a period of eight years these leaf-hoppers were abundant on the hop-trees mentioned. By late summer they became so common that they would rise in veritable clouds when one passed by the infested trees.

FOOD PLANTS

Dr. Goding (1890) in describing *Empoasca birdii* (often considered as a variety of *flavescens*) found that species on apple, hop, walnut, beans and "weeds" in Illinois. Van Duzee (1917) lists *birdii* as a distinct species. Forbes (1900) recorded *Empoasca flavescens* from sugar beet. Hawley (1918) collected specimens on plum in New York state. The present record on hop-tree (*Ptelea trifoliata*) is therefore new. At Ames the leaf-hoppers have been literally swarming over the foliage of several of these trees during the summer and fall. A hop-tree at La-Fayette, Indiana, was found well infested with these leaf-hoppers, August 12, 1917, by the writer.

AN EGG PARASITE

In July, 1911, at Ames many parasitized eggs were found. These appeared darker in color than the others. Occasionally the form of a parasitic pupa was determined within an egg pouch and many leaf-hopper eggs had tiny circular holes in them, indicating that a parasite had already emerged. Some of these eggs were cut from the leaves and placed in vials to rear the parasites. Adults emerged during July and these were sent to A. A. Girault, for determination. Mr. Girault identified the species as *Anagrus spiritus* Girault. This species has also been reared from the San

Jose scale, *Aspidiotus perniciosus,* Comstock. Similar parasitized eggs were found by the writer at LaFayette, Indiana.

BIBLIOGRAPHY

1890 Goding, Entom. News 1: 123, Describes **Empoasca birdii.**
1898 Gillette, Clarence P., Proc. U. S. Nat. Mus. 20: 745-746.
1900 Forbes, S. A., 21st Rept. State Entom. Ills. 79.
1914 Slingerland, M. V., and Crosby, C. R., Manual of Fruit Insects, 183.
1918 Hawley, I. M., Cornell Univ. Agr. Exp. Sta. Mem. 15:215.

SIMULTANEOUS FAST AND SLOW DRUM RECORDS OF FATIGUE

INTRODUCTION

FRANCIS MARSH BALDWIN

The essential details of fatigue processes as they develop in a properly prepared protoplasmic system like that of a frog muscle, are conveniently transcribed by the writing lever either upon a kymograph drum revolving comparatively rapidly, or one going very slowly and these records furnish data for subsequent analysis. In each procedure some facts are obtained as to amplitude, enhancing and diminution of responses under a given rate of stimulation and under certain physical and physiological conditions, but unfortunately neither method alone suffices for the proper analysis of the whole process. Although details of mechanical devices differ somewhat in the two methods the muscle is usually mounted in a moist chamber in such a way as to move at each response a counter-poised muscle lever which in turn transcribes its movement upon the surface of the drum.

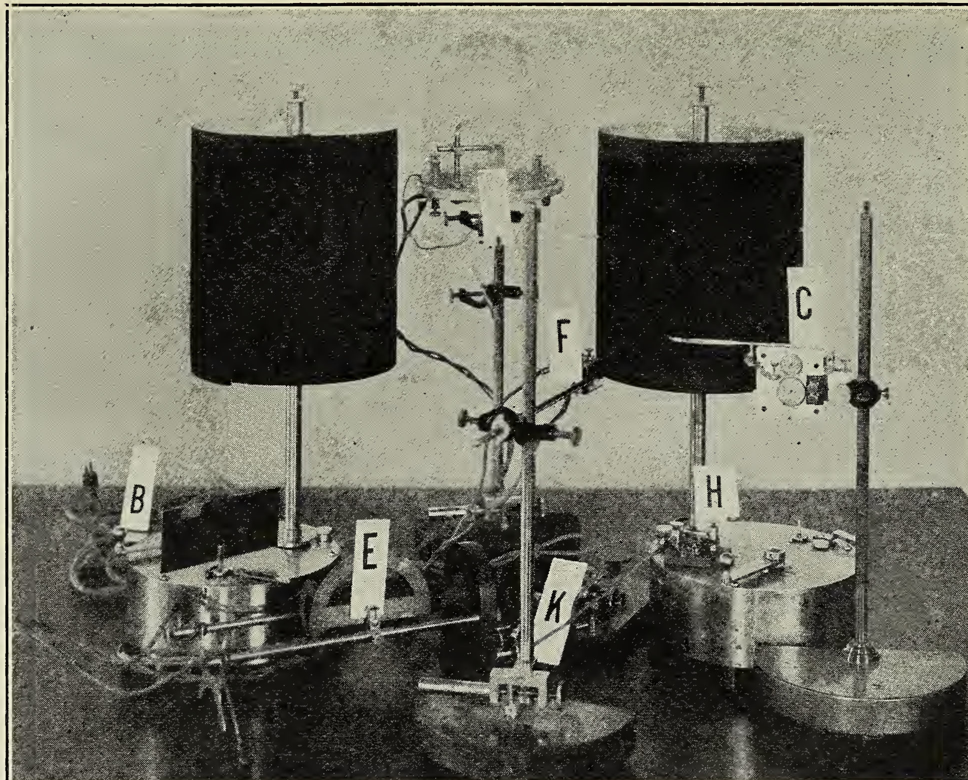
In using the slow drum method, an interrupter of some sort, which is set for a definite rhythm, usually about one stimulus per second, is placed in the primary circuit and a record is obtained under given conditions. Upon analysis by this method records usually give interesting curves whereby the comparative amplitude of successive contraction and relaxation phases of the developing fatigue process are secured. The curves also give evidence of increased contraction in the initial successive excursions with formation of the so-called "treppe" phenomenon and the accompanying production of the so-called primary contracture phase followed almost immediately by the primary relaxation phase merging more or less directly into the secondary contracture. Obviously, however, this method fails to record such comparative duration intervals as are concerned with latency, increments and decrements of irritability, as evidenced by more and more rapid contraction at the outset, followed by a corresponding decrement in the recovery velocity as evidenced in the succeeding relaxation phases. Records involving this method are commonly illustrated and analyzed in some of the many standard texts.[1]

In the rapid drum method several mechanical devices have been used by various investigators, but the one found easily adapted to this end consists of a Harvard type moist chamber in which the muscle is mounted in such a way as to move a light writing lever. The primary circuit is automatically "made" and "broken" by the rapidly revolving drum. This is done by cams rotating upon the drum spindle coming into contact with a circuit breaker (Zimmermann type) mounted upon the clock housing. Obviously upon analysis, records obtained by this method have some advantages over those obtained by the other in that they give valuable data as to the relative amplitudes of responses, and in addition the accompanying rate and duration of various phases of the oncoming process can be found especially when correlated with time intervals as recorded by a chronometer. They have some disadvantages, however, for since the stimuli fall at the same point as the drum rotates, the transcribed lines representing successive responses are more or less superimposed upon one another with consequent masking, especially in the contraction phase. In some cases this masking of individual responses is more serious than in others, due no doubt to differences in rate of metabolic reorganization, and when this is true it renders the record by this method difficult to analyze. Another objection is that the crest and trough representing any one cycle of responses are so far removed from one another, due to the rapid rotation of the drum, that indexes of such important phases as primary contracture or relaxation are impossible to accurately ascertain. Curves illustrating this mode of procedure are found quite generally, especially in the English texts.[2]

With such considerations in mind it seems desirable to combine the two classical procedures and obtain simultaneously records by both methods using the same irritable tissue. Especially such a procedure is of value in demonstration where by careful observation and notation the details in one can be made to supplement the other at critical points. By such a method also difficulties from the comparative analysis of the various phases are obviated since the same muscle produces them simultaneously in both.

1 See Howell, Textbook of Physiology, 7th ed., pp. 33-34, 1919; also Brubaker, Textbook of Physiology, 4th ed., pp. 70-71, 1912.

2 See especially Schafer, Textbook of Physiology, V. 2, 1900, p. 388; fig. 216; Starling, Principles of Human Physiology, 1912, p. 234; Halliburton, Handbook of Physiology, 1920, p. 98.



Details of the mechanism adapted for making simultaneous fast and slow drum records of fatigue. The muscle is mounted in the moist chamber and stimulated by interrupted current from wire B through contact breaker H.

EXPERIMENTAL

The mechanism to this end (Plate I), aside from the customary relative adjustments and positions of the various parts, is in its essential details rather simple and is adapted to any laboratory with little trouble. A muscle lever of the Harvard type is provided with two aluminum rods instead of one. These are curved away from their support in such a way that their distal ends each form an arc of a quadrant. Thus their writing tips may be brought into contact with their respective drums. By slight adjustments both points can be made to rub lightly upon the drums which by previous preliminary trials have been fixed to rotate at definite relative speeds. The fast type, in records soon to be discussed, was set for one revolution in four seconds, while the slow type was made to revolve once in an hour. The muscle received its successive stimuli by the automatic contact interrupter mounted upon the fast drum housing. By the use of this mechanism, comparable records are obtained in which it is possible to follow excursion after excursion of the writing points throughout the entire fatigue process. By mounting signal magnets and chronometer in proper position checks on time of stimulation and relative duration of any phase or groups of phases can be made and subsequently analyzed. By count of actual excursions of the lever or by interposing simple signal devices any response can be located at will, thus, for example, in typical records B and B′, the one, two or three hundredth responses are located definitely on each curve.

In attempting to analyze fatigue curves by either method, one is forcefully impressed with the fact that there are characteristically at least two types to be found, and possibly inter-gradations which when analyzed resemble in certain of their features one or the other of these. One of these extremes is illustrated by curve G and the other curve by A′ in Plate II. Among the chief points of difference in these, obviously, are differences in first and secondary contracture, and primary relaxation, the former exhibiting all three phases to a marked degree, the latter comparatively lacking them all. Why this should be is a matter of interesting speculation. From the physiological standpoint the phenomenon of contracture, when compared with that of a simple contraction indicates the possibility that two different contraction processes may take place in an irritable muscle, one involving the so-called state of tone and therefore the length and hardness of the muscle at all times, the other concerned with the actual production of work. Such suggestion has been made by several workers (Uexkull, Guenther, et al.)[3] on various grounds. Indeed it seems reasonable to believe as has been suggested by some, that there are two different contractile substances in muscle, one giving the usual quick "twitch," the other the slower contraction, which exhibits itself as tone or contracture.[4] Assuming that there are two different contractile substances in the muscle it seems logical to infer that when the stimuli actively or excessively irritate the tonic substance at the same time with the activation of the contractile substance, the successive responses would be accompanied by gradual shortening, as indicated by the first type of curve, and on the other hand when the reverse condition prevails, that is to say when the stimuli affect slightly or not at all this peculiar tonic substance, the second type of curve would result. Doubtless between these two extremes, there are ranges of specific irritability in each substance so that when compounded in various ratios under a given rate of stimulation and possibly under differences in metabolic condition prevailing in the muscle they would combine in responses to produce fatigue curves intermediate between the two that have been considered extremely typical. Indeed, during the course of this and previous investigations[5] such intermediate or gradation curves have not been lacking. Just what condition or conditions combine to bring about relative proportional responses in the two substances, or what conditions must be fulfilled in order to predict just what type of fatigue curve will result upon stimulation are as yet questions that need more light thrown upon them. In the light of recent investigations by Loeb, Osterhout and especially Lillie,[6] it seems probable that muscular contraction is only one of the many phases of the general problems in physiology, such as irritability, conductility, stimulation, etc., awaiting solution, and like them is dependent in the ultimate analysis upon an understanding of fundamental physical and chemical changes in membrane permeability.

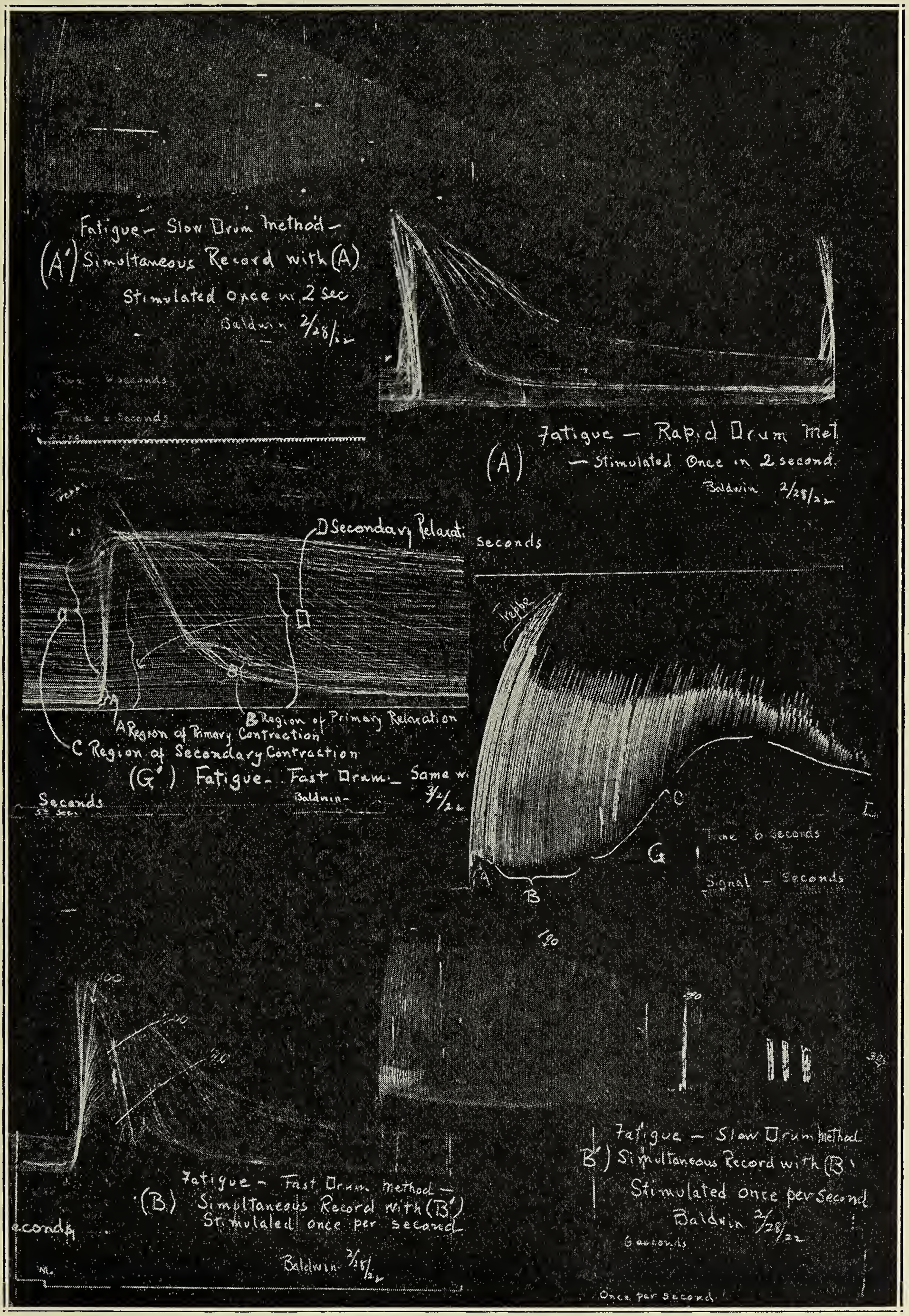
On referring to the simultaneous records B and B′, which represent one of the extreme types of fatigue curves, a number of points are evident by comparison. Upon being stimulated once per second the muscle made in the course of seven minutes about

3 Uexkall, Zentralblatt d. Physiologie, V. 22, p. 33, 1908, also Guenther, Am. Jr. Physiol., V. 14, p. 73, 1905.

4 Iotekyo, Travaux du laboratoire de Physiologie, Institut Salvay, 5, 25.

5 Baldwin, F. M., Am. Jr. Physiol., Vol. LVI, pp. 127-139, 1921.

6 Lillie, Physiol. Rev., Vol. II, No. 2, p. 1, 1922.



Typical simultaneous curves of fatigue obtained by the use of apparatus shown in Plate I. The significant differences in these curves are discussed elsewhere in this paper

three hundred and fifty responses in undergoing fatigue. Both curves show that up to about the one hundredth response, the amplitude in terms of height is not greatly affected and although the first few responses are accompanied by primary contracture subsequent relaxation is remarkably gradual as is shown in the slightly declined margin of B′ and the slight overlapping of relaxing lines in B near the base. One of the most valuable facts in comparison is brought out in connection with relative duration of the different phases. From the curve B′ one would be led to believe that successive responses following the one hundredth were being executed in about the same interval of time as those immediately preceding. On comparison with B, however, such is found not to be the case. Successive contractions here are shown to be more and more slowly produced, and in addition a very marked slowing of the successive relaxation phases. Although, of course, it is difficult to be exact because of comparative differences in various muscles it seems reasonable to assert that comparatively speaking the successive contraction responses vary from one another by intervals of .001 second in this range between the 100th to the 200th response, while the relaxation phase certainly is retarded by as much as .01 second. Beyond this up to perhaps the 300th response, the contraction response time increases until it takes a total of at least 0.2 second, while the relaxation phase is retarded so that at the end of this interval it consumes at least .08 second. Secondary contracture can best be recorded by the slow drum method, as also can secondary relaxation. These two phases develop in the record under consideration between the 100th and the 200th responses, and between the 200th and the 300th responses, respectively. In the fast drum record B and the comparable slow record B′ these phases make themselves evident as a respective rise and fall of the curves near the stimulation take-off of contraction, and as can be seen, neither are clearly defined. On the other hand, latency is not evidenced by the slow drum. By the fast method under favorable conditions and care of mechanical adjustments latency can easily be calculated as ranging in the initial responses between .004 to .005 second, and gradually this interval increases as fatigue develops so that toward the end it may be as much as 0.02 to 0.04 second, depending upon temperature, load and osmotic conditions.

Curves G and G′ represent another extreme type characterized by marked secondary contracture with equally marked secondary relaxation. The muscle is stimulated at the same rate as before (once per second) and is practically fatigued in about the same time (seven minutes). Primary contracture is certainly accompanied by treppe in both methods during the first few responses as indicated at A. That relaxation is increased in its rate immediately following the first five or six strokes is evident by the overlapping of tracing lines G′ and B. The fact that this is true expresses itself in G by the successive dropping of the lower contour of successive tracing at B. Both curves give index to the rapid onset of secondary contracture during the progress of the interval labeled C, and this is soon followed by a reversal, indicated in both curves by D. On comparing curves B and G′ it is seen that they are as characteristically different in form and content, as are their simultaneous counterparts B′ and G.

The effect of varying the rate of stimulation on the development of fatigue has of course been known for a long time. Somewhat rapid stimulation results in the production of tetanus, while stimulation at a slower rate than once in four or five seconds postpones indefinitely the onset of typical fatigue phenomena. With this in mind curves A and A′ were obtained where the stimulation was set at once in two seconds. It is seen that under this rate curves result which are fairly comparable to B and B′, which were produced by a slightly faster rate (see B and B′). The treppe phenomenon is possibly more marked, primary relaxation is perhaps less so. The total time interval is perhaps a little prolonged, consuming about nine minutes to complete, but in other respects no great differences are noted.

SUMMARY

By making simple adaptations of laboratory apparatus a method is described whereby both fast and slow drum types of fatigue records can be produced simultaneously. Such a procedure is of especial value in demonstrations before classes of students who in their general physiological course are expected to obtain records of fatigue and make proper interpretations of such records, together with a reasonable amount of the theoretical implications of such phenomena.

By the use of one muscle to transcribe both records comparable stages in the progress of fatigue processes are located on each, thus amplitude and duration of responses as well as phases of latency, contracture and relaxation are obtainable.

Different extreme types of fatigue records are noted, with

possible gradations between the extremes, and these may possibly be explained upon the basis of differences of irritability and responsiveness of the "tonic" and "contractile" substances in the muscle.

By the use of the chronometer relative duration times of the various phases are easily calculated in terms of the fast drum method. From data taken, for example, latency, contracture and relaxation lie roughly between 0.005 and 0.02; 0.04 and 0.2; and 0.02 and 1.0 second, respectively.

By proper signal device count can be kept and any response can be located at will, on curves by either method.

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NOTES ON SOME OF THE RARER BIRDS OF THE AMES REGION

H. E. EWING

While the writer was living at Ames during several past years he took various notes on birds observed in that vicinity. During the years 1917, 1918, 1919 and 1920, regular excursions were taken, sometimes alone, sometimes accompanied with other bird enthusiasts and sometimes with his college students in bird study. It was only during the year 1919 that the writer taught the course in bird study for the Department of Zoology at the Iowa State College. While this course was taught by Professor H. A. Scullen and later by Professor J. E. Guthrie, the writer frequently accompanied the classes on field trips.

The area to which these notes pertain (with a few exceptions) includes a radius of about two miles around the college. In this radius are found cultivated fields, pastures, feed lots, woodlands, Squaw creek and a few of its tributaries, the college lake, a few ponds and smaller but permanent pools. The native trees are practically all deciduous, but on the plots of the Forestry Department there is a splendid growth of conifers. Some of these conifers are small, yet others are trees of a height ranging from fifteen to twenty-five feet. The writer has noticed some distinct changes in the bird life due to the recent growth of these conifers and those of the college campus not far distant which are much older and higher.

Included with the writer's records here given are some taken by Professor Guthrie, some by Professor Scullen and some by Mrs. Ewing. Those taken by Professor Guthrie are initialed (J. E. G.), by Professor Scullen (H. A. S.), while those taken by Mrs. Ewing and based upon her determination are initialed (B. R. E.). All records not followed by initials in parenthesis, or accredited to individuals named, are by the writer, and represent his own observations and determinations. Records by accompanying observers are not included in these notes unless given as an additional record, in which the observation was not the writer's.

The species treated are arranged into three lists: First, species supposed by many to be rare but in reality common at

Ames; second, species rare at Ames, *i. e.* either never seen in numbers or not seen at all during certain years; third, species doubtfully accredited to the Ames Region.

SPECIES COMMON AT AMES BUT SUPPOSED BY SOME TO BE RARE

Belted Kingfisher
(*Ceryle alcyon*)

Kingfishers are present along the creeks about Ames every year, not in large numbers, for the habits of the bird are such that usually only a single pair is found at one place. They are frequently not observed by students in the college bird classes.

Barn Swallow
(*Hirundo erythrogaster*)

Every year the writer was at Ames, barn swallows were observed in numbers along Squaw creek north of the campus in the vicinity of the concrete bridge. Since the artificial lake has been constructed on the college campus, barn swallows have been found occasionally skimming over the surface of its waters.

Rough-winged Swallow
(*Stelgidopteryx serripennis*)

By far the most common swallow about the college campus is the rough-winged swallow, which can nearly always be found during the late spring and summer circling about the old gravel pit between the campus and the North Western tracks. This species is usually confused with its near relative the bank swallow (*Riparia riparia*) which also is found at Ames.

Cedar Waxwing
(*Bombycilla cedrorum*)

Almost every winter some excited person would rush up to the writer and in interrupted speech announce that some new birds were on the campus or that the waxwings had come. The cedar waxwing is one of our common birds at Ames as the following records show. Individuals seen as follows: 4, May 20, 1917; 45 (on the college campus), February 27, 1918; 12, March 17, 1918; 32, March 24, 1918; 8, March 31, 1918; 17, April 7, 1918; 4, June 2, 1918; 2, May 25, 1919; 4, May 29, 1920. These records are only the ones taken on regular field trips. The bird was so common that other records were not deemed sufficiently important to be put down.

SPECIES RELATIVELY RARE AT AMES

Pied-billed Grebe
(*Podilymbus podiceps*)

This grebe was not observed at Ames by the writer, and no records were brought to his notice until the artificial lake was made on the college campus. Since then the grebe has been seen probably every year. In 1921 Professor Guthrie had one as a captive for about two weeks. He writes as follows concerning it: "It was a very interesting specimen and caused more laughter than anything else we have ever had here. Its methods of walking reminded one of the first attempts of a young child. It would go faster and faster on these cement floors of Science Hall until finally it would slide into the corner on its breast."

Mallard
(*Anas platyrhynchos*)

During the writer's stay at Ames the mallard was not observed by him to light in the two mile radius of the college campus. On October 21, 1917, a flock of twenty-two was observed in flight overhead. A few miles south of Ames near Kelly the mallard is common during wet migration seasons. Five were observed here October 17, 1919. A few miles east of Ames also the mallard is found during migration.

Blue-winged Teal
(*Querquedula discors*)

While at Ames the writer flushed a blue-winged teal from the old gravel pit north of the campus. As soon as the bird was flushed I dropped to the ground on the bank and remained very quiet. The teal circled around and around for probably five minutes then with a lightning swoop it shot down to the very spot on the water from which it had sprung. In this position I viewed it at my leisure and to the very best of advantage. The teals are among the strongest of wing of all our ducks. Since the college lake was established the blue-wing has taken advantage of it.

Scaup Ducks
(*Marila marila* and *M. affinis*)

No records were obtained of the scaups stopping within the two mile radius previous to the construction of the college lake, although it is probable that some had alighted on Squaw creek. During the spring of 1918 scaups were seen for several days on the campus lake. The writer has a record of two seen on April 28, 1918. Professor Guthrie reported seeing these two for several days, and has recently written the writer that the scaups have returned again to the lake. Whether the species was the greater or the lesser scaup was not determined. Such a determination seemed to defy all attempts.

Least Sandpiper

(*Pisobia minutilla*)

Professor Guthrie observed a pair of least sandpipers in the spring of 1921, and states that he watched them for an hour or more close at hand.

Solitary Sandpiper

(*Helodromas solitarius solitarius*)

This sandpiper is probably more common at Ames than is usually supposed, but is very frequently confused with the spotted sandpiper. Records as follows: 1, May 24, 1917; 1, May 27, 1917; 1, May 30, 1917; 1, spring of 1921 (J. E. G.).

Bob-white

(*Colinus virginianus virginianus*)

The only place near the college where the writer has found the bob-white is just south of town near the country club. Here for several years a few bob-whites were found. During the spring of 1917 the writer heard them several times but never saw more than a few individuals at one time. In the last two or three years bob-whites have increased at Ames according to Professor Guthrie who states: "We flushed several coveys of half a dozen or more last year (1921) in the north woods." The fall of 1921 was one of almost unprecedented abundance of several kinds of game birds over much of the United States. This was particularly true of the quail. The writer never saw anything like the abundance of quail in his life as was seen in Mississippi, Louisiana and Texas in the month of October. This abundance was attributed in part to recent legislation in various states increasing the protection of quail, but was probably due more to the very mild and favorable season for the rearing of the brood.

Sharp-shinned Hawk

(*Accipiter velox*)

Seen once by Professor Guthrie who observed one individual from the Zoology Laboratory window. The bird had perched in a willow near the Veterinary Buildings. This specimen remained on the same limb for about two hours.

Sparrow Hawk

(*Falco sparverius sparverius*)

Common in Iowa but, strange to say, the sparrow hawk does not appear to be common at Ames. It was reported twice. One was seen April 28, 1918 (B. R. E.) and a pair was observed April 6, 1919.

Barn Owl

(*Aluco pratincola*)

The writer obtained no record for the barn owl. They were observed, however, in the larch grove in 1921 (J. E. G.).

Long-eared Owl

(*Asio wilsonianus*)

The only evidence of the presence of this owl at Ames was obtained by Professor Guthrie who found the feathers of one under a tree which evidently was the haunt of a barred owl.

Short-eared Owl

(*Asio flammeus*)

Short-eared owls were observed flying about during the fall of 1921, according to Professor Guthrie, who states that one was shot near the dairy farm. This specimen is now in the college museum.

Barred Owl

(*Strix varia varia*)

Although this species is very common in parts of Iowa only a single questionable record for this large predator was obtained. During the latter part of April, 1919, several persons reported the seeing of a large owl. On April 25, 1919, Dr. Fenton, of the Zoology Department, reported seeing an owl "larger than a crow." Judging from the description he gave, this owl must have been the barred owl.

Ruby-throated Hummingbird

(*Archilochus colubris*)

The abundance of the ruby-throat in any locality is largely dependent upon the prevalence of such nectar-producing flowers as the honeysuckle. Flowers of this kind are not plentiful at Ames, and where they occur they are usually cultivated. Records;

one seen many times around honeysuckle where I roomed during the fall of 1915; one seen June 19, 1918; a male seen May 12, 1920 (B. R. E.).

Arkansas Kingbird

(*Tyrannus verticalis*)

Professor Scullen reported observing the Arkansas kingbird at Ames. It was observed before the year 1919, probably either 1917 or 1918. I know of no other record for this species.

Bobolink

(*Dolichonyx oryzivorus*)

Until recent years the bobolink was observed at Ames. During the period from 1914 to 1920 not a single individual was seen by the writer and no records for it were reported to him. However, he thought he heard one on the college campus May 5, 1918.

Orchard Oriole

(*Icterus spurius*)

Now rare at Ames, although possibly common in former times. The only record the writer has obtained for this oriole is for May 22, 1920, when one was seen at rather close range in the north woods along Squaw creek. In the past Professor Guthrie has obtained several records of the orchard oriole.

Purple Finch

(*Carpodacus purpureus purpureus*)

The purple finch is known at Ames as a transient visitor. A flock of twenty-four was observed May 6, 1917, feeding on the tender buds and bloom of trees along the left bank of Squaw creek. In this flock only three individuals showed the deep purple of postnuptial plumage. One male seen April 12, 1920 (B. R. E.), and a very large flock (two hundred estimated) seen April 19, 1920 (B. R. E.). This flock was observed at the western end of town along the corporation limits. The birds were in the trees and some of them were singing even during an April shower. Most of the individuals lacked the rose purple characteristic of the older males.

White-Winged Crossbill

(*Loxia leucoptera*)

On February 15, 1920, Dr. Charles Murray found a dead male specimen with red plumage and took it to the Zoology Department. Professor Guthrie showed me the specimen and stated that Dr. Murray had seen this one individual with two others for several days before it had died.

Lapland Longspur

(*Calcarius lapponicus lapponicus*)

Seen once and then in large numbers. Several flocks were observed late in the afternoon of February 24, 1918, in the conifers of the Forestry Department. The day was clear, no wind, some snow on the ground, temperature at 6:20 P.M., 49° F.

On February 21, 1919, a specimen in winter plumage was sent in by M. L. Seder from Huron, South Dakota. In his letter Mr. Seder said that all of a sudden the birds had died by the thousands in the town of Huron. The affair caused much comment, and no one at Huron was able to name the bird concerned. The tragedy may have been the result of a storm.

Lark Sparrow

(*Chondestes grammacus grammacus*)

Several records for the lark sparrow have been obtained in recent years, and in 1921 Professor Guthrie found a nest with eggs in it near the college cemetery. Records as follows: 6, May 13, 1917; 3, April 25, 1919. The lark sparrow is one of the most characteristically marked of all sparrows. The white and chestnut pattern of the head and the white-tipped tail taken together at once distinguish it from others. It is a splendid singer.

Harris's Sparrow

(*Zonotrichia querula*)

Both Professor Guthrie and Professor Scullen have observed this sparrow at Ames, Professor Guthrie stating that he has seen it for three different springs. The writer has observed this sparrow but once at Ames. Two individuals were observed in a woods pasture north of town on May 6, 1920.

White-crowned Sparrow

(*Zonotrichia leucophrys leucophrys*)

First seen on May 7, 1919, when two individuals came up under a window of my home. The next year two were seen on May 29 in the woods north of Ames.

Swamp Sparrow

(*Melospiza georgiana*)

One individual observed April 26, 1919, under the willows just north of the president's house on the campus. Other records for the swamp sparrow have been made by other persons at Ames. It is known only as a rather rare transient visitor.

Cardinal

(*Cardinalis cardinalis cardinalis*)

The cardinal has now become firmly established at Ames, although formerly it probably was wanting there. The number of individuals is very small, probably never exceeding a dozen in a single season. But the species is always represented in the Ames region. Records as follows: 2, May 6, 1917; 1 (heard), February 24, 1918; 1 (heard), March 24, 1918; 1, April 18, 1918; 1, February 11, 1919 (B. R. E.); 1 (male), March 9, 1919; 2 (a pair), March 16, 1919; 5, April 20, 1919; 2 (a pair), May 2, 1919; 1, December 28, 1919; 1, May 8, 1920.

The cardinal has never become the tame bird at Ames that it is in much of its more permanent range. In the southeastern part of the country, where the bird is very abundant, individuals will come to the front porches and are frequently found at feeding stations.

Scarlet Tanager

(*Piranga erythromelas*)

The writer first observed the scarlet tanager at Ames on May 17, 1919, when a singing male was located in the top of a neighbor's tree. The next, and only other record was obtained May 16, 1920, when a male was observed in tree tops by the bird class of the college and the writer along the east bank of Squaw creek about a mile north of the college.

Cliff Swallow

(*Petrochelidon lunifrons lunifrons*)

Rare at Ames. One seen April 28, 1918, skimming over the college lake. One seen May 5 of the same year. This brightly marked swallow is easily recognized, if with the fieldglasses it can be followed successfully in its flight.

Bohemian Waxwing

(*Bombycilla garrula*)

Records of the occurrence of this waxwing in numbers at Ames during the months of January and February, 1920, were sent to Bird Lore and were published in the March-April number (page 99). These birds were first observed January 20, feeding in a thorn apple tree a few rods from my home and just outside the western city limits. I counted thirty-seven individuals in the flock this day. The next day the entire flock moved to a wild crab-apple tree less than a block away where they continued to feed for several days, being reported every day from January 28 to February 4. This crab-apple tree was loaded with frozen fruit which when eaten tasted quite tart and was observed to be very mealy.

At times practically the whole flock of waxwings would be in the crab-apple tree and feeding; at other times only a part of the flock would be feeding, while the remainder perched on nearby trees. In their feeding operations the birds worked from the top of the tree downward, and by January 24, all of the crab-apples on the upper part of the tree were gone, having been either eaten or detached and allowed to drop to the ground. As soon as the supply of the fruits on the tree became greatly reduced the birds began to feed on the fallen ones. Eventually the tree was stripped, and not only this but the hungry birds had picked up all the exposed fruits on the snow.

Some of the waxwings were unusually and almost unbelievably tame. They could be approached and almost touched by the hand before flying. This lack of fear of man has been noted by several observers. Could it not be explained by the fact that the birds are reared in the far north, in regions where man is almost if not entirely unknown, hence they have not learned to fear him? And further, their southern sojourn, being very unusual and of short duration has not exposed them sufficiently to man's depredations to teach them wariness. A third factor, that of extreme hunger, also may have been a contributing one; fear under such conditions being counteracted by the craving of food.

Since leaving Ames the waxwings have been reported by others. Professor Guthrie reported one on January 31, 1922. He stated that it was seen for two or three days in the same vicinity and was feeding on rose hips. On February 24, 1922, a flock of twenty to twenty-five were observed, and the next day Professor Cunningham reported a flock of perhaps one hundred feeding on wild apples. A boy is stated to have picked up one of these individuals while it was feeding.

Migrant Shrike

(*Lanius ludovicianus migrans*)

Two were seen July 15, 1917, about two miles north of town. One was seen May 15, 1919, along the street car tracks west of the Chemistry Building. Other records; 1, May 16, 1920; 1, May 22, 1920; 2, May 29, 1920; shrikes nesting, 1920 (J. E. G.).

The migrant shrike was most certainly a rare bird at Ames for a period of several years. However, the discovery of a nest in 1921, indicates that the species may be establishing itself again. That the migrant shrike was formerly a common bird on the campus at Ames is revealed by a contribution to the State Register by the late Professor F. E. L. Beal while he was connected with the college during the period 1879-1883. The following is a quotation from that article which is entitled "The Shrike or Butcher Bird," "Several pairs of these birds nest every year on the ground of the Agricultural College, and this is the only place where we have ever found their nests; nor have we ever seen the birds themselves during the summer in any other place. It is probable that they are attracted to this locality by the abundance of evergreens, for with a single exception, the nests have been built in those trees."

The reasons for the change in the abundance of this bird since the days of Beal are a little hard to surmise. Shelter, food and protection conditions at Ames appear to have been improved for the bird, yet until within the last two years it apparently was entirely wanting from its former haunts.

Audubon's Warbler

(*Dendroica auduboni auduboni*)

A single questionable record for this western warbler was obtained May 30, 1917, by Mrs. Ewing and myself. My notes made at the time read: "The one individual of Audubon's warbler was seen very plainly for several minutes in shrubbery growing along the west bank of Squaw creek. The heavy white band on each wing was especially conspicuous. We noticed the black lower throat, the yellow on the throat proper and at sides of body. We did not see the small yellow patch on top of the head, but did not get a view of bird from above." Since these notes were made I have been inclined to discredit the determination, since no subsequent records were obtained.

Chestnut-sided Warbler

(*Dendroica pennsylvanica*)

The chestnut-sided warbler is seldom seen at Ames. Two records for it were obtained; 1, May 27, 1917, and 1, June 3, 1917. This warbler is said to be a common summer resident in southeastern Minnesota.

Bay-breasted Warbler

(*Dendroica castanea*)

A single record was obtained, three being seen May 27, 1917. This warbler is a common transient visitor only in certain favorably situated places in the northern states. In southeastern Minnesota it is uncommon. Speaking of this warbler Chapman says: "Although close observation will reveal the presence of Bay-breasts during both the spring and fall migrations, they are generally to be classed among the rarer warblers the mere sight of which is stimulating."

Mourning Warbler

(*Oporornis philadelphia*)

The mourning warbler is said by Chapman, "to be a more or less rare bird throughout its range," and according to Brewster there are definite records of but fifteen individuals at Cambridge — this statement being made a number of years ago. It is one of the very latest of our birds to arrive in the spring. The scarcity of records may be in part due to this fact, many observers frequently stopping their migration records before the species arrives. On May 22, 1920, I observed four males in the woods north of town. They were studied at a range of only twenty to thirty feet. The day was "partly cloudy" and there was a strong southwest wind.

Winter Wren

(*Nannus hiemalis hiemalis*)

Some might consider the winter wren a common bird at Ames. Six records are here given for it; 1, April 14, 1915 (B. R. E.); 1, April 15, 1917; 1, April 22, 1917 (B. R. E.); 1, April 21, 1918; 2, March 28, 1919; 2, March 28, 1920 (B. R. E.).

Robin (Albino Specimen)

(*Planesticus migratorius migratorius*)

During the summer of 1916 and 1917 an albino robin nested on the south side of the campus. Several persons reported it to me. Finally on May 27, 1917, I observed this individual and to good advantage. The following are the notes I made at the time: "We obtained several excellent views of it. This individual was not pure white at all, in fact the only white patch in the plumage was one on the rump and base of tail which extended up the back about half way to the neck. The tail had a few white feathers in the middle, and the rest of the bird was mottled by the presence of white feathers, but the natural colors usually predominated."

The fact that the same individual was seen in the same place the year before (1916) is of significance in proving that, in this case at least, a bird may return to the same identical spot to nest from year to year.

SPECIES DOUBTFULLY ACCREDITED TO THE AMES REGION

Rusty Blackbird

(*Euphagus carolinus*)

Reliable records of the occurrence of the rusty blackbird at Ames must exist since the species has been so frequently reported there by amateurs. Such records, however, are not at hand. Most of the records by amateurs are to be questioned as they too frequently refer undoubtedly to either the cow bird or the female redwing. Professor Guthrie states of the rusty blackbird, "I do not believe I have ever seen one alive . . . ." In eastern Iowa the species is said to be fairly common.

Blue Grosbeak

(*Guiraca caerulea caerulea*)

On May 15, 1919, while I was taking my class of bird students on a trip, a bird, thought to be the blue grosbeak, was observed in the woods north of town. Subsequent observation of this individual proved it to be a somewhat "off color" specimen of the indigo bunting. A record of this species occurring at Ames was published in Bird Lore. It probably refers to the individual observed May 15, 1919.

Mockingbird

(*Mimus polyglottos polyglottos*)

The writer has never observed the mockingbird at Ames and is inclined to doubt its occurrence there. However, Professor Guthrie takes a different view. He writes: "I believe we have an undoubtedly accurate record of a mockingbird west of campus. Mrs. Battell observer. It fed at her station under observation several days."

Red-breasted Nuthatch

(*Sitta canadensis*)

A very careful study of the nuthatches at Ames for a period of four years failed to reveal a single good record for the red-breast. Nuthatches were abundant at the feeding station maintained about a rod in front of the dining-room window of the writer's home at the corporation limits of west Ames. All of these and all others observed at Ames were *S. carolinensis*. Professor Scullen, shortly before he left Ames, told the writer that he had never obtained a good record for the red-breasted nuthatch here." Professor Guthrie writes, "I have never yet seen a red-breasted nuthatch here."

Tufted Titmouse

(*Baeolophus bicolor*)

I have never seen a tufted titmouse in the vicinity of Ames and feel sure that in past years it was either absent from that region or occurred there only as a straggler. Professor Guthrie informs me that it is now reported as occuring there, and that he saw small flocks of them in the spring of 1921. This is most welcome news, and gives evidence again of positive results following a campaign of bird protection. Formerly the titmouse was absent from most of eastern Iowa. Dr. Bartsch of the United States National Museum informs me that for many years the titmouse did not occur at Iowa City, but at present occurs there in some numbers.

U. S. National Museum, Washington, D. C.
Formerly Zoology Dept., Iowa State College.

BEHAVIOR OF TRAPPED AND BANDED BIRDS

DAYTON STONER

In the course of certain bird-banding activities which I have been carrying on during the past several months, opportunity has been afforded for the observation and comparison of the behavior of a limited number of birds, both adult and young. And it is of some interest to note the different ways in which these "feathered bipeds" conduct themselves under the unusual conditions during and subsequent to the unlooked for disturbances connected with the operation of banding.

As is well known, birds as a group are highly energetic creatures. Metabolism is rapid, their senses are keenly active at all times. That different degrees and different methods of response to outside stimuli are offered is, however, to be expected.

The observations here recorded have been made principally on birds that have been taken in government sparrow traps which have been employed to secure birds for banding purposes. Two of these traps have been in almost continuous service in my back yard at my home in Iowa City since about April 1, 1921.

On May 9, after having one trap in operation for more than a month, both robins and bronzed grackles had been seen approaching the trap and even walking over it but, with the exception of two robins, they persistently refused to enter in spite of the fact that various supposedly attractive baits had been used. Even though the trap was moved from time to time, results were not forthcoming. It seemed apparent that the birds which did frequent it were those nesting or about to nest in the immediate vicinity.

A female robin when taken on April 4, 1921, made desperate efforts to escape from the trap and in doing so rubbed the feathers from about the base of the bill so that this region was bleeding slightly. When taken in the hand she struggled very little though she pecked viciously at a finger presented to her. This bird was banded as No. 57932. Apparently the experience of being trapped and banded was without terror to this robin for she was trapped again on April 20 and May 12 respectively. I have never had more than a single "Repeat" on a bronzed grackle.

On the morning of May 12, I discovered a female robin (it proved to be No. 57932 and this was the second time caught since banded) and a female bronzed grackle in the trap together. A free male grackle stood on the trap apparently contemplating his "unfortunate" companion within while another male stood on the ground at the side of the trap peering through the netting at the prisoner. Three or four other grackles were walking around and over the trap calling to the imprisoned bird which responded similarly.

The robin had apparently not profited by the experience gained in its former capture for it as well as the grackle was making desperate efforts to escape from the trap although the robin's efforts were more pronounced. As a result of these strenuous efforts to escape the forehead at the base of the bill of the robin was again bleeding but otherwise the bird was uninjured. The band when examined was in good condition and perfectly legible although scratched a little. While examining the band the bird pecked viciously at my hand and even held onto the skin with her bill during a part of the time that the examination was being conducted as well as struggling considerably during this procedure. When released she flew away quickly giving a few alarm notes.

The bronzed grackle (No. 56121) was injured in no way that I could discover. Her efforts to escape from the trap were not so energetic as those of the robin. The bird struggled only a very little in the hand and when the latter was opened for her release the grackle lay quietly for a few moments before flying away.

A good many robins and bronzed grackles have been taken since this date and all the individuals of each species seem to exhibit similar characteristics. The robins invariably struggle more while in the trap and make desperate efforts to escape when the operator approaches, the while calling wildly and loudly. The grackles, especially the males, take things more calmly; they are fighters and their efforts to escape from the trap are less pronounced. When released the grackles invariably fly much farther before alighting than do the robins.

An immature female cardinal (No. 51280) was taken in a trap on the morning of August 29. The bird was much excited and jumped about in the trap chirping loudly. When caught, it struggled hard and attempted to resist the captor by pinching with its very strong bill. Indeed it employed this weapon so effectively as almost to draw blood on the back of my hand. When forcibly induced to let go it made every effort to pinch and when once it grasped my finger or the fleshy part of the hand it could be made to release its hold only with difficulty. During the banding operation it struggled, keeping up at intervals its chirping. When released the bird flew away easily, alighting in a small bush near by. In a few seconds it left the premises.

As might have been expected, a house wren (No. 47428) proved to be an irritable, nervous and extremely active bit of feathered energy. It made strenuous efforts to escape from the trap and when the observer approached it uttered low, sharp trills in a continuous series. While being banded it fought and struggled, at the same time uttering a weak trill. When the hand was opened for its release it remained quiet for a moment before departing.

An almost fully fledged catbird about ready to leave the nest and banded July 30 (No. 51276) threw a perfect fit of rage and exhibited a decidedly pugnacious temper when attempt was made to band it. It squealed and fought more than any bird that I have yet handled for banding. All the strength, vitality and vivacity as well as the characteristic alarm notes of the adult were exhibited by this young bird, all of which of course aroused considerably the members of its immediate family as well as other birds of the vicinity.

I can not here forego a word regarding the European house sparrow as illustrating its adaptability and the rapidity with which it adjusts itself to new situations, both of which qualities are accountable, I think, for the remarkable success of this species in America.

When my traps were first placed and baited the sparrows approached cautiously, from time to time darting down for a peck at the food offered. In a few days they became bolder, even taking food partly covered by the first funnel. Two or three of the less discreet ones were caught. Familiarity has bred contempt; for a while an occasional sparrow was taken and one day eight of these scavengers found their way into the second compartment of the trap. However, I have not caught a single sparrow for several months although they eat more of the bait than all the native birds which visit the vicinity of the traps. The sparrows now walk nonchalantly under the first funnel and into the first compartment of the trap but persistently refuse to become confused or fly up; if frightened, they run out through the low entrance and thus escape easily.

I should add, too, that the bronzed grackles seem to have adopted a bit of sagacity on their own account and they also have become more wary and difficult to catch in the funnel traps. Other means are being devised to bring about the wished-for results.

While more than 150 nestlings have been banded, as yet only a limited number of adult birds has been captured and banded (about 40) and data are not at hand upon which definite conclusions as to their behavior may be based. Every available bit of evidence is of value. Our information is being constantly augmented in various parts of the country through the efforts of a considerable number of persons under the direction and leadership of the United States Biological Survey. Larger results may be looked for as the work of trapping and banding becomes a matter of more general effort among ornithologists.

University of Iowa

MORPHOLOGICAL STUDIES ON THE INJURY TO APPLE CAUSED BY CERESA BUBALIS

J. C. GOODWIN AND F. A. FENTON

Histological studies through lesions made in apple wood by *Ceresa bubalis,* the buffalo treehopper, revealed the cause of the peculiar rolling out of the wood characteristic of wounds produced by this insect. Sections were made through one, two and three year old lesions. A layer of corky tissue is formed over the wood cells that are cut by the ovipositor and exposed to the air. The two layers of corky bark adjacent to each other do not unite and this bark formation results in a wedge-shaped section of the limb being separated from the remainder. Because of this, part of the cambium layer is isolated from the rest, and is prevented from uniting with the other cambium to heal over the wound. The severed part, as well as the other cells, continues to grow and the force exerted results in the peculiar rolling of the tissue. Older lesions increase in width but there is a corresponding decrease in depth. The mechanical injury is very severe and there are evidences that decay sets in due to the wounds. While these may eventually heal over the decay has already entered the heart wood and ultimately this secondary injury may kill the entire limb.

IOWA STATE COLLEGE

NEST-DIGGING AND EGG-LAYING HABITS OF BELL'S TURTLE

(*Chrysemys Marginata Belli* Gray)

FRANK A. STROMSTEN

During the summer of 1921 some forty or fifty Bell's turtles dug their nests on the side of a small hill just north of the Iowa Lakeside Laboratory. This afforded an excellent opportunity for the study of the nest-digging and egg-laying habits of this species of turtle. When the turtle is digging her nest or depositing her eggs she is not easily frightened so that it is possible to get very close to the animal and to use a flash light within an inch or two of the body. On several occasions a number of students at the Laboratory were able to watch the entire process from the time the turtle landed on the shore until it returned to the water again. This paper presents more or less in detail the events that took place in the little more than two hours occupied by the turtle in digging the nest, laying the eggs, and concealing the nest.

SOCIOLOGY AS A SCIENCE

HORNELL HART

The term "social science" appears to be taken seriously neither by scientists nor by sociologists. Conditions in social research have justified that lack of confidence, but an increasing group has set about the systematic collection of data on specific social problems and is reaching results capable of objective verification. Three recent studies of the Sociological Division of the Iowa Child Welfare Research Station illustrate this tendency. One of these measures and describes by statistical methods the selective emigration which threatens to impoverish socially certain rural areas of the state. A second study develops by means of partial regression equations the fact that the intellectually and economically successful classes in Iowa have much lower net fecundities than the unsuccessful and the ignorant. A third investigation is developing methods of quantitative analysis of social attitudes and interests.

Sociological Division, Iowa Child Welfare Research Station.

CHANCE IN DEVELOPMENT AS A CAUSE OF VARIATION

P. W. WHITING

Variation is ordinarily considered as due to internal hereditary factors interacting with external environmental factors during development. In experimental work with a parasitic wasp considerable variation has been found in certain pure-bred stocks kept at certain constant environmental conditions. Either at other constant environmental conditions or in other pure-bred stocks this variation does not occur. Variation appearing under uniform conditions of heredity and environment is considered as due to slight irregularities of division and distribution of cells during embryology and to other more or less intangible factors of development. Individual variation resulting from chance in development is on the average predictable, just as is hereditary variation resulting from chance distribution of Mendelian units in gametogenesis and fertilization. It is highly probable that many mental and physical differences in man are due to these intangible factors of development. A knowledge of these factors will be of importance in relation to studies in eugenics such as are being conducted at the Iowa Child Welfare Research Station.

Child Welfare Research Station,
State University of Iowa

SUBMARGINAL VENATION OF FOLIAGE LEAVES

ROBERT B. WYLIE

An earlier paper* gave a brief account of experiments dealing with the conductive efficiency of certain types of vein systems in foliage leaves. By cutting the blade in various ways it was possible to show some of the advantages and also the disadvantages of different types of venation. The results indicated that larger veins, while highly efficient for conduction along their length, may constitute real barriers to movement across them, especially when interrupted by breaks in the veins, which cuts doubtless lead to leakage. On the other hand, regions free from larger veins showed marked capacity for conduction in all directions. The relatively small veins constituting the islet-borders were found to be capable not only of ready conduction in any direction in the blade but were demonstrably capable of carrying a very great overload.

By isolating peninsulas of blade with narrow isthmus at the base one could readily show that the ability of the minor venation to supply water to areas is far in excess of what would be ordinarily required in the normal leaf. Such results revealed the importance of islet-borders both for conduction and for mechanical support. The submarginal regions, relatively free from larger veins, function not only for general conduction but may provide for increased or even reversed flow of materials. This part of the leaf is thus peculiarly fitted to deal with serious wounds or breaks, and also to adapt the leaf to the shifting demands of transpiration as different parts of the blade may through external influences vary in their water loss.

Monocotyledons with their parallel venation and marginal vein present relatively uniform conditions throughout the area of the leaf. Dicotyledons on the other hand generally show marked differences in various parts of the blade due to the tree-like arrangement of the principal veins with its larger branches and smaller twigs. In such leaves there is reduction in size of veins with remoteness from midrib and the submarginal region of the blade becomes the portion of greater vascular uniformity. In

* Wylie, Robert B., concerning the capacity of foliage leaves to withstand wounding. Iowa Acad. Sci., Vol. XXVIII, pp. 293-304; 1922.

many leaves of this group there is a more or less pronounced tendency to combine branches in the peripheral region into a submarginal path for conduction. The outer portion of the leaf has, therefore, a greater freedom of conduction, especially as regards the direction of flow, and probably acts as a general equalizing system between the various parts of the lamina.

With the great diversity in form and structure of Dicotyledon leaf it is not surprising to find that even those possessing similar outline have marked differences in their venation and consequent variety in the submarginal zone. While no attempt is made at this time to present a detailed discussion of these differences, a few examples may suggest the range of differentiation. Towards one extreme of the series is the situation represented by *Ulmus fulva*, or *Betula nigra* in which the major laterals run almost to the edge of the leaf and so break up the submarginal strip. It should be noted, however, that even in such leaves the outer portion of the blade is the part most nearly free from obstructions.

Less strict are the conditions in such leaf as that of *Catalpa bignonioides* where the major laterals are widely separated and stop short of the margin leaving a peripheral plexus consisting chiefly of islet borders with occasional larger connectives. Throughout a large part of this leaf there are seen only the versatile islet-borders of proven efficiency for varied conduction.

In Lilac one finds the slanting major laterals connecting nearer the margin with a peripheral meshwork of veins that are intermediate in size. These anastomotic veins stretch around the outer part of the leaf and penetrate with larger meshes back between the chief lateral veins. Filling the entire area of the blade are, of course, the islet-borders. Lilac thus presents a triple vascular system but avoids large cross veins and never approaches the rectangular type seen in Tilia (l. c., p. 303). The graduated submarginal plexus favors distribution around the circumference and also radially between the larger veins.

Asclepias syriaca possesses a sharply defined submarginal strand located about one-eighth of the distance from the edge of the leaf to midrib. The chief laterals run out nearly at right angles to the central vein. Without giving off important branches these laterals are joined in the submarginal region by heavy outcurving connectives thus building a prominent sinuous vein parallel to the edge of the leaf. Still nearer the margin the minor veins also unite to form a smaller strand roughly parallel to the leaf margin, but much less conspicuous than the principal submarginal vein just mentioned.

In the earlier paper (l. c., p. 301) the writer noted the striking inability of *Aslcepias syriaca* to meet demands resulting from wounds. Excepting in the marginal areas the blades quite uniformly failed to meet critical tests. Slashed longitudinally the strips usually died almost to the base with the exception, of course, of the zone along the midrib and the lateral zones watered by the submarginal strands. In these earlier experiments the outside edge of the leaves was not disturbed and since this limited water loss in the outer zones to one edge, the observed results might have been due in part, at least, to the diminished loss through evaporation from but one margin in these outer strips.

During the summer of 1921 wound experiments were carried on at the Iowa Lakeside Laboratory on various leaves including those of *Asclepias syriaca* and Lilac. Conditions in the marginal strips were made then equally difficult with those of the interior zones by removing first from the outer edge of the leaves a narrow strip of tissue parallel to the margin. The leaves were then slashed longitudinally into roughly parallel zones (fig. 1). Under the circumstances of the experiment each strip should suffer approximately equal traumatic water loss.

Two leaves of *Asclepias syriaca*, exhibiting typical results, are shown in the accompanying plate (fig. 1, d.e.). It will be noted that the middle and marginal strips suffered no death of tissue while all other zones died throughout most of their length. The central zone was, of course, taken care of by the midvein, while the outer strips were obviously well supplied by the submarginal veins.

The marked inefficiency of the intermediate strips deserves attention since they show so little adaptability to the altered demands forced by the conditions of the experiment. Though supplied with water from both the inner and outer ends, and apparently with equal liberty from both ends, these strips seemed unable to conduct water through any considerable distance. Reasons for this failure must be attributed primarily to the rectangular system of major veins in this leaf. The major laterals are nearly parallel while right and left the midvein and submarginal veins fence off the leaf blade into a series of closed rectangles bordered by large strands. However efficient this plan may be in the uninjured leaf, wounds of the type described, forcing conduction across larger veins show that they always, under such circumstances, act as barriers. *Asclepias syriaca* seems then to possess right-angle efficiency but is relatively inefficient in other directions.

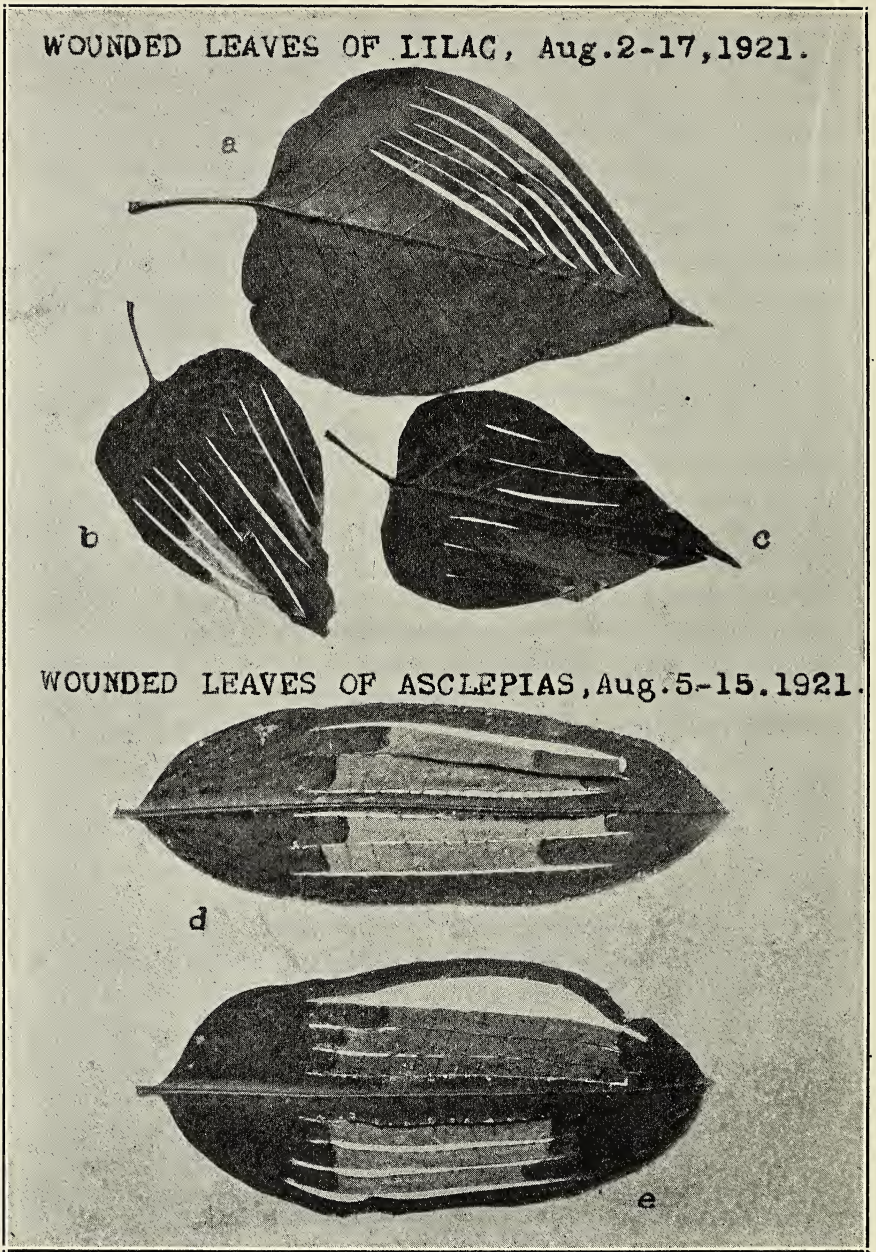

FIGURE 1.

In marked contrast to Asclepias were the results obtained with Lilac. Figure 1 shows a larger partly shaded leaf, (a), and two smaller sun leaves (b c). In all three of these the outer margin was removed with scissors before the leaf was slashed longitudinally with razor, so as to equalize water loss for all strips. Recalling the marked efficiency shown by the leaf of Lilac in earlier experiments (l. c., p. 301) conditions for these sun leaves were made doubly difficult by continuing the slashes through the end of the leaf thus reducing the blade to a series of strips with connection only at the base. The shade leaf (fig. 1, a) suffered no loss of tissue though the slits were long and the strips of tissue quite narrow. Of the sun leaves the one with broader strips (c) suffered no loss of tissue and the other (b) with much narrower zones lost only a little in three or four places.

Comparisons are difficult in the absence of precise environmental data together with facts relative to amount of water loss, etc. But assuming, roughly, proportional loss from wounds and transpiration and like efficiency of stem for raising water, etc., the type of venation seems to be an important factor in wound tolerance.

The development of a submarginal system, unless this is interrupted, adds greatly to the leaf's conductive efficiency. In *Asclepias syriaca* there is an evident transverse-longitudinal organization, the latter represented by the midvein and lateral submarginals. Wounding experiments indicate that this plan is inelastic though doubtless efficient in the normal leaf. In Lilac the oblique laterals, in combination with a marginal plexus of smaller veins, seem to constitute a versatile arrangement very useful in meeting conditions demanding modified flow of materials. It would appear that in the outer part of the leaf a plexus of connecting veins offers advantage over a definite, single submarginal vein.

DEPARTMENT OF BOTANY,
UNIVERSITY OF IOWA.

SOME WOUND RESPONSES OF FOLIAGE LEAVES

ROBERT B. WYLIE

The leaves of plants are their most exposed organs. The thin summer foliage of herbaceous plants and deciduous trees generally suffers so severely that one rarely finds an uninjured leaf. While the degree of wounding is less serious in the evergreens, since they are tougher and offer greater resistance, lesions are not uncommon on these especially on the broader leaved evergreens. The plant's ability, therefore, to deal with such frequent accidents must be highly developed to meet these daily needs for renewed cortex.

Recalling that the leaf is usually an organ of definite growth, its tissues quickly passing into functional maturity, and that wounds expose many layers of living cells remote from all growing tissues, the writer has often remarked the apparent efficiency of the leaf in dealing with its wounds. Infections through lesions in leaf tissue seem relatively unimportant in relation to plant diseases while wounds on stems commonly contribute to the liability of infection. Leaf wounds though most numerous of all types of lesion in plant tissues apparently have relatively the least to do with plant diseases.

While leaves have been studied intensively from many viewpoints their normal tissue responses to traumatic stimuli have received relatively little attention from botanists. This is in itself proof of the marked efficiency of the leaf to take care of its wounds. When galls are produced such have invited special investigation and their literature is extensive. Very few papers, however, discuss the morphological changes in consequence of lesions in a foliage leaf unless followed by abnormal growths. Since no paper at hand seems to bear directly on these morphological responses it seems best to defer the discussion of all papers that might find a place in the summary of literature to a later paper in which the writer traces the development of the cicatrice in certain leaves.

The work of the foliage leaf compels a structure that invites animal attack and also renders the leaf liable to mechanical injury. Photosynthesis is possible only as light enters the leaf, and this condition inhibits the development of cortication that would markedly cut down the interior illumination. Neither cork nor bark may be regularly employed, so foliar organs are denied the major defenses of stems. Examination of leaves always suggests that the protective covering is reduced to the minimum so as to favor the utmost light relation. It may be that the marked efficiency of the deciduous trees is due to their large, thinly covered leaves which while most efficient through the summer become a menace in autumn and are frankly abandoned at the end of the growing season. Such tropophytes possessing a rhythmic foliage in harmony with the seasonal changes have leaves that are most susceptible to injury.

Fig.1. SALVIA OFFICINALIS

To determine the nature of the healing tissues employed, wounded leaves were collected in early September from a number of plants, the injured areas were cut out together with a margin of normal blade, and the pieces prepared for sectioning. This material was killed in 1% chrom-acetic acid, imbedded in paraffin, and sections prepared 12 micra in thickness. Serial sections were used as large numbers of cuts had to be studied to find one showing what might be an average condition for the plant in question. Not only are the sections modified through any obliquity to the surface or margin but the structure of the blade and the nature of the cicatrice vary with relations to veins and islet-borders.

In this preliminary report are recorded the conditions found in a few of these leaves, Sage (*Salvia officinalis*), Honey-suckle (*Lonicera Sullivantii*), *Bryophyllum* sp., Red Clover (*Trifolium pratense*), Horse-radish (*Nasturtium armoracia*), *Pittosporum* sp. As may be noted there are included forms of diverse habitat and the series involves both herbaceous and woody plants. Included with plants growing here are *Pittosporum,* with firm evergreen leaf, mailed to me from Santa Monica, California, by Mr. N. D. Knupp; and also the thick leaved *Bryophyllum* cultivated in plant

Fig.2. LONICERA SULLIVANTII

houses. With one exception the leaves had been wounded through natural causes and were from plants growing out of doors. The *Bryophyllum* leaf was from a plant in the green house which had been wounded 72 days before collection. The cicatrices shown in the figures are all apparently mature. All figures are drawn to common scale.

Following the injury of a leaf there is probably a temporary covering over the open edge due in large part to the collapsed and dried mesophyll cells which die back for some distance from the cut edge. This is often aided by over-folding of epidermal layers, particularly in the case of the softer leaves (figs. 1, 3, 4, 5).

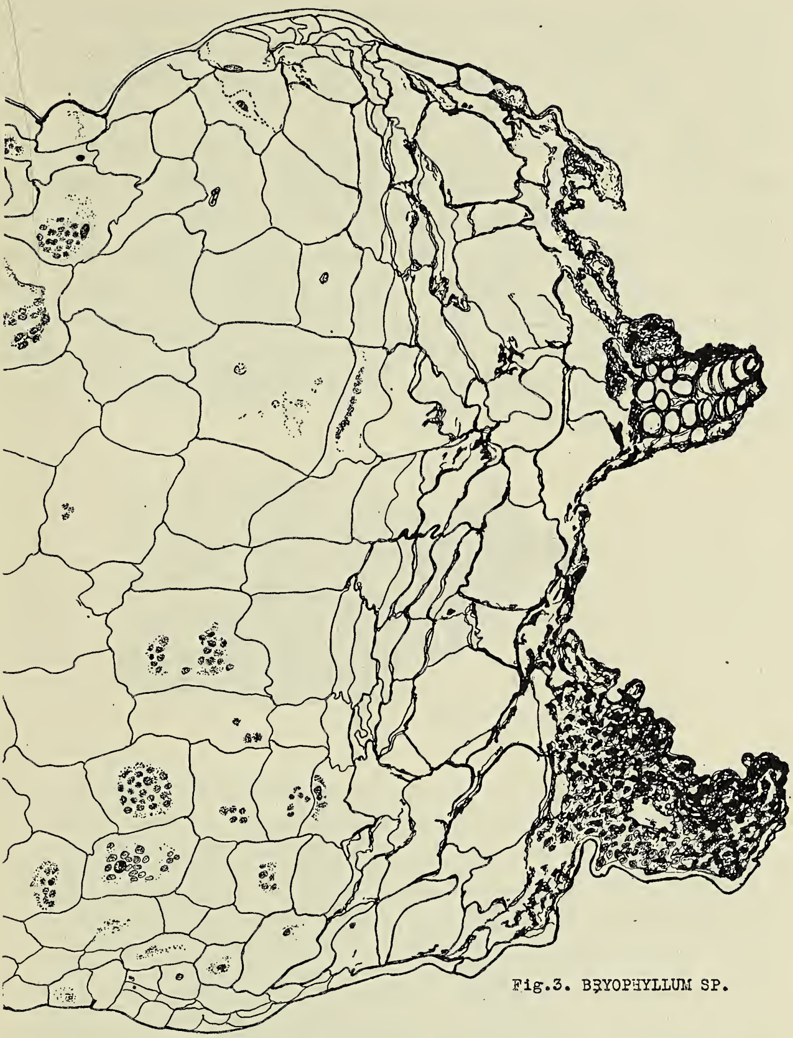

Fig.3. BRYOPHYLLUM SP.

In the thicker ones such as *Pittosporum* (fig. 6), the double upper epidermis seems to curve outward rather than inward, but probably most of the thinner leaves would show incurved epidermal margins. The combination of collapsed mesophyll cells and infolded epidermis thus partly protects the raw edge until by modification and mitosis cells are established which can provide the permanet recortication.

The cicatrice is usually clearly differentiated even in unstained free-hand sections. This is due in part to the modification of its walls, which are often brownish, and in part to the death of cells with consequent loss of contents. With reagents and stains the cicatrice generally reacts differently from the uninjured cells. Especially marked is the positive reaction for lignin with phloroglucin. Tests for cutin, and suberin gave less positive results in most cases.

In contrast to the single epidermal layer found covering most leaves their cicatrices show a considerable thickness involving always more than one layer of cells and commonly several. The cicatrice itself, moreover, shows a general correlation with the structure and thickness of the leaf concerned. Disregarding the collapsed dead leaf cells the healing tissue often approximates one-third the thickness of the blade; but observation, even with the limited number studied, shows wide variation with leaves of different habitats.

Fig.4. TRIFOLIUM PRATENSE

The nearest approach to agreement seems to be between the width of cicatrice and depth of palisade layer. In many cases the actual thickness of the cicatrice is nearly the same as that of the palisade of the same leaf (figs. 1, 2, 4, 6). In leaves where the mesophyll shows less differentiation the cicatrice is simpler and relatively thin (figs. 3, 5).

The thickness of the walls of the scar-tissue also shows general agreement with those of the epidermis. If there is a heavily cutinized epidermis the leaf is likely to develop a thicker walled cicatrice. It should be noted that in the latter such thickening is not limited to the outer walls of the cicatrice and is in no sense a reconstructed epidermis. *Pittosporum* (fig. 6) and *Lonicera* (fig. 2) present sharp contrast with Red Clover (fig. 4) or *Bryophyllum* (fig. 3).

This seeming correlation in width between palisade and cicatrice, and in character of walls between epidermis and cicatrice, might be expected on general grounds. A thick cicatrice with heavier walls would be demanded under conditions inducing much palisade and heavier epidermal walls.

Fig.5. NASTURTIUM ARMORACIA

Certain cells of the protective tissue may become considerably enlarged as in *Salvia* (fig. 1) or *Lonicera* (fig. 2), or its tissue may remain about the same size as the average interior cells of the leaf, *Pittosporum* (fig. 6) or Horse-radish (fig. 5).

The wound tissue is largely formed by the development of new

Fig.6. PITTOSPORUM SP.

cells resulting from mitoses which establish walls parallel to the wounded edge of the leaf. All cell-layers of the blade share in this work, including the epidermis in case its cells are large. There are occasional divisions of epidermal cells in *Pittosporum* (fig. 6) and *Lonicera* (fig. 2) and numerous divisions in *Bryophyllum* (fig. 3) where several cells may be derived from either an upper or lower epidermal cell.

The palisade cells divide first transversely into shorter units, and these may later divide at right angles by periclinal walls (fig. 2). Meanwhile divisions have closed the spaces in the spongy mesophyll thus completing the zone of healing tissue.

Quite striking is the appearance of a section through a porous leaf of the Horse-radish type (fig. 5), where the solid cicatrice offers strong contrast to the loose mesophyll of this leaf. Equally remarkable is the regular series of new cells bordering the wounded edge of *Bryophyllum* leaf (fig. 3) and extending from surface to surface across all of its tissues.

The completed cicatrice reveals the cambium-like behavior of those cells which by mitosis established the healing layers. Such activity seems strangely foreign to a leaf long since passed to its functional maturity.

DEPARTMENT OF BOTANY,
UNIVERSITY OF IOWA.

NOTES ON THE FLORA OF YOSEMITE AND ADJACENT REGIONS

L. H. PAMMEL

I shall not try to make an extensive paper on the flora of the Yosemite, but merely to record my impression of this interesting floristic region. To persons who wish to become familiar with the region the following papers and books will be of interest: The United States Park Service has published an interesting folder on the Yosemite National Park,[1] the Hall[2] Yosemite Flora, John Muir's general account [3], Jepson[4] on the trees of California, Brewer and Watson,[5] botany of California, a well known treatise. The work of W. L. Jepson,[6] The Flora of Western Middle California, describes the plants of western and middle California and often refers to the plants of the Sierras. It is an interesting change from the flora of the San Joaquin Valley to the flora of the Sierras. In the San Joaquin Valley as in the Sacramento there is a maximum of sunshine and a rainfall somewhat limited to the winter months. In this region there is a wealth of vernal flowering plants, making the fields aglow with the California poppies (*Eschscholtzia Californica*), Brodiaeas (*B. minor*), *Chlorogalum angustifolium* and many others which disappear during the hot summer months and are succeeded in the cultivated fields and roadsides by a lot of homely weeds like goosefoot (*Chenopodium album*), tumble weed (*Amaranthus graecizans*), smartweed (*Polygonum Persicaria*), gourd (*Cucurbita foetidissima*), camphor weed (*Trichostema lanceolatum*), horehound (*Marrubium vulgare*), tar weed (*Hemizonia luzulaefolia*), tocalote (*Centaurea melitensis*), Barnaby's thistle (*Centaurea solstitialis*), purslane (*Portulaca oleracea*), common plantain (*Plantago major*), barley (*Hordeum murinum*), wild oats (*Avena fatua*), crab grass (*Digitaria sanguinalis*), blue curls (*Trichostema lanceolatum*), barn yard grass (*Echinochloa crus-galli*), Johnson grass (*Sorghum*

1 Dept. of Interior, National Park Service, 1-77, 4 pl; 1920.

2 Hall, H. M. and C. C., 1-282; 1912.

3 The Yosemite, 1-284; 1912.

4 The Silva of California; Memoirs Univ. Calif., 2: 1-480, pl. 1-85, maps 1-3, f. 1-11; 1910.

5 Botany Calif., Geol. Survey, 1: 628; 1876, 2: 1-539; 1889. Polypetalae, Brewer and Watson; Gamopetalae, Gray.

6 A flora of Western Middle California, 2d Ed., 1-515.

Fig. 1. General view of Yosemite region. Vernal and Nevada Falls to the right

halepense) and many others which occur in late summer. Except for the more or less fleshy leaved kinds the plants of the fields are dry. Barnyard grass, Johnson grass, crab grass and other plants of this type are green only near irrigated ditches. The foothills show only the dried remains of wild oat (*Avena fatua*) and tall meadow oat grass (*Arrhenatherum elatius*), *Hordeum murinum* and *H. maritimum* var *gussonianum*. Along the San Joaquin and its smaller tributaries the valley oak (*Quercus lobata*), a beautiful tree with spreading pubescent branches, is frequent. The cottonwood (*Populus Fremontii*) occurs along living streams and willows like the sandbar willow (*Salix fluviatilis*), the black willow (*S. nigra*) and the arroyo willow (*S. lasiolepis*) as well as the box elder (*Acer negundo* var *Californicum*) and the ash (*Fraxinus Oregona*), are more or less common. A difference, however, is observed in the foothills through which Merced river flows. The foothills here, as along all other streams of the Sierras, are more or less dry. Here may be found the Digger pine (*Pinus Sabiniana*) which usually forms a very thin stand. The large cones and thin gray foliage give the foothills a peculiar aspect. Digger pine is frequently associated with the California buckeye (*Aesculus Californica*) and the western red bud (*Cercis occidentalis*). Valley oak (*Quercus lobata*) may still occur and with it the Wislizenus oak (*Q. Wislizenii*). The Oregon ash (*Fraxinus Oregona*) occurs in the foothills along streams and was found at El Portal. In ascending the valley the aspect gradually changes, the bull pine (*Pinus ponderosa*) appears and

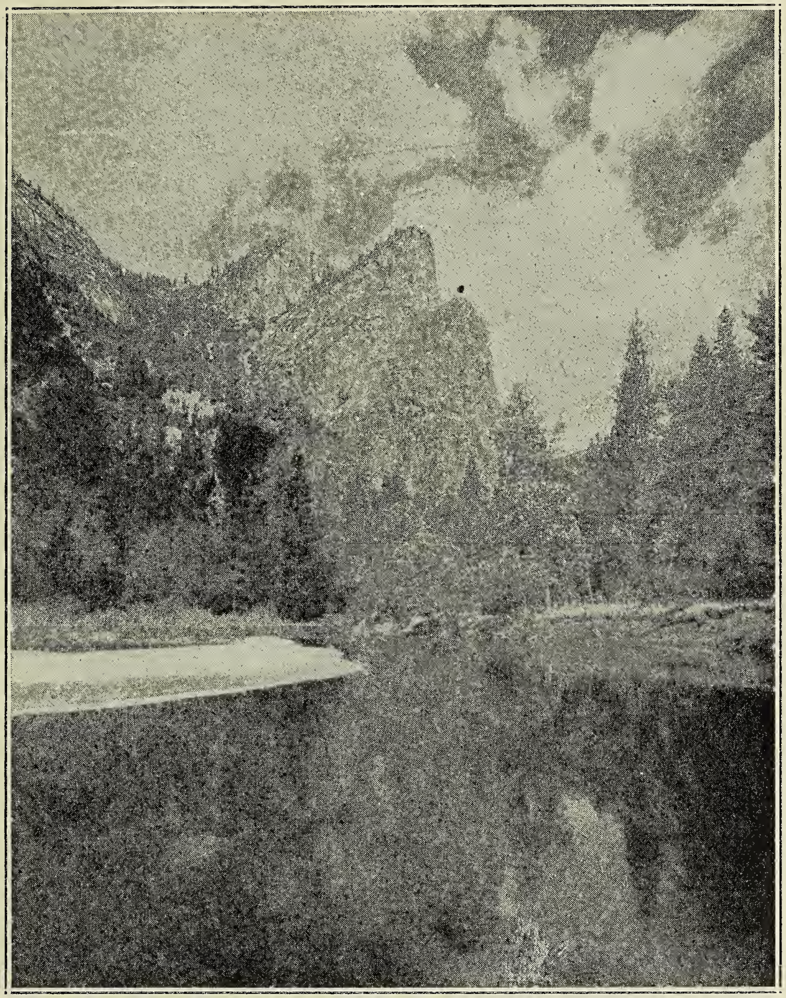

Fig. 2. Mirror Lake in the Yosemite with pine and fir in back ground.

with it in the moist canyons the large leaved maple (*Acer macrophyllum*) and an occasional stinking yew (*Tumion Californicum*), which is a rather rare tree, and unique among the California conifers. The Douglas fir (*Pseudotsuga taxifolia*) also appears as well as the incense cedar (*Libocedrus decurrens*), another of the unique North American conifers. In shady nooks where there is an abundance of moisture the beautiful *Woodwardia radicans* appears and in dry woods the widely distributed *Pteris aquilina*. The white fir (*Abies concolor*) is widely distributed in the Rockies and is a fine tree. The beautiful red fir (*A. magnifica*) occurs at higher altitudes. The hillsides contain numerous species of the so-called lilacs, species of *Ceanothus*, members of the family Rhamnaceae. These have white or bluish colored flowers. I collected the following species in the region: *Ceanothus thyrsiflorus, C. cordulatus, C. cuneatus* and *C. prostratus*. Some of the species are prostrate, others are erect. There are few twining plants in the region. The only common species in the lower Merced valley is the California grape (*Vitis Californica*).

The California nutmeg (*Umbellularia Californica*), with aro-

Fig. 3. Yosemite Falls. In the foreground lodge pole, yellow pine, fir and cottonwood. The blotches on the mountain sides are largely golden cup oak

matic leaves, is abundant on the mountain slopes. Many other trees and shrubs, some of which will be referred to later, occur in the valley below the moraine at the lower end of the Yosemite. Flowing through the valley is Merced river. This valley is an old lake and is about seven miles long and a mile or so wide. It is for the most part now covered with trees, the remainder consisting of open meadows which have been spoiled by the intensive grazing. The beautiful meadows spoken of by earlier writers are a thing of the past. The moraine is situated between the famous El Capitan and Bridal Veil Falls. El Capitan rises 3604 feet above the floor of the valley. The Bridal Veil Falls are 620 feet high, while the Yosemite falls are 1430 feet high.

The most marked features of the floor of the Yosemite Valley from the standpoint of vegetation are the large and superb speci-

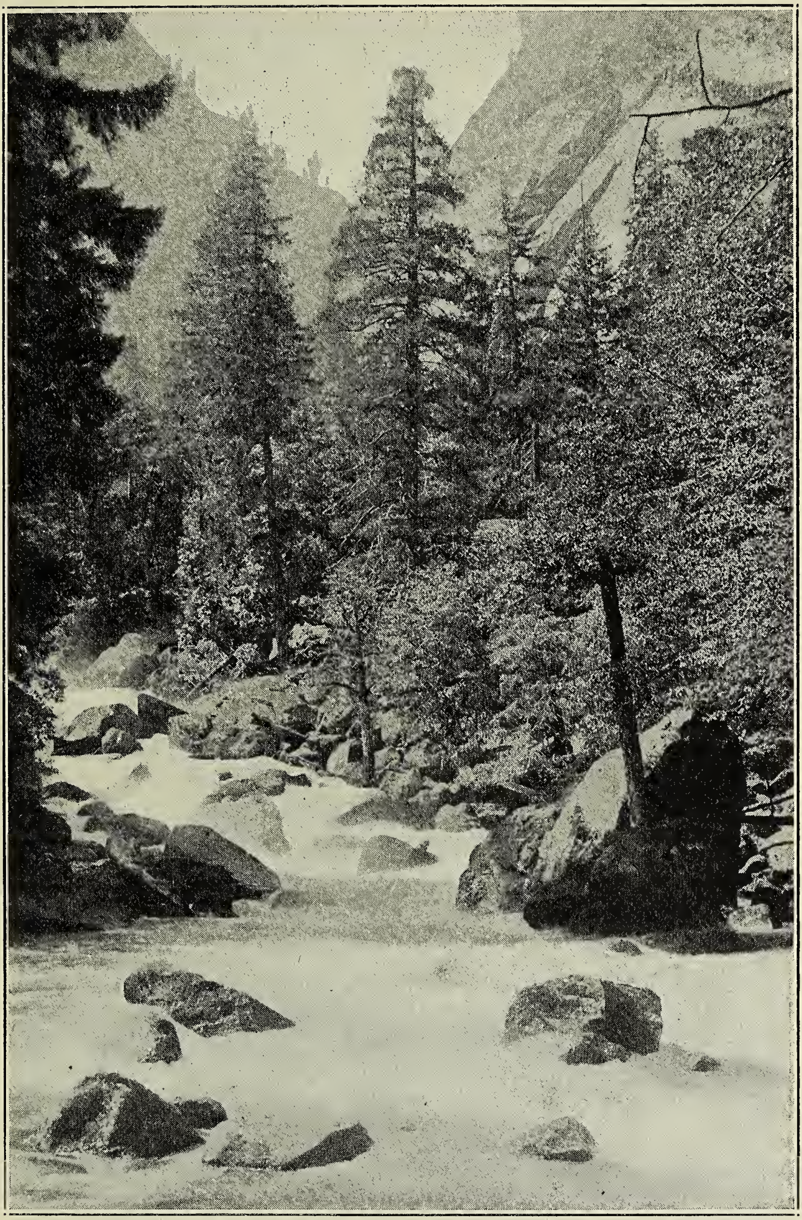

Fig 4. Merced river. Incense cedar, fir and pine. Above Happy Isles.

mens of the yellow pine (*Pinus ponderosa*), the fine and magnificent trees of *Libocedrus decurrens* and a few large sugar pines (*Pinus Lambertiana*). The latter species is not common in the floor of the valley — a few trees occur near the moraine on the banks of Merced river and a few more on the banks of the same stream a half mile above the village. A few small lodge pole pines (*Pinus Murrayana*) are scattered through the yellow pine groves. There is but little variation in the elevation of the floor of the valley or in the character of the soil. In the more or less gravelly soil there are abundant and fine specimens of the California oak (*Quercus Kelloggii*), a most graceful, beautiful tree with broad, rounded top, whose leaves resemble those of our eastern quercitron oak (*Q. velutina*). The acorn and cup also resemble those of this eastern species, except that the acorns are larger. On the mountain slopes and often in rocky soil another species of oak commonly known as the golden cup or maul oak (*Q. chrysolepis*) occurs. It is an extremely variable oak; the leaves are ovate, entire or toothed, green above and yellowish beneath, sometimes covered with pubescence. These variations occur on the same tree and the same branch. This oak is common on the slopes in the valley up to altitudes of 7,000 feet. A related species, *Q. vaccinifolia*, is sometimes called the Huckleberry oak because of the resemblance of the leaves to those of the huckleberry. The species is common at higher altitudes in the Sierras. I found it in great quantities on Feather river near Gold Lake where it covered great stretches, forming a dense undergrowth. The acorn somewhat resembles that of the white

Fig. 5. Gold Lake near Feather River Canyon on line Western Pacific Railroad. Lodge pole pine, some white pine (*Pinus monticola*).

oak. The chinquapin (*Castanopsis sempervirens*), related to the eastern chinquapin (*Castanea pumila*), is a spreading shrub from one to eight feet high, with evergreen leaves, erect, staminate catkins several inches long and bearing white flowers. Small spiny burs cover the nuts. The species was common at Chinquapin, forming a dense growth. It was just in bloom about the last of August.

In the flood plain of the stream and in some places in the valley there were great quantities of black cottonwood (*Populus trichocarpa*), a tree with somewhat variable leaves, bright green above and rusty brown below. The trees of the valley are not large, generally from forty to eighty feet high, 1½ to 2½ feet in diameter. There is only one other species of this genus in the region, namely the quaking aspen (*Populus tremuloides*). This is not what one would expect because in the Rockies *P. tremuloides* is one of the most common species of the genus. I saw only a few trees, at the head of a little open somewhat boggy area near Crane Flat. It is reported at several other points at altitudes over 6,000 feet.

The white alder (*Alnus rhombifolia*) is common on the banks of streams through the Sierra canyons along with several species of willow (*Salix*) western azalea (*Rhododendron occidentale*) with its beautiful white or pinkish corollas, the flowering dogwood (*Cornus Nuttallii*) and the common dogwood (*Cornus pubesçens* var *Californica*). The little mountain maple (*Acer glabrum*) which is especially common near Mirror Lake and the higher slopes of the mountains, is an interesting mountain species. The big tree (*Sequoia Washingtoniana*) occurs several thousand feet above the floor of the Yosemite valley. I visited only two groves; the one near Crane Flat and the well known Mariposa grove in a glaciated region. The trees are found on the slope and in the little narrow valleys. There is in this region always an abundance of moisture from the abundant rainfall and the melting snow. The little valleys have fine springs. The big trees are associated with sugar pine, *Alnus, Salix, Erigeron* and other species of plants needing an abundance of moisture. The trees are either very old or very young; there are no medium sized trees. These trees are California's most marvelous production. Fortunately the Government is trying to save most of them.

In a previous paragraph the statement was made that the floor of the valley is fairly uniform in character. At one time the open meadows were covered with an interesting lot of herbaceous plants. Severe grazing has destroyed many of the fine meadow

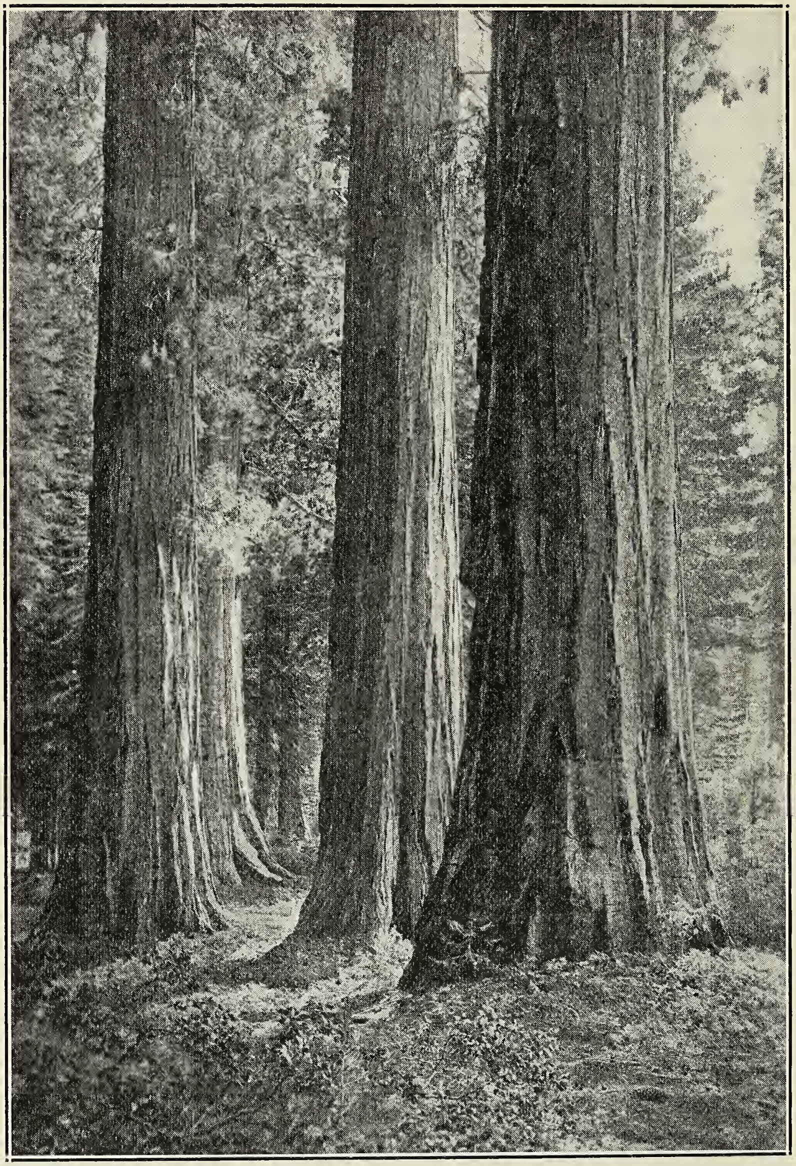

Fig. 6. The big tree (Sequoia Washingtonia) in the Yosemite National Park, Mariposa Grove

species. The white flowered smartweed (*Polygonum bistorta*) is rarely found though it is said to have been common at one time. The large yellow flowered evening primrose (*Oenothera grandiflora*) is abundant, and the large yellow flowers form an interesting feature of the region. Several species of *Gayophytum* are common in the gravelly soil. The enchanter's nightshade (*Circaea pacifica*) is frequent in moist shady woods near springs. *Godetia viminea* with purple flowers and fireweed (*Epilobium angustifolium*) form showy masses in open woods. This latter species is more common northward into British Columbia in the Rocky Mountains and northern United States. Of the Compositae the following may be mentioned: the yarrow (*Achillea Millefolium*), wormwood (*Artemisia dracunculoides*), thistle (*Cirsium Californicum*), *Wyethia angustifolia*, everlasting (*Anaphalis margaritacea*), *Chrysopsis villosa* var *Bolanderi*, goldenrod (*Solidago occidentalis* and *S. Californica*). A species of Lessingia is common in open gravelly places in the floor of the valley. The common horseweed (*Erigeron canadensis*) is naturalized in many places as is the tumbling mustard (*Sisymbrium altissimum*). There are several species of monkey flowers but the most interesting and beautiful is the cardinal monkey flower (*Mimulus cardinalis*), a perennial with villous pubescent stems and bright scarlet flowers. It is common in the vicinity of springs and little rivulets. A yellow flowered monkey flower (*Mimulus floribundus*) with slimy viscid musk-scented leaves is common also in springy places. The figwort (*Scrophularia Californica*) is common in the Sierras, especially in moist gulches.

In moist ravines near springs in the Yosemite valley there are sometimes great quantities of cleavers (*Galium aparine* and *Galium trifidum*) of the madder family Rubiaceae. There are not many plants of the honeysuckle family Caprifoliaceae. At El Portal and in the floor of the valley the slopes of hills and rocky places contain considerable quantities of the blue elderberry (*Sambucus glauca*), whose bluish fruit with a whitish bloom is quite striking. The California honeysuckle (*Lonicera hispidula* var *Californica*) is common in canyons along streams.

Of the mint family (Labiatae) the fragrant *Monarda lanceolata* with rose-purple corolla occurs in the foothills. The common mint (*Mentha canadensis*) is not uncommon in marshes. Self heal (*Prunella vulgaris*) is common in the floor of the valley. The European horehound (*Marrubium vulgare*) is a common naturalized weed in the great valley and in the foothills. It occurs commonly at El Portal. Of the milkweed family (*Asclepiadaceae*) our *Asclepias speciosa* is common as well as *A. cordifolia*. The *Apocynum cannabinum* of the Apocynaceae is common in the valley. The beautiful western azalea (*Rhododendron occidentale*) of the Ericaceae occurs in many places in great profusion overhanging small streams. The wild ginger (*Asarum Hart-*

wegii) of the Aristolochiaceae is common in deep shady woods of the Yosemite. The dogwood family (Cornaceae) is represented by the flowering dogwood (*Cornus Nuttallii*) with flowers in sessile heads surrounded by several large white petal-like bracts and a scarlet drupe, much like our eastern flowering dogwood but a larger tree. The common dogwood of river banks is the *Cornus pubescens* var *Californica* with purplish branches. The bear brush (*Garrya Fremontii*) of the Garryaceae occurs as a small shrub or tree with simple opposite leaves and dioecious flowers borne in a long pendant-like catkin.

Of the carrot family one of the most characteristic plants in marshy places is the cow parsnip (*Heracleum lanatum*), while the sweet cicely (*Osmorrhiza occidentalis*) is common in woods. The turkey mullein (*Eremocarpus setigerus*) is a rather common weed in the foothills at El Portal and forms close mats on the ground. The thyme-leaved spurge (*Euphorbia serpyllifolia*), with forked branches, also forms prostrate mats on the ground. Of the Leguminosae the Spanish clover (*Lotus americanus*) is common in open places in the foothills. There are also several beautiful species of lupines (*Lupinus* sp.) in open parks. There are several cherries in the Sierras of which the most widely distributed is the western choke cherry (*Prunus demissa*) which also occurs throughout the Rocky Mountains. The drupes are bright red and astringent. The species is more or less gregarious. The service berry (*Amelanchier alnifolia*), common in the Rockies, is another Sierra species. Two species of *Rubus* are rather common, the thimble berry (*Rubus Nutkanus*) and the common blackberry (*Rubus vitifolius*). The mountain mahogany (*Cercocarpus parvifolius*) with its grayish branches and tailed fruit is a common shrub or small tree in dry exposed situations near Wawona and in the Merced canyon. The California wood rose (*Rosa gymnocarpa*) with pear shaped red fruit, is common in woods. The nine bark (*Physocarpus capitatus*) is a gregarious shrub on north slopes of mountains, on the south bank of Tuolumne river near a grove of big trees. The meadow sweet (*Holodiscus discolor* var *ariaefolius*) is one of the common shrubs in granitic rock in the vicinity of Bridal Veil Falls. There are several interesting plants of the gooseberry family (Saxifragaceae), such as the California mock orange (*Philadelphus Lewisii* var *Californicus*), frequent along streams in the Yosemite valley. There are also several species of *Ribes*.

Common pepper grass (*Lepidium apetalum*) of the family Cruciferae is a common naturalized weed of the Yosemite Valley, as is also shepherd's purse (*Capsella bursa-pastoris*), radish (*Raphanus sativus*) and the tumbling mustard (*Sisymbrium altissimum*). *Streptanthus orbiculatus* occurs in the Yosemite Valley. The California poppy (*Eschscholtzia Californica*) of the family Papaveraceae grows as freely in the Yosemite as in other parts of California. The California strawberry bush (*Calycanthus occidentalis*) of the Calycanthaceae is common in moist canyons and streams and is found in the lower Merced between El Portal and the lodge. There are also representatives of *Aquilegia, Delphinium, Clematis* (*C. ligusticifolia*), *Thalictrum,* Spatter dock (*Nuphar polysepalum*), *Arenaria, Silene, Aster, Erigeron, Juncus, Carex, Scirpus.* There are several interesting mistletoes. The incense cedar mistletoe (*Phoradendron Libocedri*) was frequently observed on the road to Wawona from the Yosemite Valley. The oak mistletoe (*Phoradendron villosum*) is common on several species of oaks in the Merced Canyon between El Portal and the Yosemite and on the Wawona road from the valley, especially on *Quercus chrysolepis* and *Q. Californica.* The cottonwood mistletoe (*Phoradendron flavescens*) is often found on the cottonwood in the San Joaquin Valley. The *Arceuthobium occidentale* is fairly common on the yellow pine in the Yosemite Valley.

DEPARTMENT OF BOTANY,
IOWA STATE COLLEGE.

GERMINATION STUDIES OF SOME SHRUBS AND TREES

L. H. PAMMEL AND C. M. KING

A study has been made by the Botanical Department of Iowa State College during the past season of the germination of the following: *Quercus Gambellii, Pasania densiflora, Maclura pomifera, Prunus caroliniana, Rhus Toxicodendron, Rhus canadensis, Gleditsia aquatica, Rhamnus californica, Rhamnus tinctoria, Lycium halimiflorum* and *Shepherdia argentea.*

Descriptions of the seedlings of these plants, with an account of the conditions under which the seeds germinated are herein given. Previous papers may be found in Proceedings of the Iowa Academy of Science.

Quercus Gambellii. Nutt. Gambell's Oak.

Locality of specimen, Salt Lake City;

Collected September 16, 1921, by L. H. Pammel.

These acorns were placed in soil on the greenhouse bench October 1, 1921; they began to show sprouts above ground the middle of December.

The acorn fruit of this species is almost sessile; the cup is ½ to 2/3 of an inch in diameter, hemispherical, covering about 1/3

Fig. 1. Seedling of *Quercus Gambellii.* Acorns of the same oak
Drawn by C. M. King

of the acorn. Acorns barrelshaped, obtuse at apex, about 2/3 of an inch to one inch in length, color medium yellowish brown.

Germination hypogaeous. Scales of the young stem small, wooly pubescent, soon falling. Stem hairy. First leaf entire, smooth; second and third slightly dentate, prominently veined, pubescent on petioles and midrib, hairy on margin; Stipules reddish, glandular, bearing slender hairs about 1/60 to 1/75 inch in length. Leaves become dark green above, paler beneath. The upper surface of the later leaves smooth, glaucous, pubescent on midrib; Lower surface smooth. Outline rounded becoming lobed.

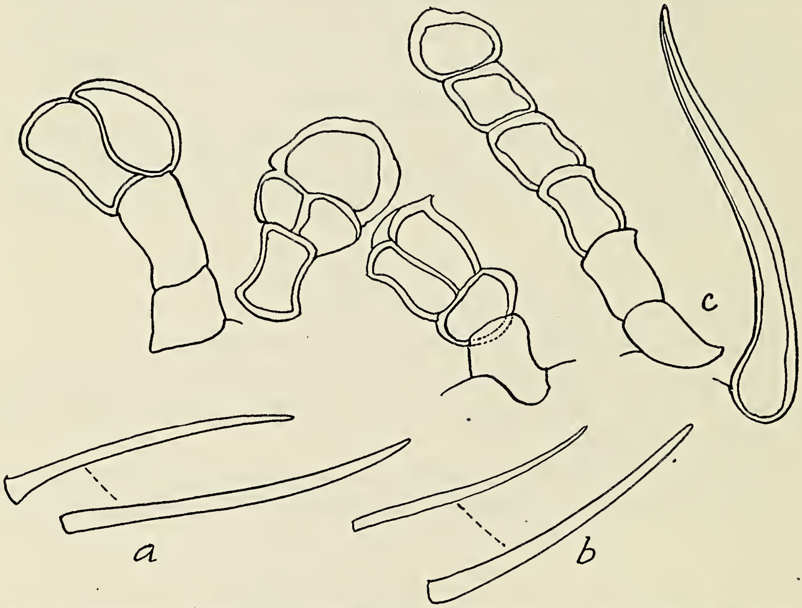

Fig. 2. Trichomes of *Quercus Gambellii*; (a) simple hairs from leaf margin, (b) from stem, (c) from stipules: glandular hairs and simple trichome
Drawn by C. M. King

Trichomes. The stem bears numerous minute hairs; simple, colorless sharp-pointed, about 1/60 inch in length. The hairs upon the stipules are larger (1/30 inch) clear, colorless, slender, pointed.

The trichomes of the upper side of the leaf vary from simple slender sharp-pointed hairs to stellate trichomes with several (2-5) rays. Upon the under side of the leaves the hairs are simple.

Along the margins of the leaves are numerous colorless hairs.

Pasania densiflora Oerst.

Specimens collected near Redlands, California, September, 1921, by L. H. Pammel.

Fig. 3. Seedling of *Pasania densiflora.* Acorns of same tree
Drawn by C. M. King

Planted in the greenhouse October 1, 1921. Seedling appeared at the surface of the ground the middle of December. The fruit about 1½ inches long, nearly an inch in diameter, ovoid, gently rounded to the apex; woolly about the apex, color uniform light brown. Cup shallow, bracts spreading. Germination hypogaeous.

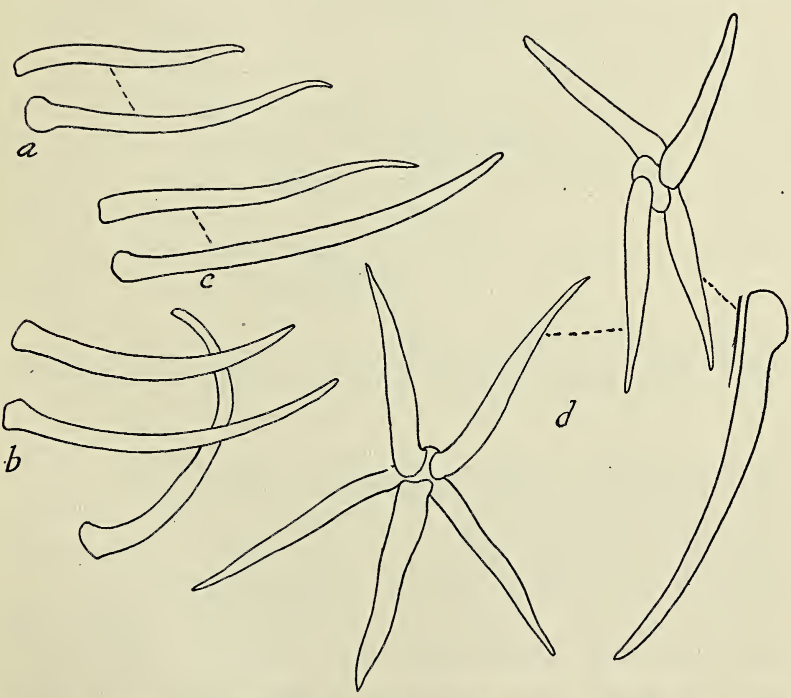

Fig. 4. Trichomes from seedling of *Pasania densiflora*; (a) stem, (b) leaf margin, (c) stipules, (d) stellate and simple hairs from upper surface of leaf
Drawn by C. M. King

Hypocotyl slightly pubescent. Early scales upon the stem, small.

First leaf 3/8 of an inch in length; lower surface puberulent, stipules green, fugacious; upper surface puberulent. Second leaf bright green below, prominently veined, coarsely dentate; upper surface puberulent, margin slightly hairy. Third leaf much like the second; coarsely dentate. Young shoots of rusty color.

Trichomes. The hairs upon the stem are numerous, simple, slender, sharp-pointed, 1/100 to 1/50 of an inch in length.

Upon the stipules are simple hairs (from 1/75 to 1/60 inch) and numerous glandular hairs composed of three to seven cells; the terminal cells are in groups of two or three; these with some of the preceding simple cells, have a yellowish content; the basal cells are colorless.

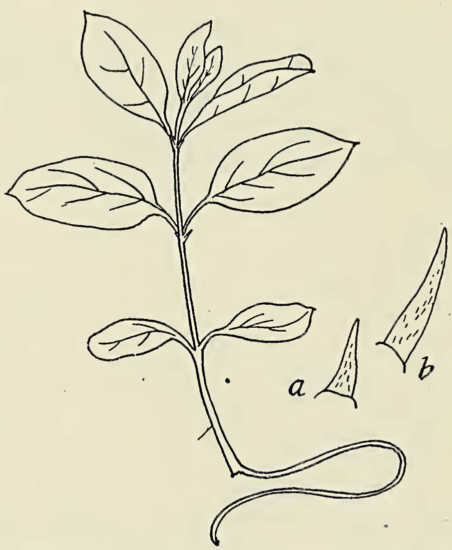

Fig. 5. *Maclura pomifera*, seedling with hairs (a) from leaf edge, (b) from stem
Drawn by C. M. King

Maclura pomifera. (Raf.) Schneider. Osage Orange.

The seedling of osage orange studies was brought in July 10 from locality of Ames.

The two cotyledons, thick, oval, obtuse, entire; petiole short; shining dark green above, paler beneath, pinnately nerved.

Stem erect, terete, herbaceous, becoming woody; covered with short hairs; first internode one inch in length. First pair of leaves lanceolate, entire acuminate, bearing minute hairs; pinnately nerved. Petioles hairy, short, channelled. Stipules acute, hairy.

Fig. 6. Seedling of *Prunus caroliniana*
Drawn by C. M. King

Prunus caroliniana. Ait. Mock Orange.

Seeds received from Dr. Morton, Greenville, South Carolina. Stratified out of doors in garden soil through the months of January and February, 1922; winter mild. Planted about March 1 in greenhouse. Germinated April 1.

Germination hypogaeous, seed remaining below the surface.

Leaves alternate, first two small, 1/4 inch long, the following leaves increasing in size, light bright green. Leaves laurel-like, firm, entire. Petioles short. Stem reddish, slightly clothed with fine hairs. Hairs on petiole and scattered along margin of leaves.

Rhus Toxicodendron. L. Poison Ivy.

Seeds stratified out of doors. Planted in greenhouse February, 1922. Cotyledons appeared March 28.

The stem below, slightly reddish, broadly elliptical, about ½ inch in length, stalked; slightly reddish above, lower surface paler and greener in color. Surface smooth, midrib prominent, lateral veins distinct. Leaves alternate, petioled, compound with three leaflets.

The lateral leaflets with prominent dentate teeth, midrib conspicuous, lateral veins prominent, smooth, lower surface pale, upper surface reddish. Second leaf like the first; terminal leaflet larger than the others, prominently dentate; margins hairy; stem slightly pubescent.

Trichomes. On edges of leaves, small, colorless; on stem small, weak, colorless.

Rhus canadensis. Marsh.

Seeds collected at Salt Lake City, September, 1921, by L. H.

Fig. 7. Seedling of *Rhus Toxicodendron.* Trichomes, edge of leaf (a); stem (b)
Drawn by C. M. King

Fig. 8. Seedling of *Rhus canadensis*
Drawn by C. M. King

Pammel. Planted in greenhouse October 1. Showed germination the middle of December.

Germination epigaeous. Hypocotyl reddish, surface granular. Cotyledons somewhat fleshy, long stalked, petiole grooved, reddish. Cotyledons green upon both surfaces. Stem above the cotyledons, granular or scurfy, whitish. First leaf 3-parted, long petioled; the leaflets prominently veined, smooth upon both surfaces; first pair of leaflets entire, terminal leaflet serrate. Second leaf like the first, except that each leaflet is coarsely 3-lobed; leaflets smooth.

Gleditsia aquatica. Marsh. Water Locust.

This seed was supplied by Dr. Morton of Greenville, South Carolina. The seeds were placed out of doors in garden soil during the months of January and February, 1922; the winter was mild.

The last of February they were planted in pots in the green-

Fig. 9. Seedlings of *Gleditsia aquatica*
Photo by E. H. Richardson

house. May 1 the large cotyledons appeared above the soil, followed by strong rapid growth of the young plant.

Germination epigaeous. Cotyledons fleshy, elliptical, sessile; at first yellowish becoming bright green above, paler beneath; stem below the cotyledons smooth, whitish.

Cotyledons lifted out of the soil in position parallel to the stem, base first. Leaves alternate, leaflets at first appressed. Leaves pinnately compound, leaflets oval, about seventeen in number.

Rhamnus californica. Eschscholtz. California Buckthorn.

Seeds obtained by L. H. Pammel, at Yosemite Park, California.

Seeds scratched and planted in greenhouse January 16, 1922. Germinated February 25, 1922.

Germination hypogaeous. Young stem reddish below, slightly

Fig. 10. *Rhamnus californica.* Seedlings at two stages, early stage showing outer seed-coat raised on tip of cotyledons
Drawn by C. M. King

puberulent. First leaves alternate, stipules small. First leaf finely serrate, 3d and 4th more coarsely serrate. The broad base of these leaves broadly ovate, prominently veined, bright green above, shiny; paler beneath. Stem between the 2d, 3d, 4th and 5th leaves more pubescent than below.

Rhamnus tinctoria. Waldst and Kit.

The seeds of this species were received from the Brooklyn Botanic Garden and planted in the greenhouse the last week of March. The first seedling germinated June 15.

Germination epigaeous. Cotyledons obcordate, prominently reticulately veined, pale green below, dark green above. Stem, and stalk of cotyledon slightly granular.

First and second leaves small, alternate; stipules erect, glandu-

Fig. 11. Seedling of *Rhamnus tinctoria,* two stages
Drawn by C. M. King

lar pubescent. First leaf lanceolate, serrate, pale below, dark green above. The midrib of the first leaf with minute hairs. Third and succeeding leaves similar to first, except somewhat larger.

Fig. 12. *Shepherdia argentea*, seedling two stages, early stage, showing outer seed-coat raised on tip of cotyledons

Drawn by C. M. King

Shepherdia argentea. Nutt. Buffalo Berry.

The seeds were planted in the greenhouse March 6, 1922.

Germination took place about July 1.

The seed covering is lifted above the ground on the tip of the emerging cotyledon.

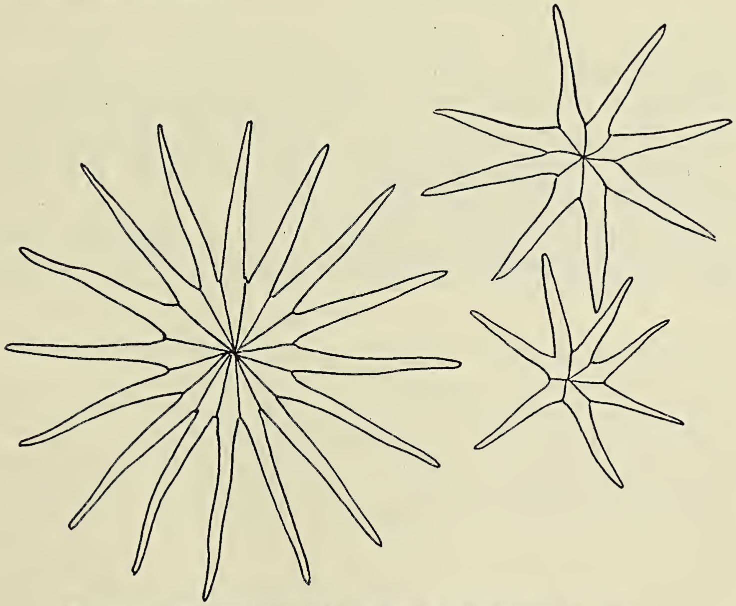

Fig. 13. Stellate trichomes from leaf of *Shepherdia argentea*

Drawn by C. M. King

Hypocotyl smooth, green, about one-half inch in length. Cotyledons oblong, obtuse, about 1/3 of an inch long, round auricled to cordate at the base, somewhat thick, bright green, surface granular above.

Stem slightly hairy, green. First internode 1/3 to ½ of an inch long; first pair of leaves opposite, lanceolate, acute, entire, midrib prominent, both sides bearing numerous stellate hairs. Second pair of leaves slightly larger, less acute, venation more distinct. Leaves with numerous characteristic stellate hairs above and below; petioles short.

Trichomes. On both sides of the leaves are borne stellate hairs, of three to sixteen rays. These hairs are colorless. They give the leaves a scurfy appearance.

Fig. 14. Seedling of *Lycium halimiflorum*
Drawn by C. M. King

Lycium halimiflorum. Mill. Common Matrimony Vine.

The seeds of this plant were gathered from the vines in March, 1922. They were planted in the greenhouse on March 17, 1922.

April 20, cotyledons appeared; slender lanceolate, pale below, green above; smooth stem slightly reddish.

Leaves alternate, entire, crowded, oblong to spatulate — lanceolate. Petiole grooved. Branchlets appearing in axil of leaves.

THE SPECIES OF RHAMNUS IN SOUTHWESTERN UNITED STATES AND THE PACIFIC COAST AND PUCCINIA CORONATA

L. H. PAMMEL

Brewer and Watson[1] in the Botany of California list four species and one variety of the genus Rhamnus in California as follows: *Rhamnus alnifolia, R. crocea, R. californica* and var. *tomentella* and *R. Purshiana.* Jepson[2] in his Flora of Western Middle California lists three species and two varieties, the only addition to that of the flora of California being the variety *ilicifolia.* Trelease[3] in his revision of North American Rhamnus records the following species and three varieties of Rhamnus of Western United States: *Rhamnus crocea* Nutt and var. *pilosa, R. alnifolia, R. Purshiana, R. Californica* var. *tomentella* and var. *rubra.* Coulter[4] lists two of the Pacific Coast species in Western Texas, the *R. Purshiana* and *R. californica.* It is not probable that either of these species occurs in the mountains of Western Texas as reported. The recorded western species are referable to other species occurring in New Mexico and adjacent regions west and north. Wooten[5] however recognizes none of the Pacific coast species. The four species enumerated by him are *R. fasciculata, R. Smithii, R. ursina* and *R. betulaefolia.* These species were segregated by Greene from the Pacific coast species previously recorded for the region.

It is interesting to note that there are only two native species of Rhamnus in Iowa, namely *R. lanceolata* and *R. alnifolia,* besides the occasionally naturalized *R. cathartica.* The Pacfic coast species of buckthorn are extremely variable and it is doubtful whether the number of species recognized by some North American botanists is entirely justified.

Rhamnus California Esch. is one of the most common and variable species of the genus in California. This is a tall shrub, with somewhat tomentose twigs, lower surface of leaves glossy or pubescent, upper surface dull green. The California buckthorn produces fruit abundantly. It occurs on margins of streams or forms a low undergrowth in coniferous woods. The altitudi-

1 1: 100-101.
2 251-252.
3 Trans. Acad. Sci. St. Louis 5; 365-367; 1892.
4 Botany of Western Texas: Contr. U. S. Nat. Herb. 2; 60; 1891-1894.
5 Flora of New Mexico: Contr. U. S. Natl. Herb. 19; 414-415; 1915.

nal range varies greatly, from nearly sea level to 6,500 feet and over. We find this species represented in I. S. C. herbarium from the following localities in California.

Yosemite, Mariposa Grove, California (L. H. Pammel)
Yosemite Valley, Glacier Point, California (L. H. Pammel)
San Francisco, California (C. C. Parry)
North American Pacific Coast (2 specimens)
Monterey
Yosemite, Merced Canyon between El Portal and Power Plant (L. H. Pammel)
Belden, California (L. H. Pammel)
Patterson, somewhat pubescent leaves (L. H. Pammel)
Fairfax, California (Katherine Jones)
Los Angeles County, California (H. E. H.)
Also in the canyons of the mountains near Pasadena, the Sierra Madre (L. H. Pammel)

The so-called *Rhamnus rubra* (Green) is evidently nothing more than a form with reddish glabrous twigs and narrowly obovate or oblong lanceolate leaves. We have this from Butte County, Forest Range, altitude 2400 feet, No. 11404 (A. A. Heller), between upper Soda Springs and Shasta Retreat.

Rhamnus tomentellus Benth. This is the *R. Californica* var. *tomentella* Brewer and Watson. It is a rather low spreading shrub with leaves and twigs densely tomentose below. It is a very striking shrub, growing in rather dry soils and on banks of streams. From a distance it has the aspect of an olive tree. We have it in the I. S. C. herbarium as follows:

Live oak, California, banks of Feather River (L. H. Pammel)
Merced Falls, banks of Merced River (L. H. Pammel)
California 1889 (C. C. Parry)
California Mountains
Blairsden (L. H. Pammel)
Gridley (L. H. Pammel)
Marysville Butte (No. 11358) (A. A. Heller)
Mud Flat, Newville, Covelo road Glenn County, (No. 11534) (A. A. Heller)

Rhamnus Purshiana DC. The sagrada is found only in the mountains of northern California and in the coast range, generally north of the Bay region to Oregon and Washington. It is a small tree with slightly pubescent twigs, leaves thinner than the California buckthorn, mostly thin and dull green, petioles pubescent. We have it in the herbarium from:

Mill Valley, California with *Sequoia sempervirens* (L. H. Pammel)

Washington, No. 3885 (A. A. & Gertrude Heller)
Defiance Park, Tacoma, Washington (L. H. Pammel)

Rhamnus Smithii Greene. This species was described by Greene[6] from specimens collected at Pagosa Springs, southwestern Colorado, and its range is given as southern Colorado and northern New Mexico. E. O. Wooten and P. C. Standley[7] record it from Chana between Tierra Amarilla and Park View in New Mexico. The only specimens I have seen are those of Miss Florence Willey, from Pagosa Springs, Colorado, and another from the same place by Willey, Clokey and Bethel. This seems to me to be closely allied to *R. Californica* in some respects. Perhaps it should be regarded as distinct.

Rhamnus Nevadensis Aven Nelson. Dr. Aven Nelson[8] has described this species from Nevada and states that it differs from *R. Californica* Esch in its non-coriaceous leaves and its short calyx lobes. The *R. Californica* in the Rocky Mountain herbarium, collected at Verdi, Nevada, by B. P. Kennedy, No. 953, and the one collected by Marcus E. Jones at Reno seem to me to be pretty closely related to *R. Californica*. There are some slight differences in the leaves of the Nevada specimens, which are somewhat more narrow than *R. Californica*. I do not find much difference in the calyx lobes. The California buckthorn is an extremely variable plant.

Rhamnus alnifolia L. Her. This is a low shrub with pubescent branches, leaves short petioled, ovate or broadly elliptical, glandular serrate. It is of course a common species in the northern states, not common in California. We have the following specimens in our collection from the west and northwest.

Sierra County, California (J. G. Lemmon)
Northern Pacific Coast (C. C. Parry)
Obsidian Creek, Yellowstone National Park (Aven and Elias Nelson)
Bitter Root Valley Warm Springs Creek (L. H. Pammel and H. S. Fawcett)

Rhamnus crocea Nutt. This is an evergreen low spreading shrub with reddish bark, leaves glossy, roundish or broadly ovate or elliptical, glandular dentate. This species has the most restricted distribution. It evidently belongs to the Mexican flora and is most common in Southern California. Specimen were collected by Parry near San Diego (Mexican Boundary Survey),

6 Pittonia 3: 17.
7 Flora of New Mexico, 415.
6 Proc. Biol. Soc. of Wash., 18: 174.

soil rather dry. We have it in the collection from the following points.

No label (probably California) (C. C. Parry)
Yosemite Valley, Yosemite Falls (L. H. Pammel)
North Pacific Coast Flora (C. C. Parry)
San Diego, California, Mexican Boundary Survey (C. C. Parry)
Ione, California (C. C. Parry)
var. *ilicifolia* Kellogg of *R. insulis* Kellogg
Southern California No. 41 (Parry and Lemmon, 1876)
Fall Brook (C. C. Parry)

CROWNED RUST AND RHAMNUS

I was requested by Dr. I E. Melhus to look for species of Rhamnus and the uredo spores of *Puccinia coronata,* especially on *Lolium perenne, Holcus lanatus* and other grasses on which it occurs. The perennial rye grass was rather common in the Rio Grande Valley, Fort Bayard, New Mexico, and at San Diego, Los Angeles, Patterson, Yosemite, Wawona, Berkeley and Sacramento, California. The *Holcus lanatus* is a common grass in clearings and meadows in the Sierra Mountains of California. Thus it occurs in the Yosemite Valley at Blairsden and Wawona. Velvet grass is one of the common meadow grasses of the mountain region. The time of my visit was in August, naturally dry and in places where irrigation was practiced, I expected to find some form of *Puccinia coronata.* It was, however, rare. I examined thousands of leaves of this grass, but in no case except at Wawona did I find any *Puccinia coronata.* Wawona is on a branch of the Merced River and the plot of grass where I found uredo spores was irrigated. Here the rust was fairly common on the leaves of *Holcus lanatus.* There were some *Rhamnus Californica* near it. I should judge therefore, that *Holcus* is not a favorable host of the infection of the rust from *Rhamnus Californica* in California. How common the aecial stage may be on the *Rhamnus Californica* I do not know. One would expect to find the *Puccinia coronata* on the introduced species of the *A. fatua* and its variety as well as on *A. barbata* the two wild species of oats of California, but I did not find any of the teleutospores though these grasses are common in many parts of California, like Berkelely, Los Angeles, Patterson, Merced Falls and San Diego. I also observed numerous young green leaves of *Avena fatua* along irrigation ditches but no rust infection.

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THE EFFECT OF WEEDS UPON CROP PRODUCTION

A. L. BAKKE AND L. H. PAMMEL

Weeds have an important bearing on the extent and the character of the crop produced. An examination of any developing crop during the growing season brings the issue to the foreground. In the case of pasture land the efficiency is much reduced by allowing weeds to grow. One of us[1] has found that more than 39 per cent of the pastures of Iowa contain the small ragweed (*Ambrosia artemesiifolia*) which not only prevents the growth of blue grass but also makes it difficult for cattle to graze. What has been specifically stated for pasture land is as pertinent to other crops in varying degrees.

It has been pointed out by Livingston[2] that transpiration is practically a simple function of the leaf surface and that the total transpiration is a measure of the growth of a plant whether it is one growing in a waste place or of economic importance. Hunt[3] makes the assertion that weeds are harmful because they exhaust the moisture from the soil. Corn plots on which weeds grew contained less moisture than plots kept cultivated. The yield was much greater where weeds were not allowed to start until June 27 instead of June 14.

Kiesselback[5] makes it clear that weeds such as sunflowers give off more than three times as much water per plant as corn, while the water used per unit of dry matter was slightly more than double that of corn. In other words, a sunflower plant will consume as much water as a hill of corn. Brenchly[6] in a recent publication states that weeds like mustard (*Brassica*) did better when they were associated with other plants than when they were subjected to the competition of their own species. Wheat is more effec-

1 Pammel, L. H., Are the pastures of Iowa producing effciently Ia. Agriculturist, **21**, 103-104; 1920.

The weed flora of Iowa: Iowa Geological Survey, Bull. **4**; 1913, Des Moines, Iowa. See p. 669.

2 Livingston, B. E., Relation of transpiration to growth in Wheat: Bot. Gaz., **40**, 178-195; 1905.

3 Hunt, Thomas F., The importance of nitrogen in the growth of plants: Cornell Univ. Exp. Sta. Bull. 247; 1907.

5 Kiesselback, T. A., Transpiration as a factor in crop production: Nebraska Agri. Exp. Sta. Res. Bull. **6**; 1915.

6 Brenchly, Winifred E., The effect of weeds upon cereal crops: New Phytol. **16**, 53-76; 1917.

tive in reducing the growth and development of other weeds than *Brassica*. According to Brenchly, mustard would then, even in moderate amounts, do considerable damage. Gates and Cox[7] have arrived at the conclusion that weeds make the cultivation of corn necessary.

Possibly in the majority of places, even in the agricultural areas of the Middle West, there are times in which there is not enough water to supply the needs of the plant. Water is used by a plant in large quantities and practically all of it passes off in the transpiration stream. Water is an important item and its conservation is a question with which we must be concerned. From the few citations given above it is evident weeds do considerable damage to growing crops by consuming the moisture. Knowing that transpiration or the giving off of water by the aerial portions of a plant goes hand in hand with the leaf area, a study in which the leaf area and transpiration are measured from time to time at specific intervals should give us much information concerning the effect of weeds upon the crop with which they are associated, both in the greenhouse and in the field.

GREENHOUSE TESTS

In a rather extended series of experiments regarding the real* status of the question as to the nature of the competition between mustard (*Brassica*) and wheat and oats which were performed in the Botanical Laboratories at Iowa State College, an attempt was made to determine the amount of water used and the amount of leaf tissue formed, from the time the seedlings appeared, until the grain was mature. In these series of experiments four cultures were given over to wheat, four to oats, one to mustard alone and finally one culture contained only soil. Each of the ten cultures was contained in a galvanized pail 25 by 20 cm. in size, and was made up as follows:

I. WHEAT SERIES

Culture No. 1. Wheat — 7 plants.

Culture No. 2. Wheat and mustard — 5 plants of wheat, 4 plants of mustard.

Culture No. 3. Wheat — 10 plants.

Culture No. 4. Wheat and mustard — 10 plants of wheat, 2 plants of mustard.

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7 Gates, J. S., and Cox, H. R., The weed factor in the cultivation of corn: U. S. Dept. Agric., Bureau Pl. Ind. 257.

* These experiments were made largely by Mr. H. H. Plagge of the Pomology Section of the Iowa Agricultural Experiment Station. He was, at that time, a Fellow in Plant Physiology.

II. OATS SERIES

Culture No. 5. Oats — 7 plants.

Culture No. 6. Oats and mustard — 7 plants of oats, 3 plants of mustard.

Culture No. 7. Oats — 10 plants.

Culture No. 8. Oats and mustard — 10 plants of oats, 4 plants of mustard.

III. MUSTARD SERIES

Culture No. 9. Mustard — 3 plants.

IV. SOIL SERIES

Culture No. 10. Soil.

To determine the amount of water lost during the course of the experiment the plants were weighed on small platform scales three times a week after February 6. As much water as had been transpired each time was added. The soil surface was not coated with a wax mixture or plasticine as it was deemed advisable to permit evaporation to take place unrestricted from both soil and plant. After the first month there is sufficient leaf surface so that the soil evaporation can be considered as negligible compared with the amount of water given off by the plant tissue. The leaf area was measured at the end of each week by means of a polar planimeter. In all cases the leaf area includes both surfaces of the leaf.

No attempt will be made to trace the different increases or decreases during the progress of development. However, the time at which the plants of the different cultures attained their maximum, produces a phase of the weed question which has not been adequately considered before. The time at which the maximum leaf area is formed coincides with the period at which the grain is ready to head out. There are no apparent differences in the time of maturity. The time for the formation of the grain is then decreased.

It is apparent that a mixed culture of wheat with mustard and of oats with mustard attains its maximum leaf area at a latter period than does a pure culture. In the case of spring wheat especially, as far as rust is concerned, this item becomes an important proposition. It also appears that the same is true for transpiration. In culture 6 the maximum transpiration is recorded as occurring at the same time as in culture 5. But the mustard in culture 6 was completely eliminated, so the culture as a whole assumed a condition similar to culture 5 where no mustard plants were present.

TABLE 1

TIME AT WHICH THE WHEAT AND OATS PLANTS ACQUIRE THEIR MAXIMUM VALUES

Culture	Maximum leaf area		Maximum Transpiration	Maximum rate of Transpiration
	Cereal	Mustard		
Wheat				
No. 1	March 30		April 11	May 21
No. 2	April 11	April 6	April 16	May 21
No. 3	March 16	March	March 16	May 21
No. 4	April 6	February 16	March 18	May 25
Oats				
No. 5	April 20		May 21	May 25
No. 6	April 28	February 16	May 21	May 25
No. 7	March 30	March	March 19	May 21
No. 8	April 6	February 9	April 11	May 21

The extent to which a weed like mustard will use up water and compete with a crop in which it is grown is shown in Table 2 taken from the same series as is recorded in Table 1.

TABLE 2

HEIGHT, DRY WEIGHT AND AMOUNT OF WATER TRANSPIRED BY WHEAT WITH MUSTARD, OATS AND OATS WITH MUSTARD CULTURES, FOR A GROWING SEASON

Culture	Maximum Height		Dry Weight	Transpiration
	Cereal	Mustard		
Wheat				
No. 1	110 cm.		127.80 gm.	53.30 kgm.
No. 2	109 cm.	66 cm.	91.61 gm.	54.56 kgm.
No. 3	86 cm.		68.10 gm.	33.66 kgm.
No. 4	90 cm.	31 cm.	57.95 gm.	33.86 kgm.
Oats				
No. 5	80 cm.		117.95 gm.	47.58 kgm.
No. 6	73 cm.	7 cm.	60.30 gm.	48.55 kgm.
No. 7	62 cm.		60.30 gm.	31.11 kgm.
No. 8	68 cm.	15 cm.	52.38 gm.	28.34 kgm.

In this table, comparison cannot be made between the wheat series and the oats series indiscriminately, for cultures 3, 4, 7 and 8 have too many plants and consequently there was a competition between the members of the same variety. Inasmuch as the same number of plants were not used, comparison can be made only between each pair in the order given.

It is noticed that there is not a material difference in the height of the wheat and oats plants. In the wheat series, the mustard plants attain a greater height than in the oats series. This suggests immediately that the oats is a better plant than wheat to use in the elimination process for the eradication of a weed like mustard. The oats series also show that it is disadvantageous to place too many plants on the same area, or in other words to plant too thick, even if a crop is grown simply to eradicate weeds.

In each case the dry weight of the pure culture of wheat alone or of oats alone is greater than is the case with mixed cultures.

With one exception, it is found that the total transpiration for the mixed culture is greater than for the pure wheat and oats cultures. The present study shows that wheat transpires more than oats during a growing season.

FIELD STUDIES

A series of field tests were made to determine the extent to which weeds would encroach upon such a crop as corn.

In these series, an attempt was made to ascertain the effect of various cultivation treatments. Plots a meter square were used.

The field work was carried on by Mr. R S. Kirby during the summer of 1917. Mr. Kirby determined the amount of green weight produced but neglected to ascertain the water requirements or the amount of water necessary for the production of a unit amount of green weight. It is known that the amount of water given off in twenty-four hours is approximately equal to what is absorbed during the same period and that a negligible amount is used in the increased material of the tissues. The authors realized this, but it was not until the summer of 1921* that they were able to conduct experiments to determine this water relation. At this time a series of plants — purslane, crab grass and pigweed — were grown in galvanized iron containers or pails of the same dimension as given previously, without sealing over the soil surface.

Of course there was some error due to this but deductions were made by having the soil only, in one container. An average was made from the seven cultures having crab grass, purslane and pig weed of the amount of water used at the time the plants were fully headed out and seed set. This was on August 15. The data obtained here were used as a basis for the amount of water transpired. It will be noticed that the collections were made from August 8 to August 16.

From what is known concerning the structure and development of corn, the data supplied from the weed cultures during the summer of 1921 cannot be used for corn. However, it is the water relation of the weeds which prompts the attention in this particular study.

* It is with pleasure that the authors hereby recognize the assistance of Mr. Oliver Miller.

FIELD EXPERIMENT NO. 1

Ground plowed before seeding; corn planted June 10; no cultivation; weeds allowed to grow. Measurements and collections made August 8. Data given in Table 3.

TABLE 3

CORN—NO CULTIVATION

Soil moisture 18.7 per cent

Designation	No. of Plants	Aver. Height cm.	Green Weight gm.	Amount Water Given Off for Growing Season gms.
Corn-stalks very slender. Leaves light yellow in color	2	71		
Polygonum pennsylvanicum (ripe seed)	10	122	1,160	82,636.08
Polygonum persicaria (seed almost ripe)	4	71	175	12,466.65
Polygonum convolvulus (seed ripe)	4	244	153	10,899.41
Convolvulus sepium (bloom)	1	391	32	2,279.62
Oxalis stricta (seed ripe)	3	12	8	356.19
Amaranthus retroflexus (bloom)	6	10	5	569.90
Setaria glauca (seed ripe)	1	79	19	1,353.53
Setaria viridis (not headed)	202	48	740	52,716.12
Panicum capillare	6	48	21	1,496.50
Total for all weeds	237		2,313	164,774.00

FIELD EXPERIMENT NO. 2

Ground plowed before seeding; corn planted June 10, weeds removed for a distance of a radius of 30 cm. from hill; later allowed to grow. Weeds cut off at ground by hoe July 13. Measurements and collections made August 16. Data for the partial cultivation are given in table 4.

TABLE 4

CORN—PARTIAL CULTIVATION

Soil moisture 14.6 per cent

Designation	No. of Plants	Aver. Height cm.	Green Weight gm.	Amount Water Given Off for Growing Season gms.
Corn-stalks slender and light yellow in color	3	91		
Polygonum persicaria (seed ripe)	25	43	450.0	32,057.10
Chenopodium album (seed ripe)	2	58	30.0	2,137.14
Portulaca oleracea	3	52	1.5	106.76
Setaria glauca (seed ripe)	23	61	164.0	11,683.03
Setaria viridis	95	40	200.0	14,247.60
Echinochloa crusgalli (seed ripe)	20	63	139.0	9,901.98
Panicum capillare	3	31	5.0	356.19
Total for all weeds	171		989.5	70,489.80

FIELD EXPERIMENT NO. 3

Ground plowed before seeding; corn planted June 10; hoed June 29; cultivated July 12. Measurements and collections made August 11. Data submitted in table 5.

TABLE 5

CORN — PARTIAL CULTIVATION

Soil moisture 6.17 per cent

Designation	No. of Plants	Aver. Height cm.	Green Weight gm.	Amount Water Given Off for Growing Season gms.
Corn	2	162		
Polygonum persicaria (ripe seed)	4	31	20	1,424.76
Portulaca oleracea	2	5	9	631.14
Digitaria sanguinalis (seed formed)	1	76	55	3,918.09
Setaria viridis	10	22	270	19,234.26
Echinochloa crusgalli (seed formed)	6	53	110	7,836.18
Total for all weeds	23		464	33,054.43

FIELD EXPERIMENT NO. 4

Ground plowed before seeding; corn planted June 18 when weeds were removed near hills; corn hoed June 29 and July 6. tion given in table 7.

TABLE 6

CORN — PARTIAL CULTIVATION

Soil moisture 14.5 per cent

Designation	No. of Plants	Aver. Height cm.	Green Weight gm.	Amount Water Given Off for Growing Season gms.
Corn — tasseling out; healthy green color	2	173		
Portulaca oleracea	3	13	15	1,068.57
Euphorbia maculata	4	10	5	356.19
Total for all weeds	7			1,424.57

FIELD EXPERIMENT NO. 5

Ground plowed before seeding; corn cultivated on following days; July 6, July 9, July 31, August 15. Data for full cultivation given in table 7.

The data submitted in the tables show that a crop like corn is seriously affected when weeds are grown with it. In field experiment No. 1 where there was no cultivation, the corn stalks

TABLE 7
CORN — FULL CULTIVATION
Soil moisture 15.2 per cent

Designation	No. of Plants	Aver. Height cm.	Green Weight gm.	Amount Water Given Off for Growing Season gms.
Corn — tasseling out, strong and healthy	2	192		
Portulaca oleracea (weed total)	6	5	8	474.13
Total for all weeds	6			

were only 71 cm. in height while in the full cultivation experiment the height was 192 cm.

In the same area, there is recorded a water outgo of 164,774 grams of water from the uncultivated plot as compared to 474 cm. for the full cultivation plot. For the plot given four cultivations, there is of course a greater amount of water given off by the corn plant due to a larger leaf surface.

In field experiment No. 2 (table 4) the weeds were removed at a distance of 30 cms. from the hill at time of planting and then allowed to grow. The average height of the corn was 91 cms., total number of weeds 171, and water loss of 70,489.8 gms. But even under this meager treatment there were 66 less weeds and a difference of 94,285.20 grams. Proceeding in order from table 4, each additional cultivation measure gives a smaller transpiration loss and at the same time, corn plants of greater height and vigor. It is clearly evident that cultivation is beneficial.

Usually the leaf area is an accurate index of water loss. However such weeds as the two common bindweeds, *Convolvulus sepium* and *Polygonum convolvulus* are climbing and as such compete by this particular means as well.

As to the kind of treatment it is interesting to note the effectiveness of hoeing. In experiment 4 (table 6) the plot was hoed twice while in Field Experiment 5 (table 7) there were four cultivations. In the former there are seven weeds, while in the latter there are six. However, there is considerable difference in size and development, for the hoed plot (table 6) evaporates 1,424.57 grams, while for the full cultivation there is an evaporation of 474.13 grams. The data of these two tables at least indicate that two hoeings are not, under these conditions, as effective as four cultivations. But at the same time one hoeing is superior to one cultivation (see tables 5 and 6). Throughout it is clear that the proposition calls for an increased development with higher water loss by the crop itself, and an elimination of water loss through the weed channel.

SUMMARY

The results submitted in this paper from greenhouse and field experiments show that:

1. Weeds give off a large amount of water.
2. A mixed culture, that is, one having both cereals and weeds growing under the same conditions on an equal surface area, will give off more water than a pure culture containing only cereals.
3. A mixed culture reaches its maximum transpiration period at a later date than a pure culture. As there is no material difference in the ripening period, the time interval for the formation of the grain is shortened.
4. A cereal like corn responds readily to cultivation.

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DESCRIPTION AND KEY OF THE GENUS CUCURBITA

FRED C. WERKENTHIN

ORIGIN OF CUCURBITA SPECIES

J. H. Trumbull, in a letter quoted in Bull. Torrey Bot. Club, Vol. *6*:69-70; 1876, states, "I could never discover *where the doubt came in,* as to the American origin of several well-known varieties of these gourds, or Millions as some call them, or Pompions as I may call them. In England, the name 'squash' was understood to be of American origin. Robert Boyle mentions his experiment with the seed of 'squash' which is an Indian kind of pompion that grows apace." "Beverley (History of Virginia, 124) describes the Macocks as 'a sort of Melopepones, or lesser sort of Pompion or Cashaw' *squash,* or *Squouter-squash,* which is their name among the northern (i.e. New England) Indians." According to Alphonse de Candolle in "Origin of Cultivated Plants, 1892," the pumpkins cultivated by the Romans and in the middle ages were *Curcurbita maxima,* and those of the natives of North America, seen by different travelers in the seventeenth century, were *Cucurbita Pepo.*

ORIGIN OF SPECIES

Dr. Asa Gray in American Journal of Science and Arts, Second Series, Vol. *24*:440-443; 1857, states "Dr. Harris has become satisfied that the North American Indians as far north even as Canada, cultivated squashes and pumpkins, one or both, along with the maize, before the whites were established here." According to Nuttall, the Indians along the whole upper Missouri half a century ago were cultivating *Cucurbita verrucosa.* This common squash is, according to Naudin, a variety of *C. Pepo,* as also is *C. aurantia* (the *C. texana vel. ovifera,* Gray. Pl. Lindh.) which has every appearance of being indigenous in the western part of Texas, on the Rio Colorado and its upper tributaries. At least, this is the opinion of Mr. Lindheimer and of Mr. Charles Wright.

According to George Don, in General System of Gardening and Botany, Vol. *3*: 40, 1834, the native country of *C. maxima* is unknown, that of *C. moschata* is Martinique and that of *C. Pepo* is the Levant.

Origin of Pumpkins and Squashes according to L. Wittmack, Die Heimat der Bohnen und Kürbisse; Bericht. Deut. Bot. Gesell. *6*:374-380, 1888. Favors the American origin.

Naudin believes that all species of *Cucurbita,* e.g. *C. Pepo, C. maxima* and *C. moschata,* originated in the old world. He says in his "Nouvelles Recherches" that *C. Pepo* most likely was known to the Greeks and the Romans. The other two are more modern, as their introduction into European gardens does not date back over two hundred years.

Alphonse de Candolle in his "Origine des plantes cultivées," p. 199, says the native country of *C. Pepo* is America, while on the other hand he believes that *C. maxima* is a native of the old world.

Among other objects Wittmack found seeds of normal size of *C. maxima* and *C. moschata* in old Peruvian tombs. Naudin himself identified some of the smaller seeds as belonging to *C. moschata.* On that account it seems clear that these two species are of American origin.

In the tombs of the old world no pumpkin or squash seeds have ever been found.

No descriptions of any species of Cucurbitaceae written before the discovery of America are in existence; not until the 16th century are such descriptions found. Asa Gray and Hammond Trumbull have tried to prove that the pumpkin was in existence in North America before Europeans entered the continent.

Gray and Trumbull in Am. Jour. of Sci. *25*: 370-379, 1883, 3rd series, state that in the Geographie Botanique not one of the cultivated cucurbits is attributed to America, and a reference to Nuttall's record that the warted squash was grown by the Indians on the upper Missouri is the only mention of any aboriginal cultivation of squashes in North America.

Yet we find abundant evidence, especially as respects North America — (1) that in various parts of the country, remote from each other, the cultivation of one or more species of cucurbits by the Indians was established before those places are known to have been visited by Europeans; (2) that these species or varieties were novel to Europeans, and were regarded by botanists of the

16th and 17th centuries, as well as by the voyageurs and first colonists, as natives or denizens of the region in which they were found; and (3) that they became known only under American names; one of these names (squash) becoming, in popular use, generic, and two others (Macock and Cushaw) surviving as names of varieties into the present century.

Through E. L. Sturtevant, "The History of Garden Vegetables," the American Naturalist *24*: 727-744, 1890, we learn that "The word squash seems to have been derived from the American aborigines, and in particular from those tribes occupying the northeastern Atlantic coast, and seems to have been originally applied to the summer squash, as by Wood (New Eng. Prosp., Pt. II., c. 6.), when he says, "In summer, when their corn is spent, isquotusquashes is their best bread, a fruit much like a pumpkin."

In 1535 Cartier (Pink. Voy. XII, 656) mentions as found among the Indians of Hochelega, now Montreal, "pompions gourds." In 1586 Heriot (Pink. Voy. 12, 596) mentions in Virginia "pompions melons and gourds," and Captain John Smith (Pink. Voy. 13, 33) pompions and macocks; Strachey (Trav. into Va., 72), who was in Virginia in 1610, mentions macocks and pumpions as differing.

If we consider the stability of types, and the record of variations that appear in cultivated plants, and the additional fact that so far as determined, the originals of cultivated types have their prototype in nature, and are not products of culture, it seems reasonable to suppose that the record of the appearance of types will throw light upon the country of their origin. From this standpoint, we may hence conclude that, as the present types have all been recorded in the Old World since the fifteenth century, and were not recorded before the fourteenth and succeeding centuries, *there must be a connection between the fact of the discovery of America, and the fact of the appearance of pumpkins and squashes in Europe.*

DESCRIPTION OF THE GENUS CUCURBITA

Flores monoici. Masculi in axillis foliorum solitarii; corolla campanulata, usque ad medium 5-loba, staminum connectivis ima basi liberis; antheris flexuosis, in columnam cylindricam coalitis vel agglutinatis, apice exappendiculatis; polline magno, globoso, subtiliter muricato, multiporosa. Foeminei pariter solitarii, staminum trium rudimentis instructi, in fundo nectariferi; stylo crasso, in stigmata 3 biloba vel bifurca papillosa diviso; ovario glabro vel hirsuto, triplacentifero. Pepo saepius magnus, carnosus aut fibrosus, saepe corticosus. Semina ovalia, complanata, margine tumida cincta, vel rarius immarginata.

Plantae utriusque orbis indigenae, herbaceae, annuae aut radice crassa napiformi perennantes; flagellis multimetralibus, humi serpentibus et ad nodos radicantibus, nonnunquam etiam scandentibus. Floribus magnis aut maximis, luteis, peponum carne dulci et tunc eduli aut amara et venenosa.

The members of this genus are annual or perennial, rough-pubescent, almost prickly, trailing, creeping or bushy vines with two-to-many branched tendrils.

Leaf blades, entire or lobed, usually cordate at the base. Fowers showy, solitary, monoecious.

Staminate flowers with campanulate and 5 lobed calyx tube and corolla, the lobes recurved at the ends. Stamens three in number, inserted on the calyx tube. The filaments distinct, anthers linear, cohering, contorted.

Pistillate flowers with calyx and corolla like those described above. Staminodia 3. Pistil 1. Stigma 3-5, each two lobed and papillose. Style short and thick. Ovary one-celled, with three to five placenta. Ovules numerous.

KEY TO THE SPECIES OF CUCURBITA

1. *Annual.* — Leaves with five lobes. Leaf petiole with stiff and prickly leaves. Peduncles of the male and female flowers obtusely 5-angled. Peduncle of the fruit 5 to 8-ridged and deeply furrowed, enlarged next to the fruit. Calyx tube of the male flowers noticeably five-sided.......................... *C. Pepo*

2. *Annual.* — Leaves more rounded than those of *C. Pepo,* but lobed, dark green, velvet, comparatively soft to the touch. Calyx tube not campanulate. Calyx-lobes large, often leaf-like, of dark green color. Peduncles of fruit 5-ridged, prominently enlarged next to the fruit...................... *C. moschata*

3. *Annual.* — Leaves orbicular or kidney shaped, commonly not lobed or with fine short, rounded lobes. Calyx tube of male flowers is campanulate or rather obconical. Corolla tube nearly the same diameter at top and bottom. Peduncle of fruit cylindrical or claviform, soft and spongy at maturity, never ridged...... *C. maxima*

4. *Perennial.* — Leaves large, cordate-triangular, grayish-

pubescent; flowers nearly as large as in *C. Pepo* and similar in shape, the pistillate on a peduncle two to three inches long. Fruit size and shape of an orange, smooth, green, and yellow splashed, not edible..*C. foetidissima.*

5. Leaves pale green, often marbled, in outline ovate or suborbicular, cordate at base, roundly 5-lobed and the sinus rounded. Calyx tube short and campanulate. Fruit large, fleshy, round-ovoid, white-striped, the flesh white....................*C. ficifolia.*

6. Leaf blades 3 to 5-lobed, sometimes deeply so. Pedicels over 5 cm. long. Similar to *C. foetidissima* in habit, but more slender. Perhaps a naturalized form of *C. Pepo*................*C. texana*

DESCRIPTION OF THE SPECIES

1. *Cucurbita Pepo.* — Stems long and trailing, or short and more or less erect, not inclining under the weight of the fruit;

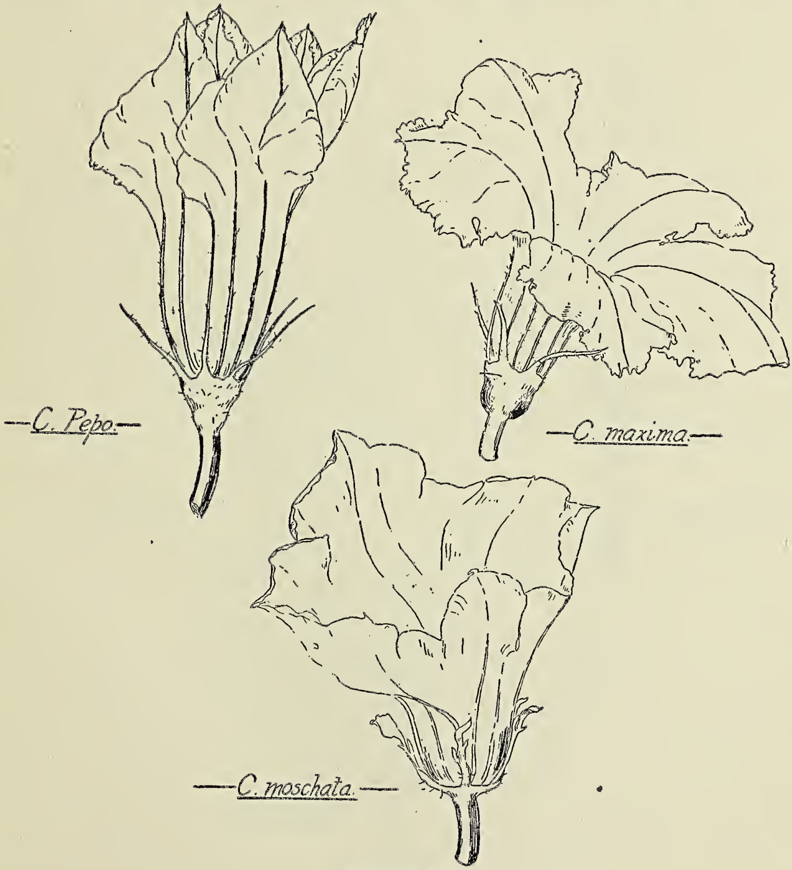

FIGURE 1.

generally polyhedric, with five obtuse angles, often deeply furrowed. The tendrils are ordinarily rudimentary or not at all present in those varieties with short and not running stems. Leaves with five, quite pointed and often quite developed lobes, oftentimes divided into secondary lobes, more or less deeply separated by the sinus. The leaves are generally stiff. Quite frequently the leaves show white triangular spots at the angles of the veins. The leaf, petioles and the underside of the leaves are armed with stiff or prickly hairs. The peduncles of the male and the female flowers are more or less prismatic and obtusely 5-angled. The calyx of the male flowers is quite characteristic. Its tube is noticeably 5-sided, its divisions are generally fleshy and awl-shaped. The corolla is yellow with a little orange. The lobes spread out to some extent. The fruit is extremely variable in form, the dominant type being a reversed ovoid, more or less

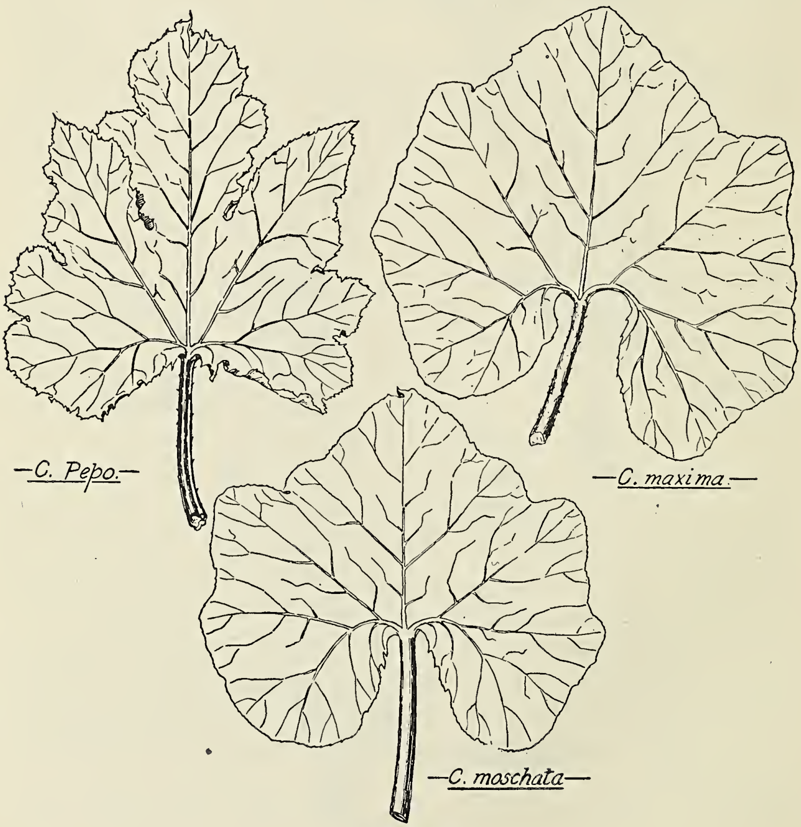

FIGURE 2.

elongated, with or without longitudinal ribs; sometimes smooth. sometimes warty.

2. *Cucurbita moschata.* — The stem of this species has not quite the same diameter as those of *C. Pepo* and *C. maxima.* The stem is nearly cylindrical or slightly 5-sided, and oftentimes shows rather dark spots at the insertion of the petiole. The petioles are cylindrical, with alternate light green and dark green stripes, uniformly hispid, but hardly ever with spiny and prickly hairs. The leaves are of a characteristic dark green, but often they are marked with white triangular spots at the angles formed by the principal veins. The leaves are velvety, or comparatively soft to the touch, round, reniform, denticulately notched at the margin, ordinarily with five or sometimes six sharp lobes, seldom obtuse or rounded, separated by the equally sharp sinus. The male flowers possess very prominent characteristics for this species. While in *C. Pepo* and *C. maxima* the calyx tube is often more or less campanulate, in *C. moschata* the calyx tube is absent or reduced to a sort of plateau, scarcely raised at its borders. The sepals instead of being filiform as among *C. maxima,* or awl-shaped as in *C.Pepo,* are flat, linear, often terminating in one or more lobes, signs of an aborted limb. Oftentimes this limb is developed into a small leaf, more or less rounded and denticular, 10 to 15 millimeters long. The sepals are of a very dark green color which also may be regarded as a special characteristic of this species. The corolla is of a less bright color. The peduncle of the fruit is angular, deeply ridged and swollen where it joins the fruit. The form of the fruit varies to a great extent.

3. *Cucurbita maxima.* — The stems are almost always long and trailing, sometimes short and only a little running, but never upright. Mostly cylindrical or very slightly angled. The leaves are more or less reniform, with five short, obtuse, rounded lobes, oftentimes without any sinus. In some instances the lobes are sharp, but the sinuses which separate them are always little pronounced. The flower peduncle (male as well as female) is cylindrical and not angled. The calyx tube of the male flowers is campanulate or rather obconic, of rounded contour, and does not show any constriction below the point where the sepals are inserted. The sepals are generally narrow, linear, thin, sometimes filiform or totally abortive, very seldom enlarged and not giving the aspect of foliage leaves. The corolla is campanulate, with reflected lobes, generally of a bright yellow color. The peduncle of the fruit is always cylindrical or claviform.

DESCRIPTION OF TYPES AND VARIETIES OF C. PEPO

1. *Thorburn's Connecticut Field Pumpkin.* — Plants with long running stems, five sided, deeply ridged, with stiff hairs. Leaf petiole five sided, from 11 to 13 inches. Leaves 5-lobed, deeply cleft. Male and female flowers long peduncled, length ¾ inch to 1 inch. The fruit is longer than broad, oftentimes ridged, of a golden yellow color.

2. *Summer Crook-Neck Squashes.* — Plants of a bushy character, stems not running. Leaves 5-lobed with stiff hairs. The fruit is decidedly crooked and narrow, the distal part is swollen but terminating in a point, the skin is orange-colored.

3. *Table Queen.* — Stems running, 5-sided, furrowed. Leaves 5-lobed, deeply notched. Short petiole. The fruit is of a dark green (or cream) color, small, deeply furrowed, few in number. Outer skin very hard.

4. *Ferry's Large Yellow Pumpkin.* — Same as No. 1.

5. *Burpee's Golden Oblong Pumpkin.* — Same as No. 1.

6. *Stoke's Big Tom Pumpkin.* — Leaves 5-lobed, not so deeply cleft. No white spots at angles of veins.

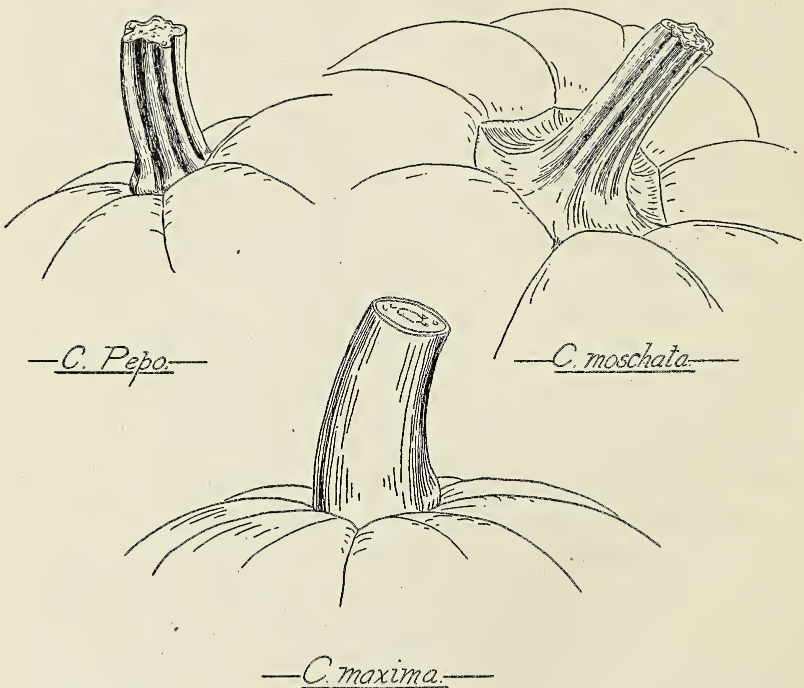

Figure 3.

7. *Burpee's Big Tom Pumpkin.* — Same as No. 1.

8. *Stoke's Small Sugar Pumpkin.* — Stems 5-sided, ridged, pubescent. Leaf long, petiolate, 5-lobed, deeply cleft. The lobes divided again. White spots at angles of veins. Fruit ridged, brownish yellow with dark lines. Peduncle of fruit dark green, ridged.

9. *Stoke's Pie Pumpkin.* — Leaves are 3-lobed, not as deeply cleft as is No. 8. The lobes not subdivided, or if so, only to a small extent.

10. *Ferry's Sugar Pumpkin.* — Stems 5-sided, ridged. Leaf 5-lobed, deeply cleft, each lobe again divided. Leaves dark green color, mottled appearance, ridged. Peduncle of fruit deeply ridged.

11. *Burpee's Small Sugar Pumpkin.* — Stems 5-sided, ridged, leaves 5-lobed, each lobe again divided. Peduncle of fruit ridged. Fruit deeply ridged, of a yellow color.

DESCRIPTION OF TYPES AND VARIETIES OF C. MOSCHATA

1. *Thorburn's Cushaw Mammoth Golden Pumpkin.* — Stems almost round, somewhat 5-sided, pubescent, not spiny. Leaves with petioles, from 12 to 15 inches long, pubescent. Leaves almost round, somewhat lobed. Peduncle of fruit angular, deeply ridged, and swollen where it joins the fruit. Fruit of the crookneck type, of a yellow color.

2. *Burpee's Large Cheese Pumpkin.* — Stems nearly round, no ridges, fine pubescent. Leaves almost kidney shaped, no cleft with white spots at intersections of veins. Peduncle of male and female flowers is 5-sided.

3. *Ferry's Cheese Pumpkin.* — Stem is 5-sided to rounded, no ridges, covered with very fine hairs. Leaves almost kidney shaped, somewhat lobed, with white spots at intersection of veins.

4. *Stoke's Sweet Cheese Pumpkin.* — The stem is more or less rounded, not ridged, covered with fine hair. Leaves almost kidney shaped, lobed very little, if any.

DESCRIPTION OF TYPES AND VARIETIES OF CUCURBITA MAXIMA

1. *Burpee's Gen. Mammoth Pumpkin.* — The stems are round, not ridged, covered with fine hairs. The leaves are kidney shaped, not lobed, covered with fine hairs on the under side.

2. *Stoke's King of Mammoth Pumpkins.* — Stems almost round, pubescent, not spiny. Leaves not lobed, no white spot

at intersection of veins. Fruit spherical, flat at both ends, of a yellow color.

3. *Thorburn's Mammoth King Pumpkin.* — Stems almost round, not ridged. Pubescent, not spiny. Leaves not lobed, no white spots in angles of veins. Fruit same as No. 5.

4. *Delicious Squash.* — Stem rounded, not ridged. Leaves not lobed, short petiolate. Flower peduncles short and round, covered with fine hairs. Fruit dark green, pointed at distal end.

5. *Symme's Big Hubbard.* — Stem more or less rounded. Leaf petiole, very long, round. Leaves not lobed, of dark green color. Flower peduncle quite long. Fruit dark green, deeply furrowed and wrinkled, tapering at distal end.

DISCUSSION

In the past, great confusion has existed as to the classification of the squashes and pumpkins grown in the United States, for many pumpkins should have been called squashes and vice versa. By following the key to the species of the genus *Cucurbita,* as given in these outlines, one should have no difficulty in placing pumpkins as well as squashes in the proper species.

CONCLUSION

The writer feels certain that the Mammoth Pumpkins are not pumpkins at all, but squashes belonging to the species *Cucurbita maxima.* Furthermore, he believes that Thorburn's Mammoth Golden Cushaw and Kentucky Field Pumpkins are not pumpkins but squashes belonging to the species *Cucurbita moschata.*

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THE FOUNDERS OF THE ART OF PLANT BREEDING

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The paper by Prof. Werkenthin on History of Plant Breeding was one of the assigned topics in the course given at Iowa State College on the History of Botany. The subject matter is so admirably treated that it has seemed wise to publish this as a posthumous paper. It was the last paper prepared by him, finished only a few weeks before he was taken sick. — L. H. Pammel.

Since there is a close relation between the mode of reproduction and the method of breeding a plant, a knowledge of sexuality was, therefore, almost a necessity before it was possible to develop the art of breeding.

Existence of fruit-bearing and sterile trees of the date palm was known to the people of Egypt and Mesopotamia in early times and records of artificial pollination as early as 700 B.C have been found. *Kazwini,* the Arabic writer on natural history, says of the date, "It is created out of the same substances as Adam, and is the only tree that is artificially fertilized. The seeds of the date produce about half and half, male and female trees." Kazwini, who died about 682 A.D., says plainly in his book, "Of the marvels of nature, and of the singularities of creating things," "the date has a striking resemblance to man, through the beauty of its erect and slender figure, its division into two distinct sexes and the property, which is peculiar to it, of being fecundated by a sort of union."

BEGINNING OF A NEW ERA

On the 25th of August, 1694, in his laboratory in the University of Tübingen, in South Germany, *Rudolph Jacob Camerer,* Professor of Natural Philosophy, better known to science under his latinized name of *Camerarius,* finished the writing of an extremely long letter to his friend, Professor Michael Bernhard Valentin, of the University of Giessen. This letter, which fills some fifty printed pages, is entitled "De Sexu Plantarum Epistola" (Letter concerning the sex of plants).

Camerarius was the first botanist to discover by actual experiments that the pollen is indispensable for fertilization in flowers, and that the pollen-producing flowers or plants are therefore male, and the seed bearing ones female in nature. Camerarius conducted his experiments with spinach, hemp, and hops, in which the pollen and seed-bearing plants are distinct and also with Indian Corn.

He was the first botanist to discover, two hundred years after maize had been introduced into Europe from America, that on removing the pollen-bearing flowers from the tassel of an isolated corn plant, the seeds on the ears remained unfertilized.

On page 28 of his book, Camerarius comes to this conclusion regarding sex in plants: "They behave indeed to each other as the male and female, and are otherwise not different from one another." On page 49 he goes on to say: "The difficult question which is also a new one, is whether a female plant can be fertilized by a male of another kind, the female hemp by the male hop; the castor bean from which one has removed the staminate flowers through pollination with the pollen of Turkish wheat (maize); and whether, in what degree altered, a seedling will arise therefrom."

Camerarius, however, seems never himself to have attempted the artificial crossing of plants, and it was a full hundred years before his discovery regarding sex in plants received any recognition whatsoever, and before we find the first recorded instance of an actual experiment in hybridization.

MISCELLANEOUS EXPERIMENTS REGARDING SEX IN PLANTS

It is of interest to know that the first person who is reported to have actually crossed plants artificially, was an Englishman named *Thomas Fairchild* who, according to Bradley, crossed two kinds of pinks in *1719*. The cross in question was known still to gardeners, one hundred years later, as "Fairchild's Sweet William."

In 1731, *Philip Miller,* in the first edition of his "Gardener's Dictionary" reported his own repetition of Bradley's experiment with seedlings. Miller also grew male and female plants of spinach apart, and found that the latter bore seeds which contained no embryos.

Eight years later, in 1739, *James Logan,* an American citizen of Irish birth, and at that time governor of Pennsylvania, published in Latin an account of his experiments with Indian corn, entitled "Experimenta et maletamata de plantarum generatione" (Experiments and considerations on the generation of plants).

In 1751, *Gleditsch,* Director of the Berlin Botanical Garden, published an account of an experiment in crossing a species of palm (Chamaerops humilis) entitled "Essai d'une fécondation artificielle fait sur l'espece de palmier qu'on nomme Palma dactylifera folio flabilliformi." According to Sach's History of Botany "This treatise, in point of scientific tone and learned handling of the question, is the best that appeared between the time of Camerarius and that of Koelreuter."

KOELREUTER, THE FIRST SCIENTIFIC PLANT BREEDER

These were the words of *Joseph Gottlieb Koelreuter*: "From the 25th of August, 1694, when Camerarius wrote his letter concerning his experiments upon sex in plants, until September 1, 1761, there has been no real progress in the scientific knowledge which underlies plant breeding." On this latter date, however, appeared Koelreuter's "Preliminary Report of some Experiments and Observations concerning Sex in Plants." This report, with three additional papers on the same subject, which were published in 1763, 1764 and 1766, records the results of 136 distinct experiments in the crossing of plants.

Koelreuter was born April 27, 1733, in the Swabian village of Sulz, in the Black Forest region of southwest Germany. He conducted his experiments partly in his native village, partly in the garden of a physician in the town of Calw in Wurttemberg, and partly in Petrograd, Berlin, and Leipzig. From 1764, until his death in 1806, he was Professor of Natural History in the University of Karlsruhe. At Sulz, in 1760, Koelreuter produced the first plant hybrid ever obtained in a scientific experiment by crossing *Nicotiana paniculata* and *Nicotiana rustica*. Some twenty of these hybrids came to maturity, but unfortunately, these hybrids were completely sterile.

Koelreuter made, besides other crosses between species of Nicotiana, crosses between species of Kedmia, pink (Dianthus), stocks (Matthiola), black henbane (Hyoscyamus) and Verbascum.

He ascertained the fact, that in general only nearly related plants, and not always even these, can be crossed. He determined experimentally the fact that if the stigmas of flowers are pollinated at the same time by their own and by pollen from another species, that fertilization is effected by the former, which would account for the comparative rarity of "species hybrids" in nature. Koelreuter also made the discovery, the explanation of which was not furnished until much later, that the continued self-pollination of hybrids finally results in re-appearance of the original parental forms.

THE SIGNIFICANCE OF SPRENGEL'S DISCOVERY TO PLANT BREEDING

Christian Konrad Sprengel (1750-1816) published in 1793 an epoch-making book "The Newly Revealed Secret of Nature in the Structure and Fertilization of Flowers." It was Sprengel's chief contribution to discover the fact of insect pollination. His conclusion; that nature in most cases intended that flowers should not be fertilized by their own pollen and that the peculiarities of flower structure can be understood only when studied in relation to the insect world, was revolutionary for his time.

The significance of Sprengel's discovery to plant breeding lies in the fact that in general most flowering plants with definite floral envelopes are naturally cross-fertilized. It means simply this, that the bringing together of new combinations of parental characters is the rule rather than the exception in nature, and that, therefore, the breeding of new types in the plant world may be said to be going on all the time.

PRE-MENDELIAN BREEDERS OF THE NINETEENTH CENTURY

At the beginning of the nineteenth century there began to appear in England the first signs of the application of the science of hybridization to the practical art of breeding, in the work of *Thomas Andrew Knight* and *William Herbert.*

Knight was a country gentlemen by occupation, born August 12, 1759, and educated at Oxford. He early began to interest himself, on his estate at Elton in Herefordshire, in experiments in the raising of new varieties of fruits and vegetables. In 1841, three years after his death, a collection of eighty-two of his papers was published by the botanists Bentham and Lindley. Knight's principal work of crossing was carried out with currants, grapes, apples, pears, and peaches, to the end of producing hardier and superior fruits. One of his discoveries of genetic interest was that, in crosses of varieties of red upon white currant, by far the greater number of the hybrids produced red fruit, i.e., the dominance of red. A conclusion formulated by Knight on the basis of his experience, and afterwards confirmed by Darwin, and since called the Knight-Darwin law, was that, "new varieties of every species of fruit will generally be better obtained by introducing the farina (pollen) of one variety of fruit into the blossom of another, than by propagating from one single kind. However, the work of Knight that attracts the most attention from the standpoint of genetics is his experiment with peas. The paper in question, read before the Horticultural Society, June 3, 1823, was entitled, "Some remarks on the Supposed Influence of the Pollen in Cross-breeding, on the color of the seed-coats of plants and the Qualities of their Fruits."

In the particular experiment in question, Knight determined that, in crossing a pea with grey seed-coats upon one with white seed-coats, no immediate change took place, but that the resulting hybrid seeds produced plants the next year which bore grey seeds, as well as having the purple-colored stems and flowers of the male parent.

He further discovered the fact that by crossing plants grown from these (heterozygous) grey seeds, with pollen from what he calls a "permanent" white variety, plants of two types appeared, one bearing grey and the other white seeds.

The work of *William Herbert* was to a considerable extent contemporary with that of Knight. Born January 12, 1778, son of the Earl of Carnarvon, educated at Eton and Oxford, he was trained for the bar which he finally left for the church, entering orders and finally becoming Dean of Manchester. Herbert worked largely on the improvement of florists' flowers, but also conducted experiments with some agricultural plants. He was engaged for a considerable time upon his own experiments, before he came upon the work of Koelreuter, which he immediately assimilated and estimated at its true value. Herbert's experimental work was animated by the connection of the fact which he felt himself to have established, that the then current botanical dogma was wrong, which regarded the existence of sterile offspring from a cross, as evidence that the two parents were of different "species." His views were contrary to those held at the time by Knight, in common with many botanists, that the production of a fertile cross was proof that the two parents were of the same species, "assuming, as a consequence" that the sterile offspring were nearly conclusive evidence that they were of different species, and this dictum was advanced without suggesting any alteration in the definition of the term "species," but leaving it to imply what it had before universally signified in the language of botanists.

A PRECURSOR OF MENDEL

Besides the work of Knight and Herbert, an experiment from the first half of the nineteenth century, which has elicited considerable interest, because of its suggestion of the later discoveries of Mendel, is that of *John Goss* of Hatherleigh, in Devonshire, England, with garden peas. In the summer of 1820, Goss pollinated flowers of the Blue Prussian variety with pollen of a dwarf pea known as Dwarf Spanish, obtaining, as the result of the cross, three pods of hybrid seeds. In the spring of 1821, when he opened these pods for planting, he was surprised to find that the color of the seeds instead of being a deep blue like those of the female parent, was yellowish white like those of the male. However, the parents growing from these seeds in that season "produced some pods with all blue, some with all white, and many with both blue and white peas in the same pod." Here was evidently a plain discovery of the fact of segregation, according to what later became known as Mendel's law. The following spring (1822) he separated the blue peas from the white, sowing the seeds of each in separate rows. He found that the blue seeds, which we should now call the "recessive," produced in turn only blue seeds; while the white seeds, or "dominants" as they are now called, "yielded some pods with all white, and some with both blue and white peas intermixed." Here, then, is the typical case of the segregation of the heterozygotes or hybrid dominants.

In 1819 the Physical Section of the Royal Prussian Academy of the Sciences offered a prize for an answer to the question — "Does hybrid fertilization occur in the plant kingdom?" On the third of July, 1826, the Academy's prize was conferred upon *Dr. A. F. Wiegman,* physician of Braunschweig. Wiegman regards chance crossing in nature, between species or sorts of plants, as having given rise to new agricultural races. "It appears from my experiments," he says, "that many species, or constant subspecies, e.g., *Pisum arvense, Vicia leucosperma, Vicia faba,* as well as the most of the varieties of cabbage and the cereals, whose origin is unknown, possibly are hybrid plants, which have been produced upon our fields and in our garden, through the proximity of a few related plants, and which have remained constant." Regarding the matter of dominance, Wiegman incidentally remarks upon the case of crossing of two species of *Dianthus,* where "the form of the father has almost entirely suppressed that of the mother." According to Wiegman's statements "there occurs even immediately after fertilization, an alteration in the form and color of the seed, and in the form and size of the pods, which is especially unmistakable in the case of the leguminous plants, although otherwise the fruits and seeds of hybrid plants from other families, have never shown themselves to be different from those of the mother plants."

In the valley of the Nagold, in the Black Forest region of Württemberg, some forty miles southwest of Stuttgart, the capital, lies the village of Calw. Here Koelreuter, whose home was in Sulz, did some of his work on hybridization, in the garden of a local physician. By a curious coincidence, in the same village of Calw lived and died *Carl Friedrich von Gärtner,* who for twenty-five years conducted experimental work in hybridization. An idea of the amount of labor expended by Gärtner during the twenty-five years of his hybridization experiments may be obtained by the statement that he carried out nearly ten thousand separate experiments in crossing, among about seven hundred species, belonging to eighty different genera of plants, and obtained in all some two hundred and fifty hybrid plants as the total result. Gärtner, recognized, as did the other hybridizers of his day, that there was always a difference between the first and the succeeding generations, the former being uniform, the later ones variously splitting up. Gärtner did not fail to recognize the fact of unusual vigor in hybrids, although he does not distinguish as to the generation. Gärtner derived, from his long experience, a certain philosophy concerning the nature of hybrids which is noteworthy. He recognized an inequality in the influence or the "potency" as he termed it, of one parent over another in a cross, which potency was maintained, whichever way the cross was made. Gärtner, not having the knowledge which has come since and in consequence of Mendel's investigations, sought a theoretical explanation for this phenomenon of dominance and gave it the designation of "sexual affinity" in the crossing of species, the magnitude of which he considered could be measured by the number of viable seeds produced in the cross. Gärtner did not realize, in spite of Sageret's experiments, that some individual characters of a parent might be found to dominate in a cross and others not. Gärtner's work is noteworthy, not only for the remarkable number of species with which he experimented but for the scrupulous care which he exercised in his operations.

During the time of the prosecution of the work of Knight and Herbert, appeared the results in hybridization obtained by *Sageret* in France. Sageret's experiments in crossing were largely confined to the Cucurbitaceae, and his results were published in a memoir entitled: "Considerations sur la production des hybrides, des variantes et des variétés en général, et sur celles de la famille des Cucurbitacees èn particulier," which appeared in 1826 in the Annales des Sciences Naturelles, Vol. 18.

Sageret made some discoveries that clearly anticipated our modern knowledge of segregation, and he was able to furnish what was, for the time, a fairly satisfactory scientific explanation for the reappearance of ancestral characters. The experiment upon which his conclusions were primarily based was a cross in which a muskmelon was the female and a cantaloupe the male parent. Each plant was regarded as a relatively pure or type representation of its kind. In stating the results of the cross, Sageret for the first time in the history of plant hybridization, aligned the characters of the parents in opposing or contrasting pairs after Mendel's fashion forty years later. Following is the list of contrasting parental characters as Sageret gives them.

Muskmelon (female)	Cantaloupe (Male)
1. Flesh white	1. Flesh yellow
2. Seeds white	2. Seeds yellow
3. Skin smooth	3. Skin netted
4. Ribs slightly evident	4. Ribs strongly pronounced
5. Flavor sugary and very acid at the same time.	5. Flavor sweet

In the two hybrid fruits reported upon, the characters were not blended or intermediate at all, but were clearly and distinctly those of the one or the other parent.

First hybrid	Second hybrid
1. Flesh yellow	1. Flesh yellowish
2. Seeds white	2. Seeds white
3. Skin netted	3. Skin smooth
4. Ribs rather pronounced	4. Ribs wanting
5. Flavor acid	5. Flavor sweet

Sageret even uses, for the first time in the literature of plant hybridization, the word "dominate" with reference to characters in crossing, in the following words. Speaking of the inheritance of flavor in various melon crosses, he says, "The acid flavor of the muskmelon is encountered in the forms of the cantaloupe and the snake-melon, in others, the form of the cantaloupe dominated."

Summing up the results of his experiments in a general conclusion, he says, with regard to the natural explanation that in a hybrid there will be a complete or partial fusion of the parental characters, that "this fusion of characters may take place in certain cases, but it has appeared to me that, in general, things did not take place in this way"; and again, "it has appeared to me that, in general, the resemblance of the hybrid to its two parents consisted, not in any intimate fusion of the diverse characters peculiar to each one of them in particular, but rather in a distribution, equal or unequal, of the same characters."

He finally concludes: "To what, then, does this faculty belong, which nature has, of reproducing upon the descendants such or such a character which had belonged to their ancestors? We do not know. We are able, however, to suspect that it depends upon a type, upon a primitive mould, which contains the germ which sleeps and awakens, and which develops or not according to circumstances, and possibly that which we call a new species is a case in which develop organs, ancient but forgotten, which have existed in the germ but have not had their development favored."

Darwin on Hybrids. — On November 24, 1859, appeared the first edition of Darwin's epoch-making book, "The Origin of Species," in which he briefly reviewed the results and conclusions regarding hybrids and hybridization up to his time. In reading Darwin's chapter, one is strangely struck by the persistence of the species-variety question.

Is this a "species," or is it merely a "variety"? — a question which crossing was expected to answer. If two organisms would not cross, or if their offsprings were sterile, they were thereby proved to be distinct "species." If they freely intercrossed, or if their offsprings were fertile, then ipso facto, they were "varieties" of the same species. Darwin's thesis — that "species," so called, grew out of "varieties" so called, by natural selection, caused him to review the evidence which the work of the hybridists, especially Koelreuter, Gärtner and Herbert, afforded. Regarding the matter of the relation of hybrids to species-affinity, Darwin writes with his usual conservative wisdom:

"No one has been able to point out what kind or what amount of difference, in any recognized character, is sufficient to prevent two species crossing. It can be shown that plants most widely different in habit and general appearance, and having strongly marked differences in every part of the flower, even in the pollen, in the fruit and in the cotyledons, can be crossed. The facility of making a first cross between any two species is not always governed by their systematic affinity or degree of resemblance to each other. This latter statement is clearly proved by the difference in the result of reciprocal crosses between the same two species, for according as the one species or the other is used as the father or the mother, there is generally some difference, and occasionally the widest possible difference in the facility of effecting a union. The hybrids, moreover, produced from reciprocal crosses often differ in fertility."

Again he says: "There is often the widest possible difference in the facility of making reciprocal crosses. Such cases are highly important, for they prove that the capacity in any two species to cross is often completely independent of their systematic affinity, that is, of any difference in their structure or constitution, excepting in their reproductive systems. It can thus be shown that neither sterility nor fertility affords any certain distinction between species and varieties. The evidence from this source graduates away, and is doubtful in the same degree as is the evidence derived from other constitutional and structural differences."

Darwin finally summarizes the evidences as follows: "First crosses between forms, sufficiently distinct to be marked as species, and their hybrids, are very generally, but not universally sterile. The sterility is of all degrees and is often so slight that the most careful experimentalists have arrived at diametrically opposite conclusions in ranking forms by this test."

In 1861 the Paris Academy of Sciences proposed the following problem to receive the grand prize in the physical sciences: "To study the plant hybrids from the point of view of their fecundity, and of the perpetuity or non-perpetuity of their characters. The production of hybrids among plants of different species of the same genus is a fact determined a long time since, but many precise researches still remain to be made in order to solve the following questions, which have an interest equally from the point of view of general physiology, and of the determination of the limits of species, of the extent of their variations.

"1. In what cases of hybrids are they self-fertile? Does this fecundity of hybrids stand in relation to the external resemblances of the species from which they come, or does it testify to a special affinity from the point of view of fertilization, as has been remarked regarding the ease of production of the hybrids themselves?"

"2. Do self-sterile hybrids always owe their stability to the imperfection of the pollen? Are the pistils and the ovules always susceptible of being fecundated by a foreign pollen, properly selected? Is an appreciable imperfect condition sometimes observed in the pistil and the ovules?"

"3. Do hybrids which reproduce themselves by their own fecundation sometimes preserve invariable characters for several generations, and are they able to become the type of constant races, or do they always return, on the contrary, to the forms of their ancestors after several generations, as recent observations seem to indicate?"

The Ideas of Godron. — The two chief competitors under the Academy's offer were *Charles Naudin* of the Museum of Natural History at Paris, and *D. A. Godron* of the University of Nancy, the prize being awarded to the former. The papers of both appeared in Vol. 19 of the Annales des Sciences Naturelles (Botanique), 4 me. Serie (1863).

The title of Godron's thesis was "Des hybrides végétaux, considérées au point de vue de leur féconditè et de la perpetuité ou non-perpetuité de leurs charactéres." His paper is devoted chiefly to the solution of the question as to whether "hybrids reproducing by self-fertilization sometimes keep their characters invariable during several generations, and whether they are able to become the types of constant races, or whether, on the contrary, they always return to the forms of one of their ancestors at the end of several generations, as recent observations seem to indicate." In answer to this query, he says: "We have determined, upon hybrids of *Linaria* that the hybrid form may become very fertile, and that a certain number of individuals, from the second generation, return respectively to the two primitive types, when they grow in company with their parents, and this return movement manifests itself much more in the following generations."

Naudin's conclusions. — The general conclusions of importance for his time, at which Naudin arrived, are as follows — in the language of the award committee of the Academy — and which are quoted in their own words to show the point of view of science at that time: "The first, and the most important of all, is that the singular beings which result from the cross-fertilization of two different types, far from being condemned to absolute sterility, are frequently endowed with the faculty of producing seeds capable of germination."

"The second consequence of major interest which proceeds from the numerous experiments in the same memoir is that fertile hybrids have a manifest tendency to return to the forms that produced them, and that without other action than that of their own proper pollen, under such conditions that the pollen of the parents is not able to exercise the influence to determine this return."

In 1864 Naudin communicated a second report to the Academy, in which he confirmed his previous results as to uniformity in the first generation crosses, the identity of reciprocal crosses, and the "disorderly variation," as he calls it, of the hybrids of the second and succeeding generation. In neither of the two papers is there any numerical classification of the hybrid types.

Naudin's memoir is often referred to as amounting virtually to a statement of Mendel's law of the disjunction of hybrids. In Naudin's case, however, the statement was of a speculative nature and consisted in the proposition of a scientific hypothesis; in Mendel's case, his "law" was a scientific conclusion derived as the result of experiment. Naudin propounded, in 1863, a well-reasoned theory of probable truth; Mendel, in 1868, formulated a statement of ascertained fact.

The work of Verlot. — in 1865, *B. Verlot,* of the Jardin des Plantes at Paris, published a brief memoir which in 1862 had received a prize from the Imperial and Central Horticultural Society, the thesis of which was as follows: "To demonstrate the circumstances which determine the production and fixation of varieties in ornamental plants." The memoir is of interest as thoroughly and typically embodying the general point of view of the day concerning hybridization and the origin of new varieties, while affording at the same time much matter of interest from the standpoint of practical horticulture. Verlot presented the view that, while the causes of variation are unknown, they arise under definable circumstances, and the ones which he enumerates are prolonged cultivation, removal from one set of climatic and soil conditions to another, and hybridization.

The thought of the time did not clearly distinguish a difference between the nature of the changes brought about by the external environment and those arising from sexual fertilization. Both were generally assumed to be equally heritable. Cultivation long continued was considered to have been especially potent in bringing about variation. In Verlot's words: "It is especially with plants cultivated for a great number of years, with those the introduction of which is so ancient that it is lost in the night of time, that one finds profound and multiplied modifications."

He further voices the then prevailing view regarding the relation between culture and variation: "If we compare," he says, "a species in its spontaneous condition with the same species cultivated, transported, that is to say, most often into conditions of climate, soil, etc., completely different from those where it lived before, we shall be struck by seeing that in our gardens this latter will show deviations of type more numerous than in the wild state. We shall derive from this fact the consequence that the faculty of varying, which is proper to the plant, augments with culture. If we observe, then, that the plants cultivated in our gardens which have varied the most — as, for example, the dahlias, the roses, the camellias, the rhododendrons, the potato, etc. — are not borrowed for the most part from our flora, nor from one of the neighboring floras, but on the contrary, come from distant countries, where they grow under conditions often absolutely different from those in which we cultivate them, we shall conclude that the more a species is depatriated, the more it will easily vary;" and again: "The more plants are cultivated, the greater their variations are, and, by the same token, the easier they are to fix. We will possibly be contradicted, but we do not hesitate to consider, once more, long-practiced culture as one of the most favorable antecedents to the rapid fixation of variations."

Verlot's Summary. — Verlot summarizes his views upon hybrids in the following words, which are worth reproducing because they fairly well represent the general knowledge of the time, as follows: (1) "Hybrid fecundation is not able to produce anything but variations which will be able, it is true, to multiply themselves mechanically, but which will not be fixable, and which consequently cannot be brought to constitute races or varieties, the products which arise from them being sterile, or if they are fertile, having only a fertility limited to a few generations, or disappearing after a certain time by the disjunction of the types. (2) One of the characters of the hybrids is also a great development of the vegetative organs, coincident with less abundant flowering. They are in general intermediate between the species types, but often approach more the father. (3) The hybrid, self-fertilized, returns more or less rapidly to the parents. (4) The hybrid, fertilized by a parent, returns also promptly to the parent. (5) Crossing — that is to say, reciprocal fertilization of varieties or races of the same species — will serve for obtaining new variations, intermediate between the parents, very fertile, and which can be fixed more or less rapidly, and constitute new varieties or races."

Reviewing this list of statements in the light of present knowledge, we can see that they constitute a more or less correct non-scientific formulation of the truth. For example, the more or less rapid return of hybrids — that is to say, heterozygotes — to the parental forms, is well established today as a fact of segregation according to Mendelian ratios, which, if there is a single pair of allelomorphs in question, goes on, on a 1.2.1 basis in each successive generation. The more or less rapid return to its parents of the hybrid fertilized by parent is simply the splitting off of 50 per cent dominants or recessives as the case may be, and which are the parental types in the case of simple ratios.

Wichura's Work. — In 1865 there appeared *Wichura's* memoir on the hybridization of plants, "Die Bastardbefruchtung im pflanzenreich, erläutert an den Bastarden der Weiden, Breslau, 1865" based upon experiments in the crossing of willows, which had occupied him from 1852 to 1858 inclusive. A brief preliminary report had appeared in Flora in 1854, and also within the same year in the report of the Schlesische Gesellschaft.

Taken as a whole, Wichura's work dealt, not with the investigations of individual specific characters but with species taken entire and crossed as such. As was the general custom, he regarded a "species" as an integral whole that could be crossed in its entirety. With this exception he made what he called "binary," "ternary" and "quaternary" crosses, i.e., crosses: (1) between two species; (2) between a species and a hybrid; and (3) crosses between two hybrids. Besides the smaller list of Wichura's successful crosses, he published a much longer one of his failures, which stand as evidence both of the considerable amount of crossing work that was done and of the scientific integrity of the experimenter. Of the ordinary, or as he calls them, "binary" crosses, Wichura made, in all, thirty-five successful crosses and combinations of crosses (of which ten were "binary," i.e., simple crosses in the ordinary sense) between twenty-one different species of willows.

Although, as has been stated, Wichura, no more than most of the other hybridists of his day, paid attention to the crossing of characters as such, he remarks upon the evidence of individual characters being inherited as such: "It was of interest," he says, "to observe how the unusual narrowness of the leaves in the experiment, utilizing *Salix purpurea x viminalis,* remained still recognizable in the following generation; a proof that, even in hybrid fertilization, individual characteristics of the parent plants can be inherited."

This closes the account of the work in the field of hybridization from the time of Koelreuter to the time of Gregor Mendel, 1760-1866. Mendel's investigations, however, did not become generally known until 1900, so that very little change occurred in the methods pursued in the study of hybrid phenomena until after the date last mentioned. Comparatively few students of plant breeding, however, realize the historical value of the work of the earlier hybridists, in whose experiments lie the germs of our present knowledge.

Lamarck (1774-1829), the noted French naturalist, taught that all living things have been derived from pre-existing forms, that the effects of use and disuse caused changes in bodily structure; that these changes were inherited and accentuated from generation to generation. According to Lamarck, in plants and animals, whenever the conditions of habitat, exposure, climate, nutrition, mode of life, et cetera, are modified, the characters of size, shape, relations between parts, coloration, consistency are modified proportionately: some of the arguments against the validity of Lamarckism are: (1) that no one has ever been able to prove by experiment or otherwise, that the effects of use, the so-called "acquired characters" are inheritable, while innumerable facts indicate that they are not; (2) the hypothesis could apply only to the animal kingdom, since plants in general have no nervous and muscular activities like those of animals. A hypothesis of organic evolution, to be valid, must apply equally to both plants and animals.

The question of the method of evolution continued to be debated, with no satisfactory solution in sight, *until 1859 when Charles Darwin* published the greatest book of the nineteenth century, and one of the greatest in the world's history, the "Origin of Species." This book was the result of over twenty years of careful observations and thought. It consisted of the elaboration of two principal theories: (1) that evolution is the method of creation, (2) that natural selection is the method of evolution, based upon inheritance, variation, fitness for environment, struggle for existence, and survival of the fittest.

The theory of heredity which was chiefly responsible for replacing pangenesis was proposed by *Weismann* who was born at Frankfort on the Main in 1834 and died in 1914. In 1893, he published "The Germ-Plasm, A Theory of Heredity," a treatise which elicited much discussion. The main features of Weismann's Theory of Continuity of Germ plasm are as follows:

(1) The germ plasm has had unbroken continuity from the beginning of life; owing to its impressionable nature, it has an inherited organization of great complexity.

(2) Heredity is accounted for on the principle that the offspring is composed of some of the same stuff as its parents. The body-cells are not inherited.

(3) There is no inheritance of acquired characters.

(4) Variations arise from the union of the germinal elements, giving rise to varied continuations and permutations of the qualities of the germ-plasm. The purpose of amphimixis is to give rise to variations. The direct influence of environment has produced variations in unicellular organisms.

(5) Weismann adopts and extends the principle of natural selection. Germinal selection is exhibited in the germ-plasm.

GREGOR MENDEL (1822-1884)

One of the most important contributions ever made to biological science, was made by a teacher who studied plants as a pastime because he loved to do it. This man was *Gregor Mendel,* a monk in the monastery at Brünn, Austria, where he finally became abbot.

In his garden he made many experiments upon the inheritance, particularly in peas, of color and of form; and through these experiments he demonstrated a law of inheritance which was one of the greatest biological discoveries of the nineteenth century. He published his papers entitled "Experiments in Plant-Hybridization" in 1866, but since the minds of naturalists at that time were very much occupied with the questions of organic evolution, raised through the publication of Darwin, the ideas of Mendel attracted very little attention.

The discovery by Mendel of alternation inheritance will rank as one of the greatest discoveries in the study of heredity. The fact that in cross-breeding the parental qualities are not blended, but that they retain their individuality in the offspring, has many possible practical applications, both in horticulture and in the breeding of animals.

In planning his crossing experiments, Mendel adopted an attitude which marked him off sharply from the earlier hybridizers. He realized that their failure to elucidate any general principle of heredity from the results of cross fertilization was due to their not having concentrated upon particular characters or traced them carefully through a sequence of generations. That source of failure he was careful to avoid and throughout his experiments he crossed plants presenting sharply contrasted characters, and devoted his efforts to observing the behavior of these characters in successive generations. Thus in one series of experiments he concentrated his attention on the transmission of the characters tallness and dwarfness, neglecting, in-so-far as these experiments were concerned, any other characters in which the parent plants might differ from one another. For this purpose he chose two strains of peas, one about six feet in height, and another of about one and one-half feet. Previous testing had shown that each strain bred true to its peculiar height. These two strains were artificially crossed with one another, and it was found to make no difference which was used as the pollen parent and which was used as the ovule parent. In either case the result was the same. The result of crossing tall with dwarf was in every case nothing but talls, as tall as or even a little taller than the tall parent. For this reason Mendel termed tallness the *dominant* and dwarfness the *recessive* character. The next stage was to collect and sow the seeds of these tall hybrids. Such seeds in the following year gave rise to a mixed generation consisting of talls and dwarfs but *no intermediates.* By raising a considerable number of each plant, Mendel was able to establish the fact that the number of talls which occurred in this generation was almost exactly *three times* as great as the number of dwarfs. As in the previous year, seeds were carefully collected from this, the second hybrid generation, and in every case the seeds from each individual plant were harvested separately and separately sown in the following year. By this respect for the individuality of the different plants, however closely they resembled one another, Mendel found the clue that had eluded the efforts of all his predecessors. The seeds collected from the dwarf recessive bred true, giving nothing but dwarfs. And this was true for every dwarf tested. But with the talls it was quite otherwise. Although indistinguishable in appearance, some of them bred true, while others behaved like the original tall hybrids, giving a generation consisting of talls and dwarfs in the proportion of three of the former to one of the latter.

Mendel is also known to have made experiments with many other plants, and a few of his results are incidentally given in his series of letters to Nägeli the botanist. The only other published work that we possess dealing with heredity is a brief paper on some crossing experiments with the hawkweeds (*Hieracium*), a genus that he chose for working with because of the enormous number of forms under which it naturally exists.

By crossing together the more distinct varieties, he evidently hoped to produce some of these numerous wild forms, and so throw light upon their origin and nature. In this hope he was dissappointed. Instead of giving a variety of forms in the F_2 generation, they bred true and continued to do so as long as they were kept under observation. More recent research has shown that this is due to a peculiar feature known as parthenogenesis and not to any failure of the characters to separate clearly from one another in the gametes. Mendel, however, could not have known of this, and his inability to discover in *Hieracium* any indication of the rule which he had found to hold good for both peas and beans must have been a source of considerable disappointment. Whether for this reason or owing to the utter neglect of his work by the scientific world, Mendel gave up his experimental researches during the later part of his life. His closing years were shadowed with ill health and embittered by a controversy with the Government on a question of the rights of his monastery. He died of Bright's disease in 1884. Mendel's experiments, published in 1866, remained unnoticed until the facts were rediscovered in 1900 by *DeVries, Correns* and *Tschermak.*

THE MUTATION-THEORY OF DEVRIES

Hugo DeVries, director of the Botanical Garden in Amsterdam, has experimented widely with the growth of plants, especially the evening primrose, and has shown that different species appear to rise suddenly. The sudden variations that breed true, and thus give rise to new forms, he called mutations, and this indicates the source of the name applied to his theory.

In his "Die Mutations theorie," published in 1901, he argues for the recognition of mutations as the universal source of the origin of species. Although he evokes natural selection for the perpetuation and improvement of variations, and points out that his theory is not antagonistic to that of natural selection, it is nevertheless directly at variance with Darwin's fundamental conception — that slight individual variations "are probably the sole differences which are effective in the production of new species" and that "as natural selection acts solely by accumulating slight, successive, favorable variations; it can produce no great or sudden modifications." The fundamental idea of DeVries' theory is that "species have not arisen through gradual selection, continued for hundreds or thousands of years, but by sudden leaps and bounds.

The work of Devries is a most important contribution to the study of the origin of species, and is indicative of the fact that many factors must be taken into consideration when one attempts to analyze the process of organic evolution. One great value of his work is that it is based on experiments and that it has given a great stimulus to experimental studies.

NILSSON'S DISCOVERY OF THE ELEMENTARY SPECIES OF AGRICULTURAL PLANTS (1890)

During the last twenty years, experiments in the breeding of cereals and other agricultural crops have been conducted on an unusually large scale at the Swedish Experiment Station of Svalof under the leadership of Dr. Hjalmar Nilsson, Director of the Station. Nilsson's principle for all breeding purposes is to derive his strains from single mother plants. Only such strains give pure breeds. A second discovery made at Svalof, and equally valuable for practice and for science was that of the almost astonishing richness in elementary species among our agricultural crops. Every cultivated species seems to embrace something like a hundred of them, and the cereals were found to include even several hundred in each of the older species. By carful search of the field in almost every case a plant may be found which complies with the ideal sought for. From such a plant a pure and constant one may be derived without other means than that of isolating and multiplying its progeny. On the basis of these facts, Nilsson has founded an elaborate method of selecting original plants for his pedigree-cultures and of comparing their value for practical purposes. Meanwhile, variation was being studied from a new point of view, which we may call *biometry*. *Francis Galton* (1889) was the founder of biometry but its full development has been due chiefly to the valuable work of *Karl Pearson*. The underlying idea in biometry is to apply to the study of evolution the precise quantitative method followed in the study of physics and chemistry with such signal success.

Biometry is the statistical study of variation and heredity. Biometry is best adapted to deal with continuous variations. Its ideal, to make biological investigation more accurate and comprehensive, is wholly commendable.

JOHANNSEN'S CONCEPTION OF HEREDITY

The conception that inheritance, as previously noted, is not the transmission of external characters from parent to offspring, but the reappearance, in successive generations, of the same organization of the protoplasm with reference to its character-units, was first developed by Johannsen, of Copenhagen, Denmark, in 1909, and published in his book "Elements der Exakten Erblichkeitslehre (Elements of the teaching of exact heredity). Johannsen proposed the term "genes." The sum total of all the genes in a gamete or zygote is a genotype. Inheritance is the appearance, in successive generations, of the same genotypical constitution of the protoplasm.

This conception of heredity is diametrically opposed to the older and popular conception but is much more closely in accord with the facts revealed by recent studies of plant and animal breeding.

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BIBLIOGRAPHY

Babcock, E. B., and Clausen, R. E., Genetics in Relation to Agriculture, 1918.

Bateson, W., Mendel's Principles of Heredity, 1909.

Castle, W. E., Genetics and Eugenics, 1916.

Coulter, John M. and M. C., Plant Genetics, 1919.

East, Ed. M., The Relation of Certain Biological Principles to Plant Breeding: Conn. Ag. Exp. Station Bull., 158, 1-93; 1907.

Gager, C. Stuart, Heredity and Evolution in Plants, 1920.

——— Fundamentals of Botany, 1916.

Green, J. Reynolds, A History of Botany (1860-1900), 1909.

Hayes, H. K., and Garber, R. G., Breeding of Crop Plants, 1921.

Johannsen, W., Elemente der Exakten Erblichkeitslehre, 1913.

Locy, Wm. R., Biology and its Makers, 1908.

Lotsy, J. P., Vorlesungen über Deszendenz theorien, 1906.

Pummett, R. C., Mendelism, 1915.

Roberts, H. F., The contribution of Carl Friedrich von Gärtner to the Theory of Plant Hybridization: Am. Naturalist 53, 451-455; 1919.

——— Darwin's Contribution to the Knowledge of Hybridization: Am. Naturalist 53, 538-554; 1919.

——— The Founders of the Art of Breeding: The Journal of Heredity, 10, 99-106, 147-152, 229-239, 257-270; 1919.

Sachs, J. von, History of Botany (1530-1860), 1906.

Scott, Wm. B., The Theory of Evolution, 1917.

Vries, Hugo De, The Mutation Theory, 1909.

——— Plant Breeding, 1907.

STUDIES OF INSECT TRANSMISSION AND CROSS-INOCULATION OF MOSAIC ON THE SOLANACEAE, CUCURBITACEAE AND LEGUMINOSAE

O. H. ELMER

The results of most investigators tend to show that the mosaic disease is quite limited in its host range. Recent experiments show that such is probably not the case.

Four petunia plants were inoculated with mosaic from squash and four egg plants with sweet potato mosaic. All became infected, while the checks remained healthy. An experiment in which juice of a mosaic plant was inoculated under long continued pressure through a capillary tube resulted in 100 per cent infection. Using this method, eight squash plants were inoculated with the mosaic from tobacco and tomato. At the same time a tobacco and a tomato plant were inoculated with mosaic from squash and became infected. An equal number of checks were held and all remained healthy. In addition, two tomato plants inoculated with mosaic from squash by means of a hypodermic needle became infected. Five tobacco plants inoculated with crookneck squash mosaic with a flamed knife became infected within twelve days. The thirty checks remained healthy.

Cow pea plants (*Vigna Catjang*) growing in the Agronomy greenhouse were found severely infected with mosaic. Inoculation by means of aphis (species undetermined) from the mosaic plants to healthy plants has shown beyond doubt that this mosaic is a transmissible disease. Two pots containing thirty-eight cow pea seedlings were infected with asphis from the mosaic cow pea plants and were placed in insect proof cages. Both pots were ringed with tree tanglefoot to keep other insects away. One hundred per cent infection occurred in both pots, while all checks remained healthy. Artificial inoculation has, to date, proved unsuccessful.

It is known that aphis are capable of transmitting mosaic. As far as I know, the mealy bug (*Dactylopus*) has not been reported as transmitting this disease. However, evidence has been obtained which indicates that this is the case. An experiment in which mealy bugs from a mosaic squash were transferred to a pot containing fourteen cow pea plants has resulted in 100 per cent infection. The pots were kept under an insect proof cage and were ringed with tree tanglefoot to keep other insects away. The checks remained healthy. These data are of interest, in addition to the fact that the disease was transmitted by the mealy bugs, in that the infection was from Cucurbitaceae to Leguminosae and gives added proof that mosaic can be transmitted to plants belonging to other families and orders.

Department of Botany,
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A COMPARATIVE STUDY OF THE RED-SEEDED AND COMMON DANDELION

JUNE BERRY

To the casual observer the dandelions which prove so serious a pest in lawns and elsewhere, appear to be of only one species. Upon closer investigation, it is found that there are two common species, the Common Dandelion, *Taraxacum taraxacum* (L) and the Red-seeded Dandelion, *Taraxacum erythrospermum* (Andrz). These two species are the most easily distinguished by their seeds which are an olive brown and dark red color respectively.

In making this study most of the observations were taken within a mile of the campus of Iowa Wesleyan College although comparisons were made over a much wider territory. Seven location types were recognized and well scattered plots from these varying habitats were studied.

The first problem was to determine, if possible, the relative number of plants of the two species in each area. Counts of one hundred plants, taken at random, were made with the following results.

Location of Count	No. of Common Dandelion Plants	No. of Red-Seeded Dandelion Plants	Percentage of Common Dandelion Plants	Percentage of Red-Seeded Dandelion Plants	Ratio
1. Old tennis court	83	17	83	17	.204
2. Orchard	83	17	83	17	.204
3. Campus	86-46	14-54	66	34	.515
4. Neglected lawns	99-74-100-63	1-26-0-37	84	16	.190
5. Pastures	98-68-85-88-74	2-32-15-12-26	82⅗	17⅖	.210
6. Along R. R. track	94-96-97-95	6-4-3-5	95½	4½	.047
7. Well kept lawns	100-100-80	0-0-20	93⅓	6⅔	.071
Total	1709	291	85.45	14.55	.170

It was next undertaken to determine the relative prolificacy of each of these species. The number of flower heads on ninety-five Common Dandelion plants, taken at random throughout the different areas studied, were counted. The smallest was one head; the largest number 258. The total was 1236 heads or an average of twelve heads per plant.

The same number of Red-seeded plants were counted. The number of heads per plant ranged from one to ninety, with an average of nine heads per plant.

Next, the number of seeds produced by a head on the Common Dandelion was compared with those produced by a head on the Red-seeded Dandelion with results as follows: The seeds were counted on 23 heads of each species. The number of seeds on the Common Dandelion heads ranged from 84 to 282 with an average of 190 per head. With the Red-seeded species the number ran from 71 to 182 with an average of 107.

These averages multiplied by the average heads per plant give a comparative ratio of 1900:969 or about 2:1 in favor of the Common Dandelion. It is noticeable that the Common Dandelion makes a much ranker growth than the Red-seeded species and that it seems to stand competition of tall growing grasses much better than its relative. The Red-seeded one seems to prefer shady places where there is scarcity of grass, also a sandy soil. As is well known, the Common Dandelion will grow anywhere. The Red-seeded variety seems to appear earlier than the common variety as on the former plants scarcely any flowering buds or flowers were present at the time of examination but an abundance of seed heads was found. The color of the flowering heads of the two varieties differs somewhat in that the head of the Common Dandelion is a brighter golden yellow while that of the Red-seeded species is a darker orange yellow. But this difference is not marked unless flowers of each are held together and examined.

No difference in the root system could be found except that the roots of the Common Dandelion seemed more brittle and less easy to dig out of the ground than the roots of the Red-seeded Dandelion. This, however, does not appear to be a constant difference.

Upon investigation of the bracts of the involucre of both species it appears that the Common Dandelion bears more bracts to the head. They are tinged with a dark green and curled downwards while the bracts of the Red-seeded species stand straight out prominently, are tinged with red and the involucre, on the whole, is glaucous.

Effort was made to find some constant difference in the leaves but no conclusion could be reached in this respect. Large numbers of leaves of the two species were collected, pressed and compared. It was found that the leaves of the Red-seeded Dandelion average more deeply cut while those of the Common species are more nearly entire. However, several red-seeded plants were found which had leaves comparatively entire as were plants of the Common species having leaves extremely notched.

In general, the Common Dandelion was found to be more numerous although on one part of the campus the Red-seeded ones were more abundant. For a distance of two blocks east of the campus not a single Red-seeded plant could be found but for the same distance north of the campus the Red-seeded plants were very numerous. The question thus arises as to whether there are special seed beds of these plants and, if so, what conditions favor them.

A definite conclusion, however, has been reached as to the color and shape of the seeds. The seeds of the Red-seeded Dandelion are of reddish brown color and in cross section are oval shaped while the seeds of the Common Dandelion are a greenish brown color and quite sharply notched, bearing tiny hairy filaments.

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A MANUAL OF THE FERNS AND "FERN-ALLIES" OF GRINNELL AND VICINITY.

HENRY S. CONARD

The writer believes that for every floristic district of the State there should be a simple and convenient manual of the local flora. As a first attempt to meet this need, the following manual is presented. The other vascular plants should be similarly covered.

Each species herein is briefly described by means of its most obvious recognition characters. There follows in some cases a more technical description. We then give the habitat, the name of some locality in or near Grinnell, the distribution, and the month in which spores may be found. The notes inserted in various places are intended to offer interesting bits of information. The keys and descriptions are avowedly artificial and are intended for the use of beginners. They are especially adapted for use in the region designated, but they will be found applicable to most of the State.

The names (excepting *Pteridium*) are as given in Gray's Manual. Authorities for the names are therefore omitted. The larger and more technical manuals should be consulted after the species have been identified by the aid of this little guide. Acknowledgment is made to the labors of many collectors whose records have made this compilation possible, and to several students who have tried out the keys and text.

TRACHEATA Vascular Plants

Plants with root, stem and leaf, containing tracheary tissue, that is, definite thick-walled water-conducting cells. The spore-producing stage is large and plainly seen, the gamete-producing stage being small or microscopic. Trees, shrubs and herbs. Fern plants and Seed plants.

Series 1. LYCOPSIDA: Herbs with small lvs., crowded in spiral order or whorled. No flowers or seeds. Spores borne in small cases one in the axil of a leaf, or few on the inner side of an umbrella-shaped body, usually in crowded, conelike groups.

Order 1. LYCOPODIALES

Lvs. crowded in spiral order, sometimes appearing 4-ranked, green, 2-5mm. long, 1-2mm. wide, spreading or like scales on the stem.

Sporangia single in the axils of ordinary or slightly modified lvs., usually forming a terminal strobilus or conelike group.

Family 1. LYCOPODIACEAE Club Moss Family

Lvs. spirally arranged, many ranked. Spores all alike.

Lycopodium Club moss; ground pine.

(Lycos, wolf; pous, foot; from a fancied resemblance)

Characters of the family.

1. L. LUCIDULUM Shining L.

Lvs. all alike, nearly at right angles to stem, sometimes a group bearing sporangia at base, finely toothed at apex.

Cool shaded rocks, very rare here.

Eldora

Nfd. to Minn., Ia., and S. C.

July

Note: Other species of *Lycopodium* are commonly imported at Christmas time for wreaths under the name of ground pine. Druggists usually have spores of these plants under the name of *Lycopodium* powder. The related genus *Selaginella* is often seen as a flat-sprayed delicate greenhouse plant, with two kinds of spores, large and small. Two species 2-5cm. tall grow wild in neighboring regions. In the coal period, the predecessors of these plants grew to the size of trees, with heavy woody trunks and roots. Their fossil prints occur in Iowa coal, and are known as *Stigmaria, Sigillaria*, and *Lepidodendron.*

Order 2. EQUISETALES

Stems jointed, with a sheathlike whorl of united minute lvs. at each node. Spores green, cottony, in conelike heads at the ends of stems.

Note: In the coal period, plants resembling *Equisetum* grew to the size of trees, with woody stems and cambial growth. Their huge jointed stems, 2-4 dm. thick, are sometimes found in coal.

Family 8. EQUISETACEAE Horsetail Family.

Characters of the Order.

Equisetum Horsetail

(Equus, horse; seta, bristle)

Scales of cone hexagonal, with 6 or 7 sporangia beneath. Spores with 4 slender, broad tipped "elaters" (threads) which coil and uncoil when moist or dry. Stems hollow, grooved, with large air canals in the cortex, and a small one in each vascular bundle.

Note: The elaters are extremely sensitive to moisture; the breath breathed over them causes great activity, especially as seen with a microscope. These plants are evidently the reduced herbaceous remnants of a once large and wide-spread family, the Calamites and Sphenophyllales.

1. Stems delicate, soft, annual; some of them much branched 2
1. Stems stiff, evergreen, little if at all branched 3

2. Spore-bearing shoot brown, soon withering — *1. E. arvense*
2. Spore-bearing shoot developing whorls of green branches — *2. E. sylvaticum*
3. Shoots scattered about, 3-7 mm. thick — *3. E. laevigatum*
3. Shoots clustered, 5-12 mm. thick, 1 m. tall — *4. E. hyemale*

1. E. ARVENSE Field E. Common horsetail

Spore-bearing shoots 1-3dm. tall, light brown, juicy, withering, preceding the much branched green shoots, which become 2-3dm. tall.

Cone 2-5cm. long, narrowly ellipsoidal; sheaths of stem loose, 8-12 toothed. Branches of green shoot 3-4-angled, whorled, rough, easily breaking at the nodes. Rhizomes long and slender, black, with frequent globular bulbs.

Moist ground, common

Railway on campus; Botanic Garden.

General over northern Eurasia and America

April

2. E. SYLVATICUM Woodland E.

Cone-bearing shoot at first branchless, later developing whorls of slender drooping green branchlets; 1-3dm. tall, slender and delicate.

Ridges of stem 8-14; branches 3-5-angled. Sheaths loose, with several rusty-colored teeth.

Moist thickets, very rare here.

Richland Twp. Jasper Co. (locality destroyed); Eldora?

Entire north temperate zone north of 40 degrees.

May-June

3. E. LAEVIGATUM Snake grass

Shoots all alike, dark green, 4-8dm. tall, stiff and harsh, 3-5mm. thick, unbranched or with a few slender erect branches, often ending in a hard cone 1-2cm. long.

Evergreen. Sheaths green, with narrow black edge, the teeth soon falling off. Spreading by running rhizomes.

Prairie banks, common

North track; Arbor Lake

Ohio to B. C. and Tex.

June, July

4. E. HYEMALE Winter E. Scouring rush

As above, except stems 5-10mm. thick, 6-12dm. tall; tufted in dense sods to the exclusion of everything else.

Evergreen. Sheaths with 2 black rings separated by an ashy ring. Cones rarely seen.

Wet ground, rare.
Railroad bank one mile west of Turner.
N. Europe and n. e. N. America

Note: Like other species of *Equisetum*, this species is very rich in silica, that is, the hard material of sand and glass. The outer surface is covered with almost pure silica. Our grandmothers used a bundle of the dried stalks to scour pots and pans; hence the common name. The local form is var. *robustum*.

Series 2. Pteropsida: Herbs, shrubs or trees, with primarily large lvs. whose attachment to the stem greatly modifies the structure of the latter at the nodes. Sporecases primarily numerous, borne on the underside of a leaf. The lower forms are reproduced by spores; the higher ones by seeds, resulting from flowers with pollen and ovules.

Class 1. Aspermae Seedless Pteropsidans. Ferns.

Propagation by means of minute spores, borne in small cases (sporangia) on the backs or surfaces of ordinary or modified lvs.

Stems always (in our species) under ground, only the lvs. coming up. Without cambium (except in Botrychium); vascular bundles variously disposed, concentric in structure. Veining of lvs. forked, occasionally the forks uniting into a network.

Key to the Genera of Aspermae

1.	Sporangia on a naked stalk rising from the leaf	*Botrychium*
1.	Sporangia on much contracted lvs. or lflts., without any green part	2
1.	Sporangia on the backs of ordinary lvs.	3
2.	Sporangia exposed all over the modified lflts.	*Osmunda*
2.	Sporangia enclosed in podlike rolled-up lflts.	*Onoclea*
3.	Lvs. simple	*Camptosorus*
3.	Lvs. compound	4
4.	Lvs. once pinnately divided	5
4.	Lvs. twice or more divided	6
5.	Lflts. contracted to a short stalk	*Polystichum*
5.	Lflts. broadly attached to midrib	*Polypodium*
6.	Sporangia covered by turned-back margin of leaf	7
6.	Sporangia not covered by margin of leaf	9
7.	Sporangia in separate patches	*Adiantum*
7.	Sporangia all around lflt.	8
8.	Plant 5 cm. to 2 dm. tall	*Pellaea*
8.	Plant 3-10dm. tall	*Pteridium*
9.	Spore dots elongate, straight or curved	*Asplenium*
9.	Spore dots circular	10
10.	Lvs. 3-8 times longer than wide	11
10.	Lvs. triangular, as wide as long	*Phegopteris*
11.	Lvs. 4-8 cm. wide; stalks 2-3 mm. thick	12
11.	Lvs. 8-15 cm. wide; stalks scaly, 3-5 mm. thick	*Aspidium*
12.	Lvs. hairless	*Cystopteris*
12.	Lvs. finely downy	*Woodsia*

Order 1. OPHIOGLOSSALES

Sporangia 1mm. across, in groups on a contracted segment of the leaf which appears on a naked stalk above the green leaf.

Stem erect, with very slow cambial growth, producing one leaf per year. A single plant may live for 30 years or more.

Family 1. OPHIOGLOSSACEAE Adder's tongue family

Characters of the Order

Botrychium Moonwort

(Botrys, a bunch of grapes, from the groups of sporangia)

Characters of the Order

1. B. VIRGINIANUM Virginia B. Rattlesnake fern

Lvs. 3-pinnately divided, broadly triangular in outline, 15-25 cm. across, 2-4dm. tall to top of spore bearing segment; green leaf attached about half way up stalk. Veins forking from a midvein, not netted.

Rich woods, rather rare.

County line near west track; Eldora.

All round n. temp. zone.

June.

Order 3. OSMUNDALES

Sporangia 0.5-0.7 mm. across, on much contracted lflts. of an ordinary or specialized leaf. Lvs. in a circle from the tip of a stout rhizome, which is matted with hard wiry black roots. Veins forked, not netted, running to margin of 1flt. Spores green.

Family 4. OSMUNDACEAE Flowering fern family

Characters of the Order

Osmunda Flowering fern

(Osmunder, the Saxon name for Thor)

Characters of the Order

1. Entire lf. brown and spore-bearing, preceding green lvs. *3. O. cinnamomea*
1. Lflts. at tip of lf. spore-bearing *1. O. regalis*
1. Lflts. near middle of lf. spore-bearing *2. O. Claytoniana*

1. O. REGALIS Royal O. Flowering fern

Lvs. 4-12dm. tall, twice pinnate, smooth; lflts. veiny, stiff. Spore bearing lflts. 8-12, pale brown, at tip of every lf.

Swamps or wet woods, very rare here.

Eldora (*fide* C. B. Frazier).

Native all round the n. temp. zone.

June-July.

2. O. Claytoniana Clayton's O. Interrupted fern

Lvs. 3-12dm. long, 1-2.5dm. wide, pinnately divided, the lflts. deeply pinnately divided into broad rounded lobes. Sporangia on 2-4 pairs of lflts. in middle of lf.

Moist woods, common.
Sugar Creek; Moore.
Nfd. to N. C., Minn. and Mo. Also in India.
May-June.

3. O. cinnamomea Cinnamon fern

Spore-bearing lvs. 4-8dm. tall, 8-12cm. wide, clothed with brown wool, withering after shedding spores. Green lvs. 8-12dm. tall, 15-25cm. wide, pinnate, the pinnae deeply pinnately lobed; lflts. veiny, stiff.

Swamps; very rare here.
Eldora (*fide* C. B. Frazier), Steamboat Rock (coll. Reppert).
Native all round the n. temp. zone.
May.

Order 4. Filicales

Sporangia minute, scarcely visible, on the backs of ordinary lvs., or covered by inrolled lflts., or on slightly contracted green lflts., usually in groups called sori (singular sorus), often with a membranous covering called indusium.

Family 9. Polypodiaceae Fern family

Characters of the Order.

1. *Polypodium* Polypody

(Poly, many; pous, foot; from the branching rhizome)

Lf. 1-2dm. long, 4-6cm. wide, simply pinnate, the lflts. attached to midrib by a broad base. Sori circular, large, without indusium. Lvs. shedding from rhizome by a neat scar.

1. P. vulgare Common P.

Our only species.
On rocks or rocky bluffs, rare here.
Eldora.
All over N. America, Europe and Asia.
July-Sept.

2. *Phegopteris* Beech fern

Small ferns with delicate annual lvs. Spore dots small, round, without indusium, borne on the back of a vein, not marginal.

1. P. Dryopteris — Oak fern

Lvs. 1-1.5dm. long and wide, of 3 nearly equal 1-2-pinnate parts; stalk slender, 1-3dm. tall, chaffy at base.

In rich rocky woods; very rare here.

Eldora.

Nfd. to Oreg. and Alaska; also Eurasia.

July.

Note: *P. hexagonoptera* is reported from Steamboat Rock.

3. *Adiantum* — Maidenhair

(A, without; diainein, to be wetted; the lflts. shed water)

Lvs. very thin, on slender, shiny, black stalks. Sporangia in groups on margin of lflt., covered by the turned back margin of the lflt.

1. A. pedatum — Bird-foot A. — Common M.

Leaf standing horizontally on top of a stalk which is 2-4dm. tall; stalk forking at summit, bearing the lflts. on one side of each fork.

Lower margin of lflt. smooth, the veins all coming from this edge; sori on opposite margin.

Rich woods, frequent.

Moore; Sugar Creek.

Ga. to Cal., N. S., and Alaska; also in Asia.

July.

4. *Pteridium* — Bracken fern

(Pteris, the ancient Greek name for ferns; from pteron, a wing, the lvs. being usually pinnate)

Lflts. firm, 1-2cm. long, the margins turned back all round to cover the sporangia. Lf. 6-10dm. tall, 3-6dm. wide, broadly triangular, at right angles to stalk.

Rhizome 5-10mm. thick, several meters long, black, with 2 bands of black fibrous tissue inside.

1. P. aquilinum — Eagle fern

Characters of the genus.

Dry wooded hills, rare here.

3 miles west of Tama; Eldora.

World wide in range.

July-Aug.

Note: The rhizomes of this fern furnish edible starch to the aborigines in our northwest, in New Zealand, and elsewhere. The leafstalk is remarkable for having 2 deep nectar glands at the top.

5. *Asplenium* Spleenwort

(A, without; splene, spleen; for supposed medicinal virtues)

Lvs. in circular groups, 1-3-pinnate. Sporangia in elongate dots roofed over by a membrane (indusium) rising from one side of dot; or, the dot curved, and the indusium appearing centrally attached.

1. A. FILIX-FOEMINA Female A. Lady fern

Lvs. twice pinnate, the leaflets sharply toothed; 4-10dm. tall, 8-12cm. wide. Spore dots often curved, and finally covering the whole lflt. Indusium visible only in young specimens.

Woods, common.

Sugar Creek; Jones Grove; Moore.

All over n. temp. zone.

July.

6. *Camptosorus* Walking leaf.

(Kamptos, flexible; sorus, fruit dot; from the connected crooked lines of fruit dots)

Lvs. simple, smooth edged, heart shaped at base, 1-2cm. wide tapering to a very long slender tip, and rooting again at tip; 6-15 cm. long; thick and firm.

Sori oblong or linear, irregularly scattered on the netted veins, with indusium as in *Asplenium*.

1. C. RHIZOPHYLLUS Root-leaf C.

Characters of the Genus.

Limestone rocks, rare.

Eldora.

N. S. to N. Car., Minn. and Kan.

7. *Polystichum*

(Poly, many; stichos, row; the spore dots of some species being in several rows)

Lvs. in circular groups, thick and firm, evergreen, once pinnate; stalks very chaffy. Spore dots circular, the indusium circular and attached precisely by the middle.

1. P. ACROSTICHOIDES Acrostichum-like P. Christmas Fern

Lvs. 3-5 times longer than broad (.2-5dm. x 6-10cm.); lflts. narrow, with a lobe on one side at base, margins bristle toothed. Spore-bearing lflts. at top of lf., distinctly contracted in size; spore dots in 2 rows, becoming continuous when old.

Rocky woods, very rare here; common eastward.

Muscatine, Ia.; rarely cult. in Grinnell.

N. B. to Fla., Wis. and Miss.

8. *Aspidium* Shield Fern

(Aspidion, a small shield; from the indusium.)

Lvs. 3-10dm. long in circular groups, 1-3-pinnate. Sporangia in circular dots, covered by a nearly circular membrane (indusium) which is attached by its center. Lf. stalks with brown scales, especially near base.

1. Lflts. cut into bristle-pointed teeth . . . *3. A. spinulosum*
1. Lflts. without sharp teeth . . . 2
2. Spore dots close to margin of lflt. . . . *1. A. marginale*
2. Spore dots close to midrib of lflt. . . . *2. A. Goldieanum*

1. A. MARGINALE Marginal A.

Lvs. twice pinnate or pinnatifid, stiff and firm, evergreen, 2-6dm. long, 6-12cm. wide. Spore dots 1-2mm. across, with conspicuous indusium, touching edge of lflt.

Shaded rocky woods, rare.

Eldora.

N. S. to Ga., Minn. and Ark.

July-Sept.

2. A. GOLDIEANUM Goldie's A.

Lvs. twice pinnate or pinnatifid, firm in texture but not stiff or evergreen, 6-10dm. long, 3-5dm. wide, broadly ovate. Spore dots 1-2mm. across, thin and flat, very near the midrib.

Rich woods, rare.

Eldora.

N. B. to Minn. and N. Car.

July.

3. A. SPINULOSUM Spiny A.

Lvs. 3-pinnate, thin, the lflts. sharply cut-toothed; 2-6dm. long, 6-12cm. wide. Spore dots about 1mm. across, the indusium early withering away.

Rich rocky woods, rare.

Eldora.

Nfd. to Va. and across the continent; also Greenland and Europe.

July-Aug.

Note: Lvs. of this fern are gathered in great numbers in autumn and kept in cold storage for floral decorations during the winter. All florists have them. Our form is var. *intermedium*.

9. *Cystopteris* Bladder Fern

(Cystis, bladder; pteris, fern; from the saclike indusium)

Lvs. few on stalks 1-2 mm. across, 2-3 pinnate, with fine lflts.

Spore dots circular, 1mm. across; indusium on one side of dot, attached beneath and arching over (like a cup lying on its side), difficult to find. Plants spreading freely by rhizomes, forming large solid beds.

1. Lvs. (without stalk) 4-6 times longer than wide, bearing bulblets along midrib *1. C. bulbifera*
1. Lvs. 2-3 times longer than wide, without bulblets *2. C. fragilis*

1. C. BULBIFERA Bulb-bearing C.

Lvs. long and narrow, 2-3-pinnate, 3-6dm. long, 4-8cm. wide, thin and soft, bearing bulblets along midrib underneath.

Moist shaded banks, rare.

2m. n. w. of Montour, Ia.

Queb. to Wis., Tenn. and Ark.

June-July.

Note: I have seen this delicate and beautiful fern flourishing in great profusion on the north side of a small house in Knoxville, Iowa. It might well be often cultivated.

2. C. FRAGILIS Fragile C. Prairie Fern

Lvs. narrowly oval in outline, 1-3dm. long, 3-8cm. wide, firm in texture.

Woods, common.

Jones Grove; Sugar Creek; Botanic Garden.

General in n. temp. zone.

July-Aug.

10. *Woodsia*

(In honor of Joseph Woods, a British botanist.)

Small ferns with narrow 1-2-pinnate lvs., usually downy. Fruit dots round. Indusium attached under the dot all the way round, completely covering the sporangia at first, but early disappearing.

1. W. OBTUSA Obtuse W.

Lvs. broadly lanceolate, pinnate, the lflts. pinnately divided, downy with glandular hairs; lflts. rather far apart, broad at base.

Indusium of a few broad spreading pointed lobes.

Rocky woods, very rare here.

Eldora.

Maine to Ga., Ariz. and B. C.

July.

11. *Onoclea*

(This name was first recorded by Dioscorides for some flowering plant)

Large coarse ferns with spore bearing lvs. much contracted into podlike bodies. Sori within the podlike bodies, on upraised stalks, "imperfectly covered by very delicate hood-shaped indusia" (Gray).

1. Spore-bearing lvs. pinnate, the podlike lflts. long and narrow *2. O. Struthiopteris*
1. Spore-bearing lvs. twice-pinnate, the parts globular *1. O. sensibilis*

1. O. SENSIBILIS Sensitive O. Sensitive fern

Lvs. scattered, from a creeping rhizome, the lamina as broad as long, with a network of veins, deeply divided into wavy-edged lflts., 3-5dm. tall. Spore-bearing lf. twice-pinnately divided bearing inrolled globular bodies containing the sporangia.

Wet meadows and thickets, common.

Jones Grove; Violet Hill; Botanic Garden.

Entire U. S.; also e. Asia.

July-Nov.

2. O. STRUTHIOPTERIS Ostrich Fern Well-fern

Lvs. in circular, funnel-shaped groups, pinnately divided into many narrow pinnately lobed lflts.; 4-7dm. tall, 8-12cm.wide. Spore-bearing lvs. rising in center of cluster, pinnate, the rolled back lflts. long and slender, containing sporangia. Spreading by runner-like rhizomes.

Cult., frequent.

1217 Fifth Ave.; Botanic Garden.

All round n. temp. zone, n. of 40 degrees; very local.

Aug-Oct.

Note: Easily cult., and attractive in appearance.

GRINNELL COLLEGE,
GRINNELL, IOWA.

A MANUAL OF THE GYMNOSPERMS ("EVERGREENS") OF IOWA, BOTH NATIVE AND CULTIVATED

HENRY S. CONARD

Series 2. Pteropsida

Class 2. Gymnospermae Naked seeded Pteropsidans.
(Gymnos, naked; sperma, seed)

Trees or shrubs with needle-shaped or scalelike lvs., or with broad 2-lobed fork-veined lvs. The pollen falls directly upon the ovule or young seed; there is therefore no stigma or ovary. Wood close grained, without ducts (pores); "soft woods."

Stam. fl. conelike or catkin-like, short-lived. Seeds various, with fleshy endospern. Cambium in stems and roots, forming rings of wood.

Note: This group includes the common "evergreens," as well as the deciduous larches, cypress and ginkgo. They are favorites for ornamental plantings and for windbreaks. There is no native species at Grinnell, and probably none nearer than Eldora. They are descendants of a vegetation that was dominant all over the earth in middle geologic time (Mesozoic). The wood of many species is of very great value. Though many of them are very hard and durable, these are all technically called "soft-woods."

Key to genera of Gymnosperms

1.	Deciduous (shedding lvs. in winter)	2
1.	Evergreen	4
2.	Cone-bearing; lvs. clustered	Larix
2.	No cones evident	3
3.	Lvs. needle-shaped; bark black	Taxodium
3.	Lvs. broad, 2-lobed, fork-veined	Ginkgo
4.	Lvs. in bunches of 2, 3 or 5, long, needle-shaped	Pinus
4.	Lvs. one in a place	5
5.	Lvs. needle-shaped, slender	6
5.	Lvs. scalelike, opposite, pressed close to stem	10
6.	Lvs. spirally arranged	7
6.	Lvs. opposite or whorled	Juniperus
7.	Lvs. flat, with distinct upper and lower sides	8
7.	Lvs. 4-sided in cross section	Picea
8.	Each leaf continued down stem in a narrow ridge	11
8.	Lvs. not extending down along stem	9
9.	Leaf scars slightly raised; buds chocolate brown, very sharp	Pseudotsuga
9.	Leaf scars not at all raised; buds yellowish, rounded	Abies
10.	Twigs 4-sided	Juniperus
10.	Twigs flat	Thuja
11.	Tree; cones 1-2cm. long	Tsuga
11.	Sprawling shrub; no cones; seed in a red fleshy cup	Taxus

Order 5. GINKGOALES Ginkgo order

Trees with cream-colored bark, and conical outline. Lvs. deciduous with broadly wedge-shaped base, a deep notch at apex, and fine forked veining, borne in groups on black, knoblike short-shoots.

Stam. fl. 1-2cm. long, catkin-like, a group of stalks, each bearing 2 large pollen sacs. Pist. fl. on another tree, a slender stalk 2-3cm. long bearing 2 naked ovules at tip. Fruit a plumlike, fleshy seed, 2cm. in diameter, dull yellow; inner seed coat shell-like enclosing endospern and a dicotyledonous embryo.

Note: In 1897 it was announced that in these plants the egg-cell is fertilized in the seed about Sept. 1 by an active swimming sperm cell, as in ferns. This fact, with the veining of the leaf and many other details of structure and development, makes this tree precisely intermediate between the ferns and the pines. Probably no plant is of greater theoretical interest and importance.

Family 4. GINKGOACEAE Ginkgo family

Characters of the order

Ginkgo Maiden-hair tree

(The Chinese name)

Characters of the order

1. G. BILOBA Two-lobed G.

The only species.

Cult., rare.

Campus; 5th Ave. and Prince St.

Native of China.

Fl. May. Fr. Oct.

Note: This is the last surviving species of a family of world-wide distribution a few million years ago. Its ancestry runs back very clearly to the coal period, being related to the Cordaitales whose long parallel-veined lvs. cover almost every slab of Iowa coal. Ginkgo may occur wild in central China. It has been cultivated for ages about temples in China and Japan. The seeds are used for food. As it does not bloom until 25-30 yrs. old, no fls. have yet been seen in Grinnell. This species is very desirable as a street and lawn tree.

Order 6. CONIFERALES Conifer order

Trees or shrubs with needle-like or scalelike lvs., opposite or alternate or clustered, mostly evergreen. Wood, bark or lvs. resinous.

Fls. monoecious or dioecious. Seeds borne on scales of a "cone" which may be fleshy and berry-like (naked in Taxus).

Family 5. PINACEAE Pine Family

Both pollen and ovules borne in catkin- or conelike groups, the ovules hidden at the base of young cone scales.

1. *Pinus* Pine

(The classical latin name)

Broadly cone-shaped or irregular trees of medium size. Lvs. evergreen, 4-10cm. long, needle-like, in groups of 2, 3, or 5, with a common sheath at base.

Pollen with 2 empty floats. Fr. a cone of persistent scales, each with 2 seeds at base.

Note: Trees of this genus furnish all of the white and yellow pine lumber of commerce. There are 80 species, all in the northern hemisphere, 20 in North America. Rosin and turpentine and "hard pine flooring" are taken from the "long leaf pine" (*Pinus palustris*) of the southern states. Young shoots of this species are often shipped north for Christmas decorations. Cones of the 5-lfd. or "white" pines ripen in one season; those of the 2- or 3-lfd. or "yellow" pines require two summers.

1.	Lvs. in 5's, slender	2
1.	Lvs. in groups of 2 or 3 on the same tree	*8. P. ponderosa*
1.	Lvs. in groups of 2 strictly	3
2.	Lvs. dark green, branchlets smooth	*1. P. Strobus*
2.	Lvs. bluish white on inner sides; branchlets finely hairy	*2. P. Cembra*
3.	Low and shrubby	*4. P. montana mughus*
3.	Trees	4
4.	Branches covered with old cones; lvs. short	*3. P. Banksiana*
4.	Cones few, not remaining long on tree after opening	5
5.	Lvs. 4-6cm. long; bark papery, yellow	*5. P. sylvestris*
5.	Lvs. 6-14cm. long; twigs dull orange color	*6. P. resinosa*
5.	Lvs. 6-14cm. long; twigs dull grey	*7. P. nigra austriaca*

1. P. Strobus White pine Weymouth pine

Lvs. in groups of 5, 6-8cm. long, soft and flexible, very dark green and feathery in appearance. Branchlets not hairy. Cones often curved, 1-1.5dm. long, slender; scales thin and pliable, without spines. Tree 20-50m. tall.

Stam. fl. oval, 8-10mm. long, with 6-8 bracts at base; pist. fl. long stalked, cylindrical. Seed smooth; cotyledons 8-10.

Sandstone bluffs, very rare here.

Eldora. Cult., common; campus.

Nfd. to Pa. and Ga., Man., Minn. and cent. Ia.

Fl. May-June. Fr. Nov.-Dec.

Note: This tree furnishes the true white pine lumber, unrivalled for smooth, firm, soft grain, ease of working, and freedom from swelling and warping. It is the best ornamental pine for Iowa. One authority pronounces it the most useful tree in the world. The locality at Eldora is the farthest natural outlier of the species toward the southwest. The next nearest natural occurrence is in Delaware county, Iowa. *P. flexilis* with 5 short stiff curved needles to a bunch is on trial at Ames and in Grinnell.

2. P. Cembra Swiss Stone Pine

Lvs. in 5's, 5-8cm. long, rather stiff, erect, dark green on outer side, bluish white on inner sides. Branchlets finely hairy.

Tree 20-40m. tall, narrowly and densely conical. Cones ovate, 6-8cm. long, with broad scales. Seeds 1cm. long, wingless.

Cult. rare.
1502 East St.
European Alps.
Fl. Fr.

3. P. Banksiana Banks's P. Jack Pine

Small tree with lvs. in 2's, 2-3cm. long, stiff. Branches beset with old dead cones. Bark black-grey.

Cone 4-5cm. long, scales thick, without a prickle. Resin ducts deep in leaf.

Cult. rare.
Mears Cottage, campus.
N. S. to Minn. and northward.
Fl. May Fr. Oct.

4. P. montana Mughus Mugho Pine Dwarf Mountain Pine

Treelike shrub, 5-20dm. tall. Lvs. in 2's, 3-4cm. long, stiff. Branchlets dull greenish brown; buds coated with resin.

Cone regular, conical; scales thickened at tip, with a prickle. Resin canals of leaf near epidermis.

Cult. frequent.
Quadrangle; 917 High St.
Mts. of central Europe.
Fl. Fr.

5. P. sylvestris Forest P. Scotch Pine

Tree with orange-yellow papery bark on parts 5-25cm. thick. Lvs. in 2's, stiff, twisted, 4-7cm. long. Cones few, falling off in May each year, pointing away from apex of shoot (recurved), 4-6cm. long. Cone scales thick at tip, without a spine. Resin canals of leaf near epidermis.

Cult. common.
Campus.
Europe and n. w. Asia.
Fl. May. Fr. Apr.-May.

Note: This species and *P. Strobus* and *P. nigra austriaca* are the only pines commonly found about lawns and windbreaks, and all are very common. While this is "one of the most important timber trees of Europe, and "is quite hardy," it "has little to recommend it as an ornamental tree" (Bailey's Cyclop.)

6. P. resinosa Resinous P. Norway Pine Red Pine

Tree with coarse brown bark; branchlets orange color. Lvs. in 2's, 6-14cm. long, slender, flexible.

Cones 4-6cm. long, the scales thickened, without a spine. Resin canals near epidermis.

Cult. rare.

Nursery.

Nfd. to Pa., Minn., Man. and northward.

Fl. Fr.

Note: A valuable, hardy and vigorous ornamental, and important source of yellow pine lumber.

7. P. NIGRA AUSTRIACA Austrian Pine

Tree with very coarse, grey-black bark; branchlets light brown. Buds not over twice as long as thick. Lvs. in 2's, 6-14cm. long, very stout and stiff, dark green.

Cones broad, 5-8cm. long, glossy; scales thickened, with a short prickle. Resin canals of leaf in midst of parenchyma.

Cult. common.

Campus; 4th and East Sts.

S. e. Europe.

Fl. May. Fr. Oct.

8. P. PONDEROSA Ponderous P. Western Yellow Pine

Tree with coarse brown bark. Lvs. in 2's and 3's, 12-16cm. long. Buds large, candle-like, 3-6 times longer than thick.

Cones 8-15cm. long, brown and shiny; scales thickened, with a stout recurved prickle. Resin canals in midst of parenchyma of leaf.

Cult. rare.

Campus; nursery.

B. C. to Mex., east to Neb. and Tex.

Fl. May Fr.

2. *Larix* Larch

(The classical name)

Cone-shaped deciduous trees of large size. Lvs. needle-shaped, soft, 2-3cm. long, in clusters on knoblike, black short-shoots. Cones 1-5cm. long, soft, numerous.

Stam. fl. globular, dull yellow, drooping; pollen globular, not winged. Pist. fl. erect, conelike, bright red.

1. Cones 2.5-3cm. long; tree symmetrical *1. L. decidua*
1. Cones 1-2cm. long; branches crooked *2. L. laricina*

1. L. DECIDUA Deciduous L. European Larch

Cones 2-3cm. long. Tree with straight trunk, straight branches and slender, drooping branchlets.

Bract shorter than seminiferous scale, erect, or incurved; scale finely downy on the back; lvs. without white lines beneath.

Cult. common.
Campus.
N. and cent. Europe.
Fl. April. Fr. Oct.

Note: This is deservedly popular as an ornamental tree, and greatly superior to the following.

2. L. LARICINA Larch-like L. American L. Tamarack

Cones about 1cm. long; trunk crooked, branches and branchlets curved.

Bract shorter than seminiferous scale, erect or incurved; scale glabrous; lvs. without white lines beneath.

Cult. frequent
Campus; 1807 Fourth Ave.; 1510 East St.
Lab. to Penna., Minn. and northward.
Fl. Apr.-May Fr. Oct.

Note: The source of a tough, light timber, especially prized in ship building.

3. *Picea* Spruce

(The latin name of a pine)

Cone-shaped evergreens with lvs. 1.5-2.5cm. long, bristling all round the branch; lvs. slightly curved, 4-sided or diamond shaped in cross section. Cones drooping.

Lvs. spirally arranged (one in a place) leaving a hard prickle when they fall off. Cone scales thin, roundish. Stam. fl. catkin-like, each sporophyll with 2 sporangia. Pist. fl. crimson, the rounded scales longer than the bracts. Winter buds interspersed with lvs. at ends of shoots.

1. Twigs yellow; lvs. green; cones 10-15cm. long — *1. P. abies*
1. Twigs ashy yellow; lvs. ashy; cones 2.5-5cm. long — *2. P. canadensis*
1. Twigs pale; lvs. bluish-waxy, very sharp — *3. P. pungens*

1. P. ABIES Fir S. Norway Spruce

Large trees with horizontal branches and drooping branchlets. Lvs. pure green; branchlets deep yellow. Cones 1-1.5dm. long, the scales rounded.

Stam. fl. 2-3cm. long. Pist. fl. 3-4cm. long.
Cult. common.
Campus; 1302 East St.
Northern Europe.
Fl. May Fr. Oct.

Note: Probably the best tree for windbreaks, retaining the foliage well down to the ground. Distinguishable when young by the color of twigs and lvs.

2. P. CANADENSIS Canada S. White S. Black Hills Spruce

Branches somewhat rising, the branchlets not drooping. Lvs. ashy green; branchlets pale ashy yellow. Cones 2-5cm. long, the scales rounded.

Pist. fls. about 2cm. long. Branchlets not hairy. Cones falling off at maturity (March-Apr.).

Cult. common.

Campus; nursery.

N. B. to S. Dak. and northward.

Fl. Apr.-May. Fr. Oct.

Note: Often planted for ornament and for windbreaks, but less dense than the preceding. A hardy strain from the Black Hills of S. Dak. is cult. as Black Hills Spruce.

3. P. PUNGENS Piercing P. Colorado Blue Spruce

Branches horizontal, the branchlets stiffly horizontal or rising. Lvs. very stiff, needle-pointed, bluish white on the sides. Twigs with pale yellow bark.

Cones 1dm. long, hanging on a long time, the scales soft and thin, notched at margin. Branchlets glabrous.

Cult. common.

Campus.

Col., Utah, Wyo.

Note: The stiffest, and in its most waxy-blue forms, the most showy of evergreens; very variable in color. Healthy, hardy, clothed with lvs. to the ground; of fine conical form. *P. Engelmanni* will doubtless be introduced ere long; distinguished by having branchlets downy.

4. *Abies* Fir Balsam

(The classical name)

Cone-shaped evergreens with lvs. 1-5cm. long, spirally arranged but spreading out in 2 rows, flat, paler beneath.

Twigs with flat circular scars where the lvs. have fallen off. Bark with swollen sacs of resin (balsam). Foliage and resin pleasantly scented, especially in drying. Cones erect, the scales falling from the axis at maturity. Winter buds crowded and touching at ends of shoots.

1. Lvs. 2cm. long or less *1. A. balsamea*
1. Lvs. 2.5-7cm. long *2. A. concolor*

1. A. BALSAMEA Balsam Fir Canada Balsam

Lvs. short, very dark green, 1-2cm. long, blunt. Tree slender and spirelike, thinly leafed.

Pist. fl. violet colored; cones cylindric, 6-10cm. long, 2-3cm. thick.

Cult. frequently.

Nursery; Hazelwood.

Nfd. to Va., cent. Ia., and northward.
Fl. Apr. Fr.

2. A. CONCOLOR One-color F. White Fir Silver Fir
Lvs. long, blunt, light green, flexible, 2mm. wide. Tree broadly conic, dense.
Cones 7-12cm. long, oblong, green, purple or yellow.
Cult. frequent.
Campus.
Oreg. and Col. to Mex.
Fl. Fr.

5. *Tsuga* Hemlock
(Japanese name of one species)
Broadly conical evergreens, with slender branches, horizontal or drooping. Lvs. spirally arranged but displayed in 2 rows, short-stalked, and continuing down the stem as a low ridge. Cones small, 1-2cm. across. Stam. fls. axillary, stalked inside the bud scales. Pist. fl. terminal.

1. T. CANADENSIS Canadian Hemlock Eastern Hemlock
Characters of the genus.
Cult. rather rare.
Nursery; Woods farm.
N. B. to Wisc. and Ala.
Fl. Apr.-May. Fr.

Note: This very feathery and beautiful tree is in many ways the most attractive of the evergreens. It is of slow growth, but seems perfectly hardy here. In the northern U. S. it formerly grew in great abundance. The wood has long been used in great quantities for rough construction work; it is coarse and splintery. The bark is very valuable for tanning. Much timber has been destroyed simply for the bark, the 3 or 4 ft. logs being left to rot. This process was formerly called "developing our resources;" it is now known to be destroying our heritage. Eastern hemlock lumber has nearly all been cut.

6. *Pseudotsuga* Douglas Fir
(Pseudo, false, and Tsuga)
Conical or oval dark green trees, with branches rising. Lvs. spirally arranged but spreading in 2 rows, flat, flexible, paler beneath, shedding so as to leave a round upraised scar. Winter buds conic, very sharp and smooth, chocolate brown.
Cones with 3-lobed bracts extending beyond the thin rounded scales.

1. P. TAXIFOLIA Yew-leafed P. Oregon Pine Douglas Fir
Characters of the genus.
Pist fl. a cluster of slender pink bracts. Bark with pustules of resin. Lvs. about 2cm. long.

Cult. frequent.

Campus; East city line.

B. C. to Mex. from Rocky Mts. to coast.

Fl. April. Fr. Oct.

Note: The Douglas fir is the most majestic tree of the northwestern forests, towering to 70 m. in height, averaging 2 m. in diameter, and often attaining a diameter of 3 m. The timber is hard and of great value. In this region it is a handsome tree, but loses its lower branches rather early.

7. *Taxodium* Bald Cypress Southern Cypress

(Taxus, yew-tree; eidos, resemblance. The foliage resembles that of the yew-tree)

Conical tree with stringy bark. Lvs. spirally arranged but spreading out in 2 rows, light green, 15mm. long, 1-2mm. wide. Leaf-bearing twigs fall off in autumn with the lvs.

Cones spherical, rough, Stam. fl. in branching spikes, the scales bearing 2-5 sporangia.

1. T. DISTICHUM Two-rowed T.

Characters of the genus.

Cult. very rare.

Campus.

Del. to s. Ill., Mo., Fla., and Tex.

Fl. May. Fr.

Note: One specimen of this tree prospers on the Grinnell College campus. It is native of swamps, often in deep water, in the southern states. There it grows to a great diameter, and sends up huge woody breathing roots called cypress or cedar "knees," often 2 m. high and 3 dm. thick. The cypress lumber now so much used comes from this tree, but not the so-called cypress shingles. Shingles are made from *Chamaecyparis thyoides* in the east, and from *Thuja plicata* in the west; both are then called cypress or cedar.

8. *Thuja* Arbor-vitæ

(A Greek name of some resinous evergreen)

Small evergreen trees with flat twigs. Lvs. scale-like, opposite, in 4 ranks; two of the ranks have flat lvs., the other two have the lvs, folded or "keeled."

Pist. fl. about 2mm. across, greenish white; stam. fl. brown, 3mm. across, each scale with 4 sporangia. Cone scales opposite, 4-ranked, 8 or 10 in number.

1. Twigs horizontal, with distinct upper and lower sides; cone dry, scales thin *1. T. occidentalis*
1. Twigs vertical, both sides alike; cone fleshy-knobbed *2. T. orientalis*

1. T. OCCIDENTALIS Western T. American Arbor-vitæ

Twigs mostly horizontal, always with upper and lower surfaces different. Cone scales thin, flat.

Cult. common.

Campus; Woods farm.

Queb. to N. C., Minn. and Man.

Fl. March-Apr. Fr. Oct.

Note: A valuable ornamental, appearing in many forms: globular, pyramidal, golden, etc. It furnishes the white cedar posts and telephone poles of the middle west. Its home is in cold northern bogs.

2. T. ORIENTALIS Eastern T. Oriental Arbor-vitæ

Twigs mostly vertical, without distinction of upper and lower sides. Cone scales with a prominent fleshy knob.

Cult. rare.

Nursery; Traer, Ia.

Persia to e. Asia.

Fl. Apr. Fr.

Note: A pleasing ornamental, but often suffering winter injury. It becomes a large tree in favorable conditions. The young plants of this genus have needle-like lvs. 0.5-1 cm. long; specimens which retain this juvenile foliage are often cult.

9. *Juniperus* Juniper

(A classical name)

Evergreens with small lvs. which are needle-like or scalelike, opp. or whorled in 3's.

Pist. fl. 2mm. wide, greenish white, of about 6 opposite 4-ranked scales. Stam. fl. ovoid, 3-4mm. long, brown, with 8-12 opposite scales, each with 3-4 sporangia. Fr. a fleshy "berry," black or bluish-waxy.

1. Erect shrub; lvs. in whorls of 3, needle-shape ,at rt. angles to stem *1. J. communis*
1. Sprawling shrub; lvs. in 2's or 3's, short, slightly spreading *2. J. horizontalis*
1. Erect tree; lvs. mostly opposite, needle-like or scalelike; if needle-like, at acute angle with stem *3. J. virginiana*

1. J. COMMUNIS Common J.

Erect, much branched, columnar shrub, to 1-2m. tall, with lvs. whorled in 3's, about 1cm. long, standing nearly at right angles to stem, bluish-waxy above.

Fls. axillary. Lvs. 12-20mm. long. Berry 6-8mm. in diameter.

Cult. rare.

Nursery.

Mass. to N. C., N. Mex. and Man.; also in Europe. Rare in America.

Fl. Apr. Fr. Sept.

Note: An ornamental columnar evergreen, but too tender for our winters. The berries are used in medicine, and formerly served to flavor that strong alcoholic beverage Gin (short for Geneva).

2. J. HORIZONTALIS Horizontal J. Savin

Low trailing shrub, 0.5-1m tall, the trunk horizontal, the branches wide spreading. Lvs. needle-like, or scalelike and needle-pointed, usually opposite.

Berry on a short recurved stalk.

Cult. frequent.

Nursery; 1510 Broad St.

Nfd. to Minn. and northward.

Fl. Fr.

Note: A very desirable and hardy low dark evergreen.

3. J. VIRGINIANA Virginia J. Red Cedar

Trees to 15m. tall, pyramidal, dark green. Bark fibrous. Lvs. opposite (sometimes whorled in 3's), on young specimens needle-shape, 5-7mm. long; on mature trees scalelike, closely pressed to the twig, giving the smallest branchlets a square shape.

Berries on straight stalks. Fls. at end of branchlets; stam. cone 3mm. long, brown; pist. fl. about 1mm. long, whitish green.

River bluffs, frequent; cult. common.

Moore; Eldora; campus.

Maine, southward and westward.

Fl. April. Fr. Oct.

Note: A good hardy ornamental, losing its lower branches. Cult. in many shapes and tints of foliage. The red and deliciously scented heart wood is soft and easily worked, and takes a high polish; it is used in making "moth proof" and ornamental chests and window seats.

Family 7. TAXACEAE Yew Family

Shrubs with ovules borne singly and exposed on the ends of short scaly shoots; pollen in globular strobili, 2-4mm. in diameter. The exposed dark brown seed, 2-4mm. across, is borne in a fleshy crimson cup 1cm. in diameter.

Taxus Yew

(Taxon, bow; the wood having been formerly used for bows)

Characters of the family.

1. T. CANADENSIS Canada Yew

Lvs. linear, narrowed to a very short stalk, 1.5-2.5cm. long, green on both sides. Pollen and ovules on different plants.

Moist shaded bluffs, very rare.

Palisades of Cedar River.

Nfd. to Va., Ia. and Man.

Fl. Apr. Fr. Oct.

Note: *T. cuspidata* of Japan has been tried in gardens, but rarely survives our winters.

GRINNELL COLLEGE,
GRINNELL, IOWA.

PARRY'S CATALOG OF IOWA PLANTS OF 1848

WINIFRED ELLSWORTH

In 1852, David Dale Owen, United States Geologist, published his "Report of a Geological Survey of Wisconsin, Iowa, and Minnesota," and included in the volume as Article V a systematic catalog of plants of the Northwest by C. C. Parry. Parry's list bears the misleading title "Systematic Catalogue of Plants of Wisconsin and Minnesota, made in Connection with the Geological Survey of the Northwest, during the season of 1848." But in the second paragraph of Mr. Parry's explanatory introduction to his list he says, "I have also incorporated some personal observations made during a previous season in the State of Iowa, being properly comprised within the District of the Northwest, and enabling me to present a more complete view of the botanical features of the region than could otherwise be done during a single season's operations." His Iowa collection was made, therefore, during a season previous to 1848, and thus precedes Bessey's list of 1870 by more than twenty-two years. The Iowa plants are scattered in the list among the Wisconsin and Minnesota plants and it seems worth while to cull them out into the separate list given below. In most cases Mr. Parry has indicated the time of collection, the locality and its soil condition. He acknowledges his indebtedness to Dr. John Torrey for the authentication of his doubtful specimens.

6. Betulaceae	
Corylus americana	thickets on rich prairies
11. Juglandaceae	
Juglans nigra	interior
Carya alba	
21. Santalaceae	
Comandra umbellata	dry banks
28. Aristolochiaceae	
Asarum canadense	rich woods
31. Polygonaceae	
Rumex crispus	Davenport, Iowa
32. Chenopodiaceae	
Chenopodium album	cultivated fields
33. Amaranthaceae	
Amaranthus hybridus	fields and around gopher-holes
Amaranthus graecizans	wherever there is a garden

40. Caryophyllaceae	
Silene nivea	July, ravines, Davenport, Iowa
Silene antirrhina	June, dry soil and exposed rocks
45. Ranunculaceae	
Clematis viorna	June 9, banks of Mississippi, Davenport, Iowa
Anemone caroliniana	May 3, banks of Mississippi
Anemone virginiana	July, woods
Actaea rubra	May, woods and copses
Actaea alba	with preceding
57. Lauraceae	
Benzoin odoriferum	Southern Iowa
67. Cruciferae	
Cardamine rhomboidea	May, wet places on prairies
Sisymbrium canescens	May, pastures and river banks, Davenport, Iowa
Draba caroliniana	April, dry and exposed banks of Mississippi, Davenport, Iowa
72. Saxifragaceae	
Heuchera Richardsonii	June, dry rolling prairie
Ribes Missouriense	borders of streams
81. Rosaceae	
Spiraea opulifolia	June, rocky river banks
Potentilla arguta	June, dry prairie
Fragaria virginiana	Fields and prairies
Rosa lucida	May, dry soil
Rosa blanda	May, prairie
Crataegus coccinea, var. mollis	May, Davenport
Pyrus coronaria	Apr., Davenport, banks of Mississippi
83. Leguminosae	
Phaseolus diversifolius	August, gravelly banks of Mississippi, Davenport
Lespedeza capitata	August, dry prairies
Astragalus caryocarpus	May, gravelly ridges in the interior
Tephrosia virginiana	July, sandy soil, Davenport
Amorpha canescens	July, rocky crevices, dry soil
Psoralea argophylla	July, high prairies
Trifolium reflexum	June, low grounds
Baptisia leucantha	July, rich soil, Davenport
Baptisia leucophaea	May, dry prairies
Cercis canadensis	Apr., banks of Mississippi, Davenport
Cassia chamaecrista	July, sandy soil
85. Geraniaceae	
Geranium carolinianum	May, waste places
86. Oxalidaceae	
Oxalis violacea	May, dry banks
88. Linaceae	
Linum rigidum	July, high prairies
101. Polygalaceae	
Polygala purpurea	July, wet and rather barren places
Polygala incarnata	dry soil, interior
Polygala verticillata	dry hills
103. Euphorbiaceae	
Euphorbia platyphylla	dry fields
Euphorbia corollata	dry prairies
Pilinophytum capitatum	August, streets of Davenport
109. Anacardiaceae	
Rhus aromatica	June, sandy shore of Red Cedar river

114. Celastraceae	
Staphylaea trifolia	May, thickets
120. Aceraceae	
Acer saccharinum	interior
126. Rhamnaceae	
Rhamnus longifolius	banks of Mississippi, Davenport
Ceanothus americanus	July, prairies
Ceanothus ovalis	May, interior
149. Cistaceae	
Helianthemum canadense	June, dry hills and prairies
153. Violaceae	
Viola pedata	May, prairie
Viola delphinifolia	May, Davenport
171. Lythraceae	
Lythrum alatum	July, margins of ponds
181. Onagraceae	
Oenothera serrulata	June, interior
Gaura biennis	August, dry fields, Davenport
182. Haloragidaceae	
Myriophyllum verticillatum	floating in still ponds, interior
186. Umbelliferae	
Eryngium aquaticum	moist prairies
Polytaenia Nuttallii	June, prairie, Davenport
Archemora rigida	August, banks of streams
Zizia integerrima	June, dry banks of rivers
Cicuta maculata	June, rich, moist prairies, interior
191. Ericaceae	
Gaylussacia resinosa	Davenport (only place)
196. Primulaceae	
Dodecatheon Meadia	
Androsace occidentalis	Apr., banks of Mississippi, Davenport
204. Gentianaceae	
Gentiana quinqueflora	dry prairies
206. Asclepiadaceae	
Asclepias purpurascens	hills, Davenport
Asclepias obtusifolia	dry sandy prairies
Asclepias Meadii	June, dry rolling prairies
Asclepias incarnata	swamps
Asclepias tuberosa	June, dry prairies
Asclepias verticillata	dry hills, Davenport
Acerates longifolia	moist places
Acerates viridiflora	June, dry hills and prairies
207. Convolvulaceae	
Calystegia sepium	copses
208. Polemoniaceae	
Polemonium reptans	May, shady places
Phlox maculata	June, wet places on prairies
Phlox divaricata	April, shady hillsides
209. Hydrophyllaceae	
Hydrophyllum virginicum	June, rich woods
Hydrophyllum appendiculatum	June, copses
Ellisia ambigua	May, cultivated fields
210. Boraginaceae	
Onosmodium molle	about gopher-holes on prairies
Batschia Gmelini	dry, sandy ridges
Batschia canescens	richer soil

Batschia longiflora	May, banks of Mississippi, Davenport
Mertensia virginica	April, Davenport
Cynoglossum Morisoni	waste places about villages
211. Verbenaceae	
Verbena hastata	waste places, Davenport
Verbena urticaefolia	roadsides
Verbena spuria	dry fields
Verbena angustifolia	June, dry fields
Verbena stricta	river banks and prairies
Verbena bracteosa	roadsides
212. Labiatae	
Isanthus caeruleus	August, gravelly banks
Lycopus sinuatus	springy places
Hedeoma hirta	dry exposed places
Pycnanthemum pilosum	dry hills
Pycnanthemum lanceolatum	thickets
Scutellaria versicolor	copses
Stachys hispida	margins of rushy ponds
214. Solanaceae	
Datura stramonium	waste places, interior
Physalis viscosa	dry fields
215. Scrophulariaceae	
Verbascum thapsus	roadsides
Scrophularia nodosa	June, copses
Chelone glabra	swamps
Pentstemon pubescens	June, banks of Mississippi, Davenport
Pentstemon laevigatum	roadsides
Veronica americana	brooks
Veronica peregrina	waste places, Davenport
Gerardia pedicularia	September, dry prairie
Castilleja coccinea	June, prairie
Pedicularis canadensis	prairie
222. Lentibulariaceae	
Utricularia vulgaris	ponds
266. Phrymaceae	
Phryma leptostachya	rich woods
227. Plantaginaceae	
Plantago cordata	April, edges of brooks
229. Caprifoliaceae	
Triosteum perfoliatum	June, copses and river banks
234. Campanulaceae	
Campanula americana	July, woods
Specularia perfoliata	June, dry hills
234. Lobeliaceae	
Lobelia cardinalis	August, low ground
239. Compositae	
Liatris cylindracea	August, dry hillsides
Liatris scariosa	August, dry rolling prairies
Liatris pycnostachya	Moist places in prairies
Kuhnia eupatorioides	September, dry hills, Davenport
Eupatorium serotinum	September, dry banks of rivers
Aster sericeus	August, dry prairies
Aster azureus	August, dry hillsides
Aster multiflorus	September, dry fields
Aster oblongifolius	June, rocky banks of Mississippi, Davenport
Erigeron bellidifolium	May, grassy places
Erigeron Philadelphicum	June, Davenport

Erigeron annuum	June, Davenport
Solidago speciosa	August, dry, rolling prairies
Solidago nemoralis	August, dry hillsides
Silphium laciniatum	July, prairie
Silphium perfoliatum	borders of streams
Echinacea angustifolia	June, prairie
Echinacea purpurea	July, prairie
Rudbeckia hirta	June, dry soil
Rudbeckia triloba	September, dry hillsides
Rudbeckia subtomentosa	August, wet places
Rudbeckia laciniata	August, copses
Lepachys pinnata	July, dry prairies
Helianthus rigidus	September, dry prairies
Helianthus occidentalis	July, dry hills
Actinomeris squarrosa	September, thickets
Coreopsis tripteris	borders of streams
Coreopsis palmata	June, dry copses and prairies
Dyssodia chrysanthemoides	August, waste places about towns
Artemisia caudata	dry prairies and river banks
Artemisia ludoviciana	dry rolling prairies
Artemisia biennis	roadsides
Artemisia dracunculoides?	
Cacalia reniformis	copses, Davenport
Cacalia atriplicifolia	Davenport
Cacalia tuberosa	moist prairies
Senecio aureus, var. balsamitae	rocky banks, Davenport
Cirsium altissium	fall, prairie thistle
Cynthia virginiana	May, dry hills, Davenport
Nabalus racemosus	September, moist prairies
Nabalus asper	dry prairies
Troximon cuspidatum	April, prairie
251. Gramineae	
Bouteloua oligostachya	interior
Stipa juncea	rolling prairie
Koeleria cristata	dry prairies
Poa compressa	
Triticum repens	fields
Hordeum jubatum	dry soil
Panicum capillare	sandy soil
Cenchrus echinatus	sandy soil
Sorghum nutans	dry soil
255. Araceae	
Arum triphyllum	May, woods
Symplocarpus foetidus	swamps
266. Commelinaceae	
Tradescantia virginica	copses and grassy hills
272. Liliaceae	
Trillium sessile	May, rich woods and copses
Smilacina stellata	moist places in prairies
Ornithogalum umbellatum	May, fields
Scilla esculenta	fields, Davenport
Uvularia grandiflora	May, hills and vales
Uvularia sessifolia	woods and copses
Allium canadense	rich hillsides
Lilium philadelphicum	June, rolling prairies
Erythronium albidum	April, Davenport
274. Amaryllidaceae	
Hypoxis erecta	dry soil
277. Dioscoreaceae	
Dioscorea villosa	thickets

278. Iridaceae	
Iris versicolor	swamps
Sisyrinchium Bermudianum	May, prairies
284. Orchidaceae	
Plantanthera leucophaea	moist places on prairie
Calopogon pulchellus	June, bogs and moist sandy places
Cypripedium pubescens	hillsides and prairies
Cypripedium candidum	moist banks
Cypripedium spectabile	June, shady hills
Filices	
Allosorus gracilis	shaded rocks, Davenport
Polystichum acrostichoides	shady river banks

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STRUCTURE AND FUNCTION OF THE STIGMA IN RELATION TO THE GERMINATIVE REQUIREMENTS OF THE POLLEN IN THE EASTER LILY

J. N. MARTIN, FRED C. WERKENTHIN, AND ELIZABETH HUDSON

Abstract

Stigma of Easter Lily is papillate. Over the surface of the papillae a mucilaginous layer is formed and from this mucilaginous layer the pollen absorbs the requisite amount of water for germination. The papillae and nearly all cells of the stigma previous to the opening of the flower contain much starch which is transported from cell to cell chiefly in the form of dextrin. As the starch disappears in the papillae the mucilage appears on the outside of their walls.

The pollen germinates on almost any media or in almost any solution that furnishes the required amount of water.

Iowa State College.

THE STRUCTURE AND DEVELOPMENT OF THE SEED COAT AND CAUSE OF DELAYED GERMINATION IN MELLILOTUS ALBA

J. N. MARTIN

Abstract

The epidermis of the ovules forms the much elongated cells, known as the Malpighian cells of the seed coat. The outer walls of the Malpighian cells are much thickened and are composed of layers differing in physical properties. One of these layers is the light line which in most seeds is impervious to water until it is modified by weathering or by some artificial means. The light line is apparently only more compact cellulose for it hydrates quickly in water at 80° C. and then gives a distinct cellulose reaction and is permeable to water.

The action of the weather on seeds lying out over winter is

to open the line and thus permit the embryos of the seeds to obtain water.

Iowa State College.

THE RELATION OF CUCURBIT MOSAIC TO WILD CATNIP

J. H. MUNCIE

Cross inoculations from mosaic cucurbits to non-cucurbitaceous hosts, according to published records, have been unsuccessful except in a few cases. Doolittle obtained infection by aphis inoculation from mosaic cucumbers to *Martynia louisiana,* while Jagger obtained infection on *Lobelia crinus* var. *Gracilis* and *Helianthus debilis.* Preliminary experiments by the writer show that cucurbit mosaic can be transmitted to *Nepeta cataria* by the insertion of crushed mosaic leaf tissue of mosaic gourd into the stems of Catnip. Typical mosaic symptoms appeared on the tips of the leaves of the catnip in about three weeks, and after six weeks practically every leaf showed the mosaic. Mosaic of catnip has not been observed in the field by the writer, but with the ease of obtaining infection and chances of insect inoculation, this perennial host may be a source of early infection to cucumbers in the field.

Department of Botany,
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THE NODAL INFECTION OF CORN BY *DIPLODIA ZEAE*

L. W. DURRELL

Dry rot of corn caused by *Diplodia zeae* was very prevalent in Iowa the past season (1921), particularly in the central portion of the state. The disease originates in the old stubble and stalks of the previous season from which the spores of the organism are blown to the corn plants. Under conditions of extreme moisture and high temperature the spores germinate, grow and attack the corn.

Infection may take place on the roots, stems or ears of the corn. Seedlings growing over old Diplodia-infected stubble may have their roots attacked by the dry rot fungus. Spores blown to the silks may germinate and grow down the silks and infest the tip of the ear. The most common points of attack, however, are the nodes. Here infection takes place after pollen fall. Masses of pollen and blown spores of *Diplodia zeae* are caught within the moist leaf sheath where the pollen furnishes a starting medium for the fungus which later attacks the base of the leaf sheath and nodes. Similar infection takes place within the husk at the base of the ear.

There is no consistent evidence of a migration of the disease from the soil up to the ears or higher parts of the plant. Thirty-nine per cent of infected ears are borne on unaffected stalks while only 22 per cent of all infected stalks showed diplodia higher than the third from the ground. Further, but 31 per cent of the internodes have been found attacked by the fungus.

All observations and experiments emphasize the fact that *Diplodia zeae* infects locally at any point where blown spores may lodge, and that moisture and temperature are essential to growth there.

Department of Botany,
Iowa State College.

EFFECT OF HARDNESS OF WATER ON THE FUNGICIDAL VALUE OF MERCURIC CHLORIDE SOLUTIONS

J. C. GILMAN

A comparison of the fungicidal value of mercuric chloride solutions made up in tap water with those made up in distilled water showed that the tap water solutions were much less effective in killing the sclerotia of *Rhizoctonia solani* on potato tubers. Of the 182 sclerotia treated with bichloride, 1-1000 in distilled water, only 6 or 1.1 per cent grew. In the case of a similar treatment of tap water solution of the 139 sclerotia examined, 34 or 7.1 per cent grew. Ninety per cent of untreated sclerotia grew in the control experiments.

These facts are important in the application of seed treatments where the grower uses hard water in making up disinfecting solutions.

Iowa State College.

DOLOMITES FROM THE AUSTRIAN TYROL AND OTHER LOCALITIES

NICHOLAS KNIGHT

Deodat Dolomieu was born in Dolomieu, France, June 23, 1750, and died November 16, 1801. In infancy he was created a Knight of Malta. He seemed precocious in many directions. When nineteen years of age he quarreled with a companion and killed him. He was condemned to death for the crime, but after nine months' imprisonment, he was pardoned on account of his youth. He early became interested in geology and mineralogy, and wrote some important treatises on his favorite subjects, especially while residing in Metz, the interesting old capital of Lorraine.

He discovered dolomite while making an extended tour and observations among the Alps in 1789-90. The mineral was first described by him in 1791, and the name was bestowed upon it in honor of the discoverer.

The dolomite mineral and rock are important from both a theoretical and practical standpoint. Much work has been done upon them, and the mineral can be artificially produced by a number of different methods.

Marignac was probably the first to make it artificially. His method was to heat calcium carbonate and a solution of magnesium chloride to 200 degrees under a pressure of fifteen atmospheres. In a closed gun barrel, J. Dorocher heated porous limestone and dry magnesium chloride to about 1200°. The vapor of the chloride permeated the porous limestone, which was partly transformed into dolomite. In a similar way, it has been suggested, the heat in the neighborhood of volcanoes may produce the mineral and rock.

One of the simplest methods was devised by C. Sainte-Claire Deville. He saturated chalk with a solution of magnesium chloride, and heated the mixture upon a sand-bath. More or less of the materials change into dolomite.

By heating powdered calcite with magnesium sulphate to 200 degrees in a closed tube, von Morlot obtained a mixture of dolomite and calcium sulphate. It has been suggested by Haidinger that this reaction accounts for the frequent association of gypsum with dolomite.

T. Sterry Hunt conducted a long series of experiments on the precipitation of calcium and magnesium carbonates, from which he reached the conclusion that dolomite is simply a chemical precipitate. This view has not been generally adopted.

In more recent times, 1909, G. Linck published a report of a new method of making dolomite. He mixed solutions of magnesium chloride, magnesium sulphate, and ammonium sesquicarbonate, and then added a solution of calcium chloride. An amorphous precipitate came down, which on being gently heated for some time in a closed tube became crystalline. This had the composition and optical properties of dolomite. Linck believes that his experiment explains the formation of marine dolomite, and that the ammonium salt necessary can easily result from the decomposition of organic substances.

An ideal dolomite would consist of calcium carbonate 54.35 per cent, and of magnesium carbonate 45.65 per cent. Possibly such a dolomite has never been found as produced by nature and may not exist. The calcium carbonate or magnesium carbonate or both may be partly replaced by different substances, especially by silica, iron and alumina.

The rock formation of northeast Iowa is dolomite and fairly typical. The analysis of a specimen from near Mount Vernon, Iowa, resulted as follows:—

	PER CENT
SiO_2	0.86
Fe_2O_3 and Al_2O_3	1.14
$CaCO_3$	54.35
$MgCO_3$	43.65
Total	100.00

Analyses are here given of specimens from the Austrian Tyrol, the locality where Deodat Dolomieu first studied dolomite rocks and made known their composition.

1. Specimen from Martinswand, Tyrol, Austria. This is a compact, crystalline, greyish-white variety.

	PER CENT
SiO_2	1.10
Fe_2O_3	1.70
Al_2O_3	0.00
$CaCO_3$	49.71
$MgCO_3$	48.53
Total	100.04

This is a fairly typical dolomite although the magnesium carbonate nearly equals in amount the calcium carbonate.

2. Specimen from Grossachenthal, near St. Johann, Tyrol, Austria. It is a grey, compact, non-crystalline variety.

	PER CENT
SiO_2	0.20
Fe_2O_3	0.85
Al_2O_3	0.00
$CaCO_3$	53.62
$MgCO_3$	45.31
Total	99.98

The specific gravity is 2.84. The specimen is quite a typical dolomite.

3. Specimen from Andrian, Ueberetsch, Tyrol, Austria. It is a white, granular rock, resembling marble.

	PER CENT
SiO_2	1.10
Fe_2O_3	0.58
Al_2O_3	0.00
$CaCO_3$	54.45
$MgCO_3$	44.84
Total	99.97

The specific gravity is 2.71. The specimen is almost a typical dolomite.

4. Specimen from St. Martin, Tyrol, Austria. It is a pure white crystalline variety, resembling marble.

	PER CENT
SiO_2	0.20
Fe_2O_3	0.60
Al_2O_3	0.00
$CaCO_3$	51.91
$MgCO_3$	47.52
Total	100.23

5. Specimen from Munknerbach, Tyrol, Austria. It is a pink, massive variety, of a pearly luster, and also contains transparent crystals.

	PER CENT
SiO_2	0.48
Fe_2O_3	0.35
Al_2O_3	0.00
$CaCO_3$	53.21
$MgCO_3$	45.91
Total	99.95

The specific gravity is 2.75. It is a fairly typical dolomite.

6. Specimen from Pinegal, near Bozen, Tyrol, Austria. It is a pure white crystalline mineral, resembling marble.

	PER CENT
SiO_2	0.70
Fe_2O_3	0.60
Al_2O_3	0.00
$CaCO_3$	84.03
$MgCO_3$	14.76
Total	100.09

The specific gravity is 2.70. The specimen is not a dolomite, but a magnesian limestone.

7. Specimen from Sonnenvendjoch, Tyrol, Austria. It is a compact, massive greyish rock.

	PER CENT
SiO_2	3.58
Fe_2O_3	3.18
Al_2O_3	0.00
$CaCO_3$	73.75
$MgCO_3$	19.59
Total	100.07

The specimen is also a magnesian limestone. The specific gravity is 2.74.

8. Specimen from Reiterkogel, near Brixlegg, Tyrol, Austria. It is a greyish-white crystalline, compact rock.

	PER CENT
SiO_2	0.35
Fe_2O_3	3.40
Al_2O_3	1.85
$CaCO_3$	52.01
$MgCO_3$	42.52
Total	100.13

The specific gravity is 2.80. The rock is a fairly typical dolomite.

9. Specimen from Zirler Klamm, Tyrol, Austria. It is a black, massive rock and bears a rsemblance to quartz, having a conchoidal fracture.

	PER CENT
SiO_2	14.50
Fe_2O_3	9.50
Al_2O_3	7.00
$CaCO_3$	48.55
$MgCO_3$	20.39
Total	99.94

The specific gravity is 2.80. The rock contains relatively large amounts of silica, iron and alumina.

10. Specimen from Kloster Alpe, Tyrol, Austria. It is a grey, compact, massive, hard variety, one side of which seemed to have been fused.

	PER CENT
SiO_2	0.75
Fe_2O_3	4.30
Al_2O_3	3.00
$CaCO_3$	85.73
$MgCO_3$	6.19
Total	99.97

The specimen is a magnesian limestone. The specific gravity is 2.70.

11. Specimen from Little Falls, New York. Light grey in color, uniform throughout the entire specimen.

	PER CENT
SiO_2	3.96
Fe_2O_3 and Al_2O_3	0.62
$CaCO_3$	55.42
$MgCO_3$	40.44
Total	100.44

The specific gravity is 2.84. The specimen is quite a pure dolomite.

12. Specimen from Kasota, Minnesota. The color throughout the mass is light yellowish brown.

	PER CENT
SiO_2	9.08
Fe_2O_3 and Al_2O_3	30.91
$CaCO_3$	51.80
$MgCO_3$	38.64
Total	100.43

The specific gravity is 2.72.

13. Specimen from Freiberg, Saxony. A yellowish-grey crystalline deposit on quartz. By the analysis, it can not be considered a dolomite or even a limestone.

	PER CENT
SiO_2	26.60
Fe_2O_3 and Al_2O_3	51.41
$CaCO_3$	4.46
$MgCO_3$	17.54
Total	100.01

The specific gravity of the crystalline deposit and the quartz together, the entire rock, is 3.52.

The analyses show that dolomite is quite a variable mineral in its composition, and many formations called dolomite can hardly be called by that name.

We desire to express our thanks to Lawrence R. McKay and William E. Moore for making the analyses of the specimens considered in this paper.

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A CHEMICAL CLASSIFICATION OF THE ACTIVITIES OF SOIL MICROORGANISMS

PAUL EMERSON

At the present time it may be said that the process of decomposition with its resultant complex chemical changes taking place in the soil is controlled primarily by the activities of microorganisms and that Soil Fertility is mainly dependent upon these microscopic forms. At first the action is probably limited to a comparatively few forms and is entirely biological in nature, due to the efforts of the organism to digest the organic matter with which it is in intimate contact. The organism is interested only in securing the proper amount of food for its metabolic processes. But in the process of digestion it splits off certain substances, for instance carbon dioxide, which cause an appreciable chemical reaction in the soil. As the digestive action continues, the complex organic molecules are subjected to the attacks of a greater variety of soil organisms and are split in various ways with the subsequent formation of hundreds of simpler compounds. Some of these compounds may be in such a form that they are capable of being again assimilated by the growing plants. Others may be in such a condition that they form an acceptable food for other forms of microorganisms and are changed to such a form that they ultimately become available for plant use or are lost to the soil in various ways. During the process many compounds are formed that react with the insoluble constituents of the soil, changing them to the soluble form, thus forming more and more available plant food. It is seen, therefore, that while the decomposition of the complex organic plant remains in the soil with its attendant influence on Soil Fertility is dependent upon the activity of microörganisms, the action is not entirely biological, as there are many chemical actions and reactions involved. In fact, the microorganisms are in reality the instigators and accelerators of various reactions, which, when well started may proceed to some extent without them. Apparently the chemical products have the ability to continue the process of decomposition for some time. Recent investigations at this Station have shown that sterile soils give off large quantities of carbon dioxide for an appreciable time after sterilization and there is still a measurable amount given off up to twelve weeks. On the other hand unsterilized soils will give off amounts decidedly in excess of the sterilized. This indicates very definitely the possibility of a joint chemical and biological action of the agencies in the soil responsible for the decomposition of the organic matter and the liberation of its plant food constituents.

The soil itself may be considered as a great reservoir that ultimately receives all plant and animal life living upon or within it. Also it may be considered as a culture medium for the very numerous and complex microscopic population that habitually lives in it. But viewing the soil from the standpoint of its crop producing power we find that we are not so much interested in the particular kinds of microörganisms living in it as we are in the results of the activities of these organisms. We cannot measure these results except by chemical methods, hence the soil biologist studies his problems by chemical means through the use of microbiological technic. These problems involve primarily the determination of the activities of the soil microflora in liberating or producing those elements essential for plant growth either wholly or in part from the decomposable organic matter in the soil.

In describing the various microbiological activities in the soil, the soil biologist uses a number of terms that more or less describe the end point of the chemical reaction involved but do not indicate how the action has been accomplished. For instance he uses the term "Ammonification" to describe the reduction of higher nitrogen compounds to ammonia and "nitrification" to describe the oxidation of ammonium compounds to nitrates. The term "azofication" describes the fixation of elementary nitrogen from the air. Whether it is directly assimilated or is acted upon before assimilation is not known; most assuredly the elementary nitrogen is oxidized at some stage in the process. The term "rhizofication" is used to designate the fixation of nitrogen in the roots of the legume. Evidently the organism has some ability that corresponds closely to the activities of the Azofying organism, yet it has a different name. If we look at the names we find that the terms "azo" and "nitra" have the same meaning while the term "rhizo" means root. The first two terms mean practically the same thing while the latter means simply that the root has the same ability to fix nitrogen as the infecting organism.

On the other hand the chemist has definite and exact reactions to designate the decomposition or synthesis of an organic compound. The decomposition is accomplished by enzymatic processes and may proceed by the aid of life processes or it may proceed independently according to the presence or absence of certain factors. It appears that in the soil all of the necessary factors are present and that the presence of the biological life merely stimulates the reactions involved. The question naturally arises then, "Why is it not possible to classify the action of the organisms mainly from the standpoint of the chemical actions involved instead of from the standpoint of the physiological actions?" Such a classification appears to be more necessary than ever before because of the fact that the soil biologist has to take into account the numerous organisms that are concerned with the decomposition, oxidation or assimilation of many compounds other than those containing nitrogen. For instance the fleshy fungi apparently are influenced more by the amount of carbonaceous material in the soil than by any other factor. We do not know how important they are in soils, due to lack of methods for their determination, but they always occur, and in wooded areas the effects of their activities are seen on all sides. The filamentous fungi and the thread bacteria apparently have a greater effect on the carbohydrate material in the soil than any other group of micröorganisms. They are interested mainly in carbon and only incidentally in nitrogen and this fact should certainly be recognized. It appears that a scheme of classifying based mainly on the enzymatic processes involved and using the terms usually used to describe these actions would make the situation clearer. The following classification is suggested with the idea that it will stimulate discussion along this line and with the hope that eventually some scheme acceptable to chemists and biologists alike will be evolved. It must be remembered that there are five elements that may be lost from soils in the form of gas. Two of these, hydrogen and oxygen, are so abundant and appear in so many compounds that they may be eliminated. The other three, carbon, nitrogen, and sulfur are very important from the standpoint of soil fertility, and their absence from soils has a large effect on crop yields. The other elements essential for plant growth never occur in gaseous forms and consequently are lost only through such physical means as leaching, wind action, etc. The classification therefore will include only the three elements, carbon, nitrogen, and sulfur, it being assumed that the others may be substituted, taking care to recognize the fact that the latter never occur in the free state.

CLASSIFICATION

DIGESTION:—Largely hydrolytic, rendering soluble insoluble compounds. Primarily extracellular. Slight changes in energy relationships. May be anaerobic or aerobic.

Carbon:—hydrolytic splitting, (the hydrolysis of starch) no designation of the bacterial action involved.

Nitrogen:—splitting of higher nitrogen-containing compounds with the formation of peptoses, peptids, peptones, amino acids and ammonia as end products.

Bacterial term — ammonification.

Sulfur:—splitting of organic sulfur compounds with the formation of hydrogen sulfide as the end product.

No designation of bacterial action involved.

ASSIMILATION:—Elements or compounds taken into the cell and there built up into protoplasm, cell walls, etc. Intracellular action, possibly the result of extracellular enzymatic action.

Carbon:—usually involves dehydration, may also involve reduction (sugars to carbon dioxide).

No designation of bacterial action involved.

Nitrogen:—

1. Assimilation of nitrogen compounds.
   No designation of action.
2. Assimilation of elementary nitrogen
   - (a) by bacterial action.
     - (1) By aid of plants.
       Bacterial term — Symbiotic nitrogen fixation or Rhizofication.
     - (2) By bacteria alone.
       Bacterial term — Non-symbiotic nitrogen fixation or azofication.
   - (b) By other microscopic plants — yeast, algae, etc.
     No designation of action.

Sulfur:—Assimilation of compounds only.

No designation of bacterial action.

OXIDATION:—Elements or compounds oxidized partly or completely in order to secure growth energy. Action usually intracellular.

Carbon:—Action as above.

No designation of bacterial action.

Nitrogen:—Ammonia or ammonium compounds oxidized to oxides of nitrogen, to nitrites, to nitrates, by various stages or directly in order to secure growth energy, usually for the assimilation of carbon dioxide.

Bacterial term — Nitrification.

Sulfur:—Free sulfur or hydrogen sulfide oxidized to sulfites or sulfates.

Bacterial term — sulfofication.

REDUCTION:—Aerobic or anaerobic processes by which compounds are reduced to furnish oxygen.

Carbon: — Occasionally a part of assimilation, part of the carbon may be reduced while another is oxidized.

No designation of bacterial action.

Nitrogen:—Primarily anaerobic; end products, reduced nitrogen compounds or free nitrogen.

Bacterial term — Denitrification or deazofication.

Sulfur:—The reduction of sulfates and sulfites.

Bacterial term — Desulfofication.

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Contribution from the Chemical Laboratory of Grinnell College

ELECTROMETRIC TITRATION OF SULFUROUS ACID WITH PERMANGANATE

W. S. HENDRIXSON AND L. M. VERBECK

The purpose of this work was to determine whether sulfurous acid in acid solution is completely oxidized to sulfuric acid by an excess of permanganate as stated in the literature. If so the excess of permanganate should be easily and accurately determinable electrometrically with potassium iodide thus giving a simple method for determining sulfur dioxide, sulfurous acid or sulfites. The results show that with a small or large excess of permanganate only about 90 per cent is oxidized to sulfuric acid, the remainder of the sulfurous acid probably forming dithionic acid.

The practicability of titrating sulfurous acid with permanganate seems so obvious that it is not surprising that it has been attempted by many chemists, though the results have many times been shown to be too low and discordant. For this fact two causes have been assigned, loss of sulfur dioxide and the incomplete oxidation to sulfuric acid by permanganate whether in excess or not. Nearly forty years ago Honig and Zatzek[1] stated that permanganate did not oxidize sulfurous acid completely to sulfuric acid in acid solution, but only in neutral or alkaline solution. In titrating sulfurous acid with permanganate Dymond and Hughes[2] obtained as the average 88.9 per cent of oxygen used as compared with theory for complete oxidation. By separate experiments on a large scale they definitely proved the formation of dithionic acid when they at the same time ran permanganate and sulfur dioxide into cold water, keeping the sulfur dioxide in excess. They regarded the formation of the dithionic acid as an essential part of the reaction, and due to a stage in the reaction, namely, the reduction of MnO_2 to MnO. Their equation is,

$$17\,H_2SO_3 + 6\,KMnO_4 = 2\,K_2S_2O_6 + K_2SO_4 + 6MnSO_4 + 6\,H_2SO_4 + 11\,H_2O$$

1 Honig and Zatzek, Monatshefte, f. Chem., 4, 738.
2 Dymond and Hughes, Jour. Chem. Soc. 71, 314 (1897).

which would require 88.2 per cent of the oxygen required for complete oxidation to sulfurous acid. They say, however, "When a solution of sulfurous acid is poured into an excess of permanganate only sulfuric acid is found."

Pinnow[3] carried out several series of titrations of sulfite with permanganate in parallel with titrations by the iodine method. The oxidation to sulfuric acid was never found to be complete. Temperature, concentration and acidity had little influence. His results vary from 90.9 per cent in acid to 97.2 in alkaline solution. He also assigned the discrepancy to the formation of varying amounts of dithionate.

Possibly encouraged by the statement quoted from Dymond and Hughes two papers have appeared which propose the determination of sulfurous acid by oxidation with an excess of permanganate. Milbauer[4] added a very dilute solution of the sulfurous acid to ten times the requisite permanganate to oxidize it to sulfuric acid according to theory and determined the excess with oxalic acid. Even though the oxidation were complete it would be difficult to determine the fact by difference in his method owing to the large magnification of the unavoidable error in determining such a great excess of permanganate. Sweeney, Autcault and Withrow[5] added sulfur dioxide or sulfite to an excess of permanganate and determined the excess colorimetrically. They insist on an excess of permanganate at all times. This permanganate was standardized with specially purified sodium sulfite. However, a later communication[6] from the same laboratory showed the impossibility of preparing in weighable condition pure sodium sulfite and called in question all determinations of sulfite basis on sodium sulfite as a standard.

Though the preponderance of evidence seemed to be against the complete oxidation of sulfurous acid in acid solution by a moderate excess of permanganate, the question seemed to merit a more rigorous test than had apparently been applied to it, and the electrometric method, as one of us[7] had applied it in the determination of nitrous acid, seemed to meet the requirements.

The starting point was a solution of sodium sulfite placed in an atmosphere of hydrogen by use of an apparatus practically the same as that used by Thornton and Chapman.[8] After stand-

3 Pinnow, Zeit. Anal. Chem., 43, 91 (1904).
4 Milbauer, Zeit. Anal. Chem., 47, 17.
5 Sweeney, Autcault and Withrow, J. Ind. and Eng. Chem., 9, 949 (1917).
6 Shenefield, Vilbrandt and Withrow, Chem. and Met. Eng., 25, 953 (1921).
7 Hendrixson, Jour. Amer. Chem. Soc., 43, 1309.
8 Thornton and Chapman, Jour. Amer. Chem. Soc., 43, 91.

ing three or four days it was standardized by the iodine method. In all titrations recently boiled water was used and the titrating vessel was kept full of carbon dioxide. Loss of sulfur dioxide was prevented by use of series of bulbs containing iodine and potassium iodide solutions in the standardizations, potassium permanganate in the titrations with permanganate. On account of the rapid change in the concentration of the sulfite solution it was restandardized by the iodine method on the same days that its concentration was determined with permanganate. Though protected in the apparently perfectly working apparatus which maintained an outward pressure of hydrogen equal to about 20 cms. water pressure, the sulfite solution lost about 1 per cent of its reducing power daily. This would require for the average amount of solution stored, the access of about 40 cc. of air daily, which seems impossible, and the facts incline one to the view of Shenefield, Vilbrandt and Withrow[9] that the salt suffers auto-oxidation.

In carrying out the electrometric determinations with permanganate a weighed amount of this solution was placed in the titration vessel, an amount of dilute, recently boiled and cooled sulfuric acid was added to make the acid concentration about normal at the end of the experiment and a rapid stream of purified carbon dioxide was run through the solution for several minutes. The current of gas was slowed down, the mechanical stirrer was started and sufficient sulfite solution was run in to use about half of the permanganate in series (1), nearly all in series (2), and to the end point in series (3). In series (1) and (2) the excess of permanganate was destroyed by a slight excess of known potassium iodide and then permanganate was run in till the voltage showed the end point had been reached. The high degree of uniformity attained by essentially the same method in the determination of nitrous acid[10] was not reached in the titration of sulfurous acid, indicating that the reaction in the latter case is

SERIES (1)

TITRATION OF SULFUROUS ACID WITH A LARGE EXCESS OF PERMANGANATE

	$KMnO_4$ reduc. cc.	Excess $KMnO_4$ cc.	Na_2SO_3 cc.	H_2SO_3 to 1 cc.
1.	37.61	39.64	24.50	0.00325
2.	38.86	41.74	24.95	0.00329
3.	51.27	30.88	33.25	0.00326
4.	31.28	16.73	20.00	0.00330
			Average	0.003275

9 Shenefield, Vilbrandt and Withrow, loc. cit.

10 Hendrixson, loc. cit.

variable, depending upon small differences in conditions that cannot be easily discovered or controlled. Only a few representative determinations are selected for each series. The value of the permanganate was found by $Na_2C_2O_4$ to be N/20 x 1.033.

The iodine method may not be perfect, but it is the best we have and is doubtless accurate enough for present purposes. Three determinations in parallel by the iodine method gave 0.00352 sulfurous acid in 1 cc. of the sulfite solution, which means that the permanganate gave only 93 per cent of its value.

SERIES (2)

TITRATION OF SULFUROUS ACID WITH SLIGHT EXCESS OF PERMANGANATE

	$KMnO_4$ reduc. cc.	Excess $KMnO_4$ cc.	Na_2SO_3 cc.	H_2SO_3 to 1 cc.
1.	36.39	4.10	24.95	0.00309
2.	37.10	2.84	25.00	0.00314
3.	53.20	3.39	36.20	0.00311
			Average	0.003113

The iodine method gave at the same date 0.003476, or the permanganate method gave 89.6 per cent of the sulfurous acid present.

Two titrations as shown in series (3) were made by running the sulfite solution into acidified permanganate to the end point, with the result that the percentage of oxidation was found not materially different.

SERIES (3)

TITRATION OF SULFUROUS ACID WITH PERMANGANATE TO THE END POINT

	$KMnO_4$ reduced cc.	Na_2SO_3 used cc.	H_2SO_3 to 1 cc.
1.	44.72	30.50	0.00311
2.	63.18	42.60	0.00314
		Average	0.003125

The iodine method gave on the same day 0.00340, which is equivalent to 91.9 per cent of the sulfurous acid present.

The conclusion from our results and the records of the work of others on this subject, is that the development of an accurate method for the determination of sulfurous acid with permanganate is impracticable, perhaps impossible.

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Contribution from the Chemical Laboratory of Grinnell College

THE ELECTROMETRIC STANDARDIZING OF TITANOUS SOLUTIONS. (Preliminary Report)

W. S. HENDRIXSON AND L. M. VERBECK

The great value of titanous salts in analytical chemistry has become well known through the work of many chemists. Titanous chloride has been used in determining not only inorganic but also many organic substances, which are likely to be colored or to give colored solution on reduction, thus interfering in the accurate determination of end-points in the usual methods of analysis where colored indicators are used. Such difficulties would, of course, be removed by the application of the voltage method. Moreover, so intensely reducing is the titanous ion that an interval of nearly one volt is given between a slight excess of titanous ion and excess of such oxidizing agents as dichromate and permanganate, when the calomel-platinum cell is used, and this wide interval permits the determination with titanium of two oxidizing agents of quite different intensities when present in the same solution.

The application of the electrometric method in determinations with titanium seemed to promise so much of value and convenience that we took up the subject early in the fall of 1921. At that date we could find no reference to any such application, but 2 months later discovered a reference to such a determination by Treadwell[1] and his collaborators. Their work seems merely incidental to research on a new cadmium reductor, and they mention it as interesting and probably capable of improvement. It seems they have not pursued this line further and it is believed that our work does not interfere with theirs, nor with that of Jones and Lee[2] on the electrometric titration of azo dyes.

We sought in the beginning to determine whether a titanous solution could be easily and accurately standardized with the standard solutions found in every laboratory, — permanganate and dichromate. Until quite recently titanous chloride, usually in hydrochloric acid solution, has been exclusively used in quantita-

1 Treadwell, Luethy and Rheiner, *Helv. Chim. Acta*, [4] **1921**, 551.
2 Jones and Lee, *J. Ind. Eng. Chem.*, **14**, 46 (1922).

tive analysis. To avoid possible side reaction we, however, chose to use the sulfate in dil. sulfuric acid. Careful testing of the material bought on the market[3] showed the presence of even a trace of iron to be doubtful. The solution was kept in an atmosphere of hydrogen by means of the apparatus of Knecht and Hibbert[4] as improved by Thornton and Chapman.[5]

A standard potentiometer, a highly sensitive galvanometer and other standard apparatus were used. The end-points obtained by titrating titanous salt against either oxidizing agent were always marked by very sharp and large changes in potential.

In the experiments of Table I the procedure was as follows. Into the titration vessel containing 50 cc. about 0-1 *N* ferric alum

TABLE I

TITRATION OF TITANOUS SULFATE ELECTROMETRICALLY WITH PERMANGANATE THROUGH THE MEDIUM OF FERRIC IRON

$KMnO_4$ cc.	$Ti_2(SO_4)_3$ cc.	$Ti_2(SO_4)_3$ 0.05 *N* times
47.10	33.50	1.406
47.12	33.50	1.407
48.91	34.85	1.403
47.08	33.50	1.405
47.05	33.49	1.405
		Average 1.4052

made up to about 150 cc. with recently boiled dil. sulfuric acid, was passed a rapid stream of washed carbon dioxide for several minutes. The electrodes were inserted, stirring was commenced and titanous solution was rapidly added in sufficient quantity, but not enough to prevent a liberal excess of ferric iron. Permanganate was then added until the voltage rose to the indicated end-point as shown by the curve constructed from the data of a previous titration. The concentration of the permanganate was 0.05165 *N*.

The determinations of Table II were parallel with the determinations in Table I, except that the titanous solution was run into a measured volume of permanganate until the end-point was indicated by the voltage.

Though some chemists may regard it as not good practice to add a reducing solution to permanganate, and doubtless such a procedure is not best in some cases, particularly in that of oxalic acid,

3 From the LaMotte Chemical Company.

4 Knecht and Hibbert, "New Reduction Methods in Volumetric Analysis," Longmans, Green and Co., p. 47; **1918**.

5 Thornton and Chapman, Jour. Am. Chem. Soc., 43, 91 (1921).

TABLE II

TITRATION OF TITANOUS SULFATE BY ADDITION TO PERMANGANATE SOLUTION

$KMnO_4$ cc.	$Ti_2(SO_4)_3$ cc.	$Ti_2(SO_4)_3$ 0.05 *N* times
47.00	33.35	1.409
47.08	33.48	1.406
48.91	34.83	1.404
48.86	34.80	1.404
		Average 1.4057

the results in Tables I and II are identical within the limit of experimental error. One of us[6] found that permanganate and hydriodic acid could be titrated by running one into the other interchangeably without apparent difference.

A new solution of titanous sulfate was made up and standardized with 0.05 *N* potassium dichromate solution which was used in essentially the same way as the permanganate in the experiments of Tables I and II. Table III contains the results of its titration through the medium of ferric iron.

TABLE III

ELECTROMETRIC TITRATION OF TITANOUS SULFATE WITH DICHROMATE THROUGH THE MEDIUM OF FERRIC IRON

$K_2Cr_2O_7$ cc.	$Ti_2(SO_4)_3$ cc.	$Ti_2(SO_4)_3$ 0.05 *N* times
29.28	30.40	0.9631
29.00	30.07	0.9644
29.80	30.90	0.9644
31.15	32.30	0.9644
		Average 0.9641

The results of the direct titration of titanous salt by adding it to dichromate to the end-point are shown in Table IV.

TABLE IV

ELECTROMETRIC TITRATION OF TITANOUS SULFATE BY ADDING IT TO POTASSIUM DICHROMATE

$K_2Cr_2O_7$ cc.	$Ti_2(SO_4)_3$ cc.	$Ti_2(SO_4)_3$ 0.05 *N* times
25.00	25.98	0.9623
27.83	28.95	0.9613
30.35	31.51	0.9632
30.57	31.68	0.9649
		Average 0.96292

In order to determine the extent to which the standardizations with permanganate and dichromate agree and confirm each other,

[6] Hendrixson, Jour. Am. Chem. Soc., 43, 1309 (1921).

the new solution of titanous sulfate was also treated with the same solution of permanganate used in Tables I and II, running the titanium solution into the permanganate. The results are seen in Table V.

TABLE V

DIRECT ELECTROMETRIC TITRATION OF NEW TITANOUS SULFATE SOLUTION WITH PERMANGANATE

$KMnO_4$ cc.	$Ti_2(SO_4)_3$ cc.	$Ti_2(SO_4)_3$ 0.05 *N* times
42.46	43.90	0.9672
37.20	38.75	0.9600
36.09	37.55	0.9611
49.25	50.94	0.9668
31.37	32.62	0.9617
		Average 0.96336

The average result with permanganate is, doubtless largely by accident, almost precisely the same as the averages obtained with dichromate, and the fact makes it extremely probable that both methods are accurate. Any question in this respect is settled by the work of Jatar[7] which proved that dichromate and titanous chloride act upon each other quantitatively, the valence of chromium changing from 6 to 3 and that of titanium from 3 to 4; in fact, he used titanous chloride for standardizing dichromate and employed a mixture of ferrous iron and thiocyanate as external indicator. It would seem that either oxidant may confidently be used either directly or through the medium of ferric iron for the determination of titanium by the electrometric method.

The sharp change in potential from a slight excess of titanous ion to slight excess of permanganate is about 0.9 volt, and from a slight excess of titanous ion to an excess of dichromate ion about 0.6 volt, and as already indicated these facts may permit the determination in certain instances of 2 substances of quite different oxidizing or reducing power when present in the same solution; for example, titanous and ferrous ions with permanganate or dichromate, ferric ion and permanganate with titanous ion. We have made such titrations of mixtures, and that they are entirely practicable is best shown by the voltage curves in Fig. 1. Curve 1 shows the titration of a mixture of ferrous and titanous ion with permanganate; Curve 2 shows the titration of ferrous and titanous ions with dichromate; Curve 3 is the reverse of Curve 1 and shows the titration of ferric ion and permanganate with titanous ion; Curve 4 is the reverse of 2 and illustrates voltage changes in titrating dichromate and ferric iron with titanous ion.

7 Jatar, *J. Soc. Chem. Ind.*, **27**, 673 (1908).

SUMMARY

This paper emphasizes the value of titanous ion in volumetric analysis, the advantages of the electrometric method for end-points in its use, and shows that titanous sulfate solutions may be easily and accurately standardized with permanganate or dichromate, either directly or through the medium of a ferric-iron solution.

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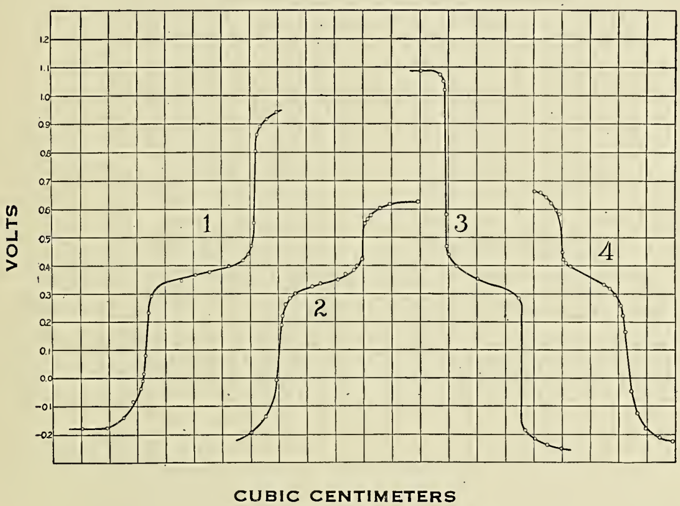

FIGURE 1

STUDIES ON YEAST V- IS BIOS A SINGLE SUBSTANCE

ELLIS I. FULMER AND V. E. NELSON

Abstract

In previous communication (Journal of Biological Chemistry, March, 1922) Fulmer and Nelson showed that the water extract of alfalfa is much richer in the yeast growth stimulant, Bois, than is the 95 per cent alcoholic extract of the same material. In the work here described two extracts were prepared as follows from alfalfa which had been previously extracted with ether. Extract A was an extract by long extraction with absolute alcohol. Extract B was an extract prepared by long extraction of the absolute-alcohol-extracted material with water. Both extracts showed optimum concentrations for maximum stimulation and were about equally potent. Combinations of the two extracts were much more potent than the optimum concentration of either alone. Detailed studies are being made of the properties of the two extracts. Bois is not a single substance but is composed of at least two materials. Bois A is soluble in absolute alcohol and in water. Bois B is insoluble in absolute alcohol and is soluble in water.

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