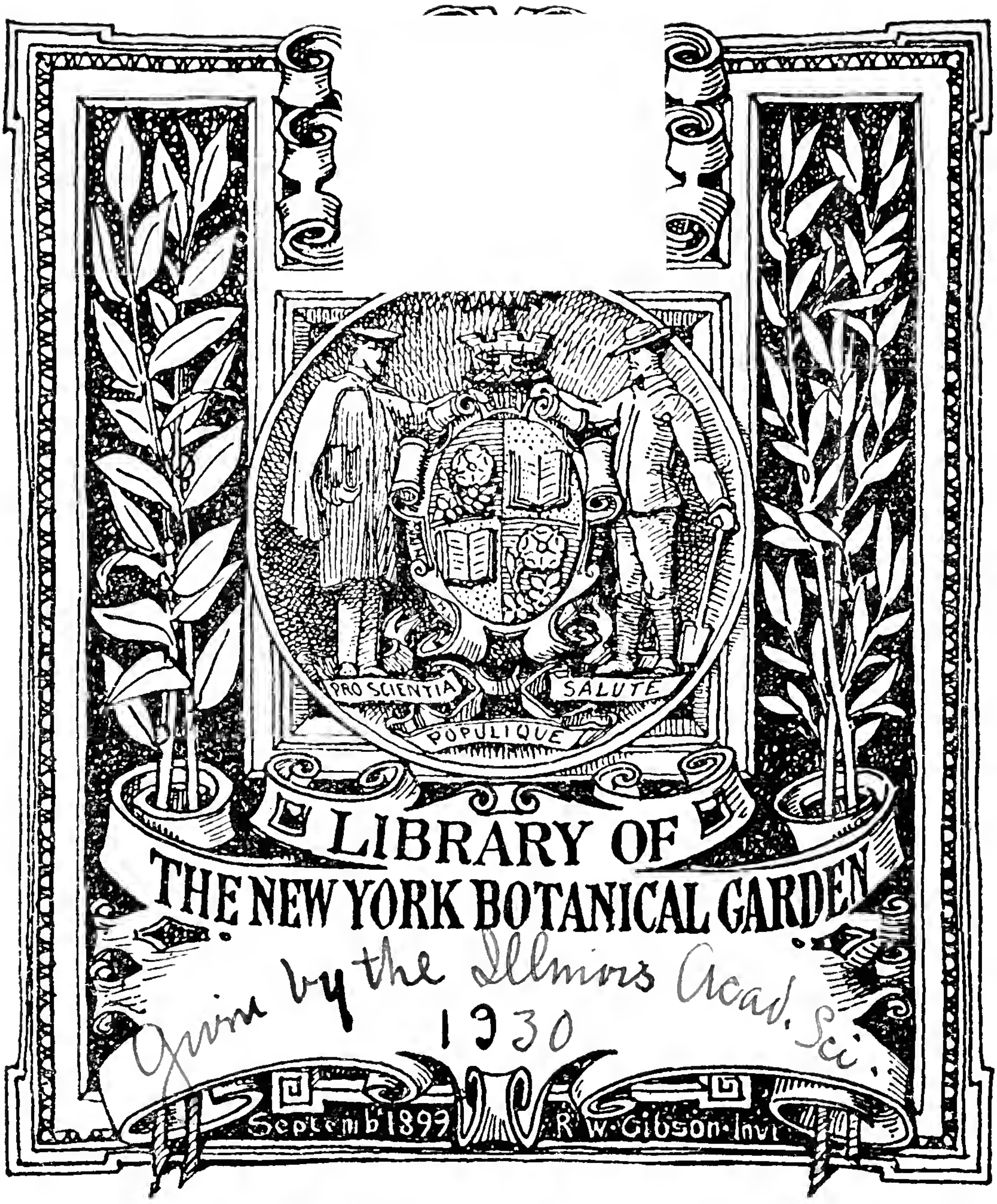
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TRANSACTIONS

OF THE

Illinois State Academy of Science

TWENTIETH ANNUAL MEETING

JOLIET, ILLINOIS

April 29 and April 30, 1927

VOLUME XX

[Printed by authority of the State of Illinois]

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A. R. Crook, *Librarian*

State Museum, Springfield, Ill.

	PRICE
Vol. I, 1908, paper binding. Published by the Academy	$1.50
Vol. II, 1909, paper binding. Published by the Academy	1.50
Vol. III, 1910, paper binding. Published by the Academy	1.50
Vol. IV, 1911, paper binding. Published by the State	Gratis
Vol. V, 1912, paper binding. Published by the State	Gratis
Vol. VI, 1913, paper binding. Published by the Academy	1.50
Vol. VII, 1914, paper binding. Published by the Academy	1.50
Vol. VIII, 1915, paper binding. Published by the Academy	1.50
Vol. IX, 1916, paper binding. Published by the Academy	1.50
Vol. X, 1917, paper binding. Published by the Academy	1.50
Vol. XI, 1918, paper binding. Published by the State	Gratis
Vol. XII, 1919, paper binding. Published by the State	Gratis
Vol. XIII, 1920, paper binding. Published by the State	Gratis
Vol. XIV, 1921, paper binding. Published by the State	Gratis
Vol. XV, 1922, paper binding. Published by the State	Gratis
Vol. XVI, 1923, paper binding. Published by the State	Gratis
Vol. XVII, 1924, paper binding. Published by the State	Gratis
Vol. XVIII, 1925, paper binding. Published by the State	Gratis
Vol. XIX, 1926, paper binding. Published by the State	Gratis
Vol. XX, 1927, paper binding. Published by the State	Gratis

78782-1M
ILLINOIS PRINTING COMPANY
DANVILLE, ILLINOIS
1927

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OFFICERS AND COMMITTEES FOR 1927-1928

President, H. J. VAN CLEAVE, University of Illinois, Urbana.
First Vice-President, C. FRANK PHIPPS, State Teacher's College, DeKalb.
Second Vice-President, R. M. Linkins, Illinois State Normal University, Normal, Illinois.
Secretary, LYELL J. THOMAS, University of Illinois, Urbana.
Treasurer, GEO. D. FULLER, University of Chicago, Chicago.
Librarian, A. R. CROOK, State Museum, Springfield.

The Council.

The Council is composed of the above officers and the last two retiring presidents.

Committee on Membership.

MRS. ELEANOR C. SMITH, Englewood High School, Chicago, Chairman.
W. P. HAYES, University of Illinois, Urbana.
R. G. BUZZARD, Illinois State Normal University, Normal.
V. A. LATHAM, 1644 Morse Ave., Chicago.

Committee on Affiliation.

H. R. GEAUQUE, Lombard College, Galesburg, Chairman.
F. H. COLYER, Southern Illinois State Teachers College, Carbondale.
L. E. HILDEBRAND, New Triar Township High School, Winnetka.
C. F. GRONEMAN, Elgin.

Committee on Ecological Survey.

E. L. STOVER, State Teachers College, Charleston, Chairman.
W. G. WATERMAN, Northwestern University, Evanston.
V. O. GRAHAM, University of Chicago, Chicago.
SAMUEL EDDY, University of Illinois, Urbana.
W. B. MCDOUGALL, University of Illinois, Urbana.
R. B. MILLER, Dept. of Conservation, Springfield.
C. J. TELFORD, State Natural History Survey, Urbana.
RUTH MARSHALL, Rockford College, Rockford.
C. E. MONTGOMERY, State Teachers College, DeKalb.
L. W. TURNER, Blackburn College, Carlinville.
MARY M. STEAGALL, State Normal University, Carbondale.

Committee on Conservation.

H. C. COWLES, University of Chicago, Chicago, Chairman.
M. M. LEIGHTON, Chief, Geological Survey Division, Urbana.
W. N. CLUTE, Editor, American Botanist, Joliet.
W. H. HAAS, Northwestern University, Evanston.

Committee on Legislation and Finance.

FRED R. JELLIFF, Editor, Daily Republican Register, Galesburg, Chairman.
DON W. DEAL, Leland Office Building, Springfield.
EDWARD W. PAYNE, First Trust & Savings Bank, Springfield.
H. C. COWLES, University of Chicago, Chicago.
F. H. COLYER, Southern Illinois State Teachers College, Carbondale.

Committee on Publications.

THE PRESIDENT.
THE SECRETARY.
FRED R. JELLIFF, Editor Daily Republican Register, Galesburg.

Committee on High School Science and Clubs.

H. H. Radcliffe, 1346 W. Macon St., Decatur, Chairman.

Delegate to the American Association for the Advancement of Science.

W. P. FLINT, University of Illinois, Urbana.

Delegates to the Conservation Council of Chicago.

Stuart Weller, University of Chicago, Chicago.
V. O. Graham, University of Chicago, Chicago.

PAST OFFICERS OF ILLINOIS STATE ACADEMY OF SCIENCE.

1907

(Organization meeting, Dec. 7, 1907, Springfield.)

Chairman, U. S. Grant, Northwestern University.
Secretary, A. R. Crook, State Museum, Springfield.

1908

(First annual meeting, Decatur, Feb. 22, 23, 1908.)

President, T. C. Chamberlain, University of Chicago.
Vice-President, Henry Crew, Northwestern University.
Secretary, A. R. Crook, State Museum, Springfield.
Treasurer, J. C. Hessler, James Millikin University.

1909

(Second annual meeting, Springfield, Feb. 20, 1909.)

President, T. C. Chamberlain, University of Chicago.
Vice-President, Henry Crew, Northwestern University.
Secretary, A. R. Crook, State Museum, Springfield.
Treasurer, J. C. Hessler, James Millikin University.

1910

(Third annual meeting, Urbana, Feb. 18, 19, 1910.)

President, S. A. Forbes, University of Illinois.
Vice-President, John M. Coulter, University of Chicago.
Secretary, A. R. Crook, State Museum, Springfield.
Treasurer, J. C. Hessler, James Millikin University.

1911

(Fourth annual meeting, Chicago, Feb. 17, 18, 1911.)

President, John M. Coulter, University of Chicago.
Vice-President, R. O. Graham, Illinois Wesleyan University.
Secretary, A. R. Crook, State Museum, Springfield.
Treasurer, J. C. Hessler, James Millikin University.

1912

(Fifth annual meeting, Bloomington, Feb. 23, 24, 1912.)

President, W. A. Noyes, University of Illinois.
Vice-President, J. C. Udden, University of Texas.
Secretary, Frank C. Baker, Chicago Academy of Science.
Treasurer, J. C. Hessler, James Millikin University.

1913

(Sixth annual meeting, Peoria, Feb. 21, 22, 1913.)

President, Henry Crew, Northwestern University.
Vice-President, A. R. Crook, State Museum, Springfield.
Secretary, Otis W. Caldwell, University of Chicago.
Treasurer, J. C. Hessler, James Millikin University.

1914

(Seventh annual meeting, Evanston, Feb. 20, 21, 1914.)

President, Frank W. DeWolf, State Geological Survey, Urbana.
Vice-President, H. S. Pepoon, Lake View High School, Chicago.
Secretary, E. N. Transeau, Eastern Illinois State Normal School, Charleston.
Treasurer, J. C. Hessler, James Millikin University.

1915

(Eighth annual meeting, Springfield, Feb. 19, 20, 1915.)

President, A. R. Crook, State Museum, Springfield.
Vice-President, U. S. Grant, Northwestern University.
Secretary, E. N. Transeau, Eastern Illinois State Normal School, Charleston.
Treasurer, J. C. Hessler, James Millikin University.

1916

(Ninth annual meeting, Urbana, Feb. 18, 19, 1916.)

President, U. S. Grant, Northwestern University.
Vice-President, E. W. Washburn, University of Illinois.
Secretary, A. R. Crook, State Museum, Springfield.
Treasurer, H. S. Pepoon, Lake View High School, Chicago.

1917

(Tenth annual meeting, Galesburg, Feb. 23, 24, 1917.)

President, William Trelease, University of Illinois.
Vice-President, H. E. Griffith, Knox College, Galesburg.
Secretary, J. L. Pricer, State Normal University, Normal.
Treasurer, H. S. Pepoon, Lake View High School, Chicago.
Librarian, A. R. Crook, State Museum, Springfield.

1918

(Eleventh annual meeting, Joliet, Feb. 22, 23, 1918.)

President, J. C. Hessler, James Millikin University.
Vice-President, James H. Ferriss, Joliet.
Secretary, J. L. Pricer, State Normal University, Normal.
Treasurer, T. L. Hankinson, State Normal School, Charleston.
Librarian, A. R. Crook, State Museum, Springfield.

1919

(Twelfth annual meeting, Jacksonville, March 21, 22, 1919.)

President, R. D. Salisbury, University of Chicago.
Vice-President, Isabel S. Smith, Illinois College, Jacksonville.
Secretary, J. L. Pricer, State Normal University, Normal.
Treasurer, T. L. Hankinson, State Normal School, Charleston.
Librarian, A. R. Crook, State Museum, Springfield.

1920

(Thirteenth annual meeting, Danville, Feb. 20, 21, 1920.)

President, Henry B. Ward, University of Illinois.
Vice-President, Geo. D. Fuller, University of Chicago.
Secretary, J. L. Pricer, State Normal University, Normal.
Treasurer, W. G. Waterman, Northwestern University.
Librarian, A. R. Crook, State Museum, Springfield.

1921

(Fourteenth annual meeting, Carbondale, April 29, 30, 1921.)

President, Henry C. Cowles, University of Chicago.
Vice-President, Chas. T. Knipp, University of Illinois.
Secretary, J. L. Pricer, State Normal University, Normal.
Treasurer, W. G. Waterman, Northwestern University.
Librarian, A. R. Crook, State Museum, Springfield.

1922

(Fifteenth annual meeting, Rockford, April 27, 28, 29, 1922.)

President, Chas. T. Knipp, University of Illinois.
Vice-President, Miss Ruth Marshall, Rockford College, Rockford.
Secretary, C. Frank Phipps, State Teachers College, DeKalb.
Treasurer, Wm. F. Schulz. University of Illinois.
Librarian, A. R. Crook, State Museum, Springfield.

1923

(Sixteenth annual meeting, Galesburg, May 3, 4, 5, 1923.)

President, W. S. Bayley, University of Illinois.
Vice-President, W. G. Waterman, Northwestern University.
Secretary, C. Frank Phipps, State Teachers College, DeKalb.
Treasurer, Wm. F. Schulz, University of Illinois.
Librarian, A. R. Crook, State Museum, Springfield.

1924

(Seventeenth annual meeting, Elgin, May 1, 2, 3, 1924.)

President, W. G. Waterman, Northwestern University.
Vice-President, H. J. Van Cleave, University of Illinois.
Secretary, C. Frank Phipps, State Teachers College, DeKalb.
Treasurer, Wm. F. Schulz, University of Illinois.
Librarian, A. R. Crook, State Museum, Springfield.

1925

(Eighteenth annual meeting, Springfield, Feb. 20, 21, 1925.)

President, Dr. W. G. Bain, St. John's Hospital, Springfield.
First Vice-President, C. H. Smith, Hyde Park High School, Chicago.
Second Vice-President, R. C. Lanphier, Sangamo Electric Co., Springfield.
Secretary, C. Frank Phipps, State Teachers College, DeKalb.
Treasurer, W. B. McDougall, University of Illinois.
Librarian, A. R. Crook, State Museum, Springfield.

1926

(Nineteenth annual meeting, Harrisburg, April 30, May 1, 1926.)

President, Stuart Weller, University of Chicago, Chicago.
First Vice-President, Mrs. Eleanor C. Smith, Englewood High School, Chicago.
Second Vice-President, Clarence Bonnell, Township High School, Harrisburg.
Secretary, C. Frank Phipps, State Teachers College, DeKalb.
Treasurer, W. B. McDougall, University of Illinois.
Librarian, A. R. Crook, State Museum, Springfield.

1927

(Twentieth annual meeting, Joliet, April 29, 30, 1927.)

President, Willard N. Clute, Editor, American Botanist, Joliet.
First Vice-President, Mary M. Steagall, Southern Illinois State Teacher's College, Carbondale.
Second Vice-President, C. E. Spicer, Joliet High School, Joliet.
Secretary, Lyell J. Thomas, University of Illinois, Urbana.
Treasurer, W. B. McDougall, University of Illinois, Urbana.
Librarian, A. R. Crook, State Museum, Springfield.

ILLINOIS STATE ACADEMY OF SCIENCE

Office of the Secretary

University of Illinois, Urbana, Illinois.

Council Meeting, Botany Department, University of Chicago, June 17, 1926.

All officers of the Academy, except the Librarian and the immediate predecessor of the retiring president were present. President W. N. Clute presided.

The Council by vote recommended the following changes in the Constitution that they may be acted upon at the Annual Meeting: Article III, last paragraph, insert after 'be approved', the words *by the Council and;* after 'membership', the words, *at the Annual Meeting.* Article V, insert in the first paragraph after 'President', the words, *First Vice President, Second Vice President.*

By vote the Council recommended the following addition to the by-laws, to be acted on at the Annual Meeting: By-law XI. Except by invitation of the Council, no paper may be accepted for the program unless the author is a member of the Academy or an applicant for membership and no paper will be published unless the M. S. be handed in to the secretary within thirty days after the Annual Meeting.

The place for the Annual Meeting was discussed and invitations for the 1927 meeting considered. By vote it was decided that the Academy meet in Joliet. The Council instructed the Secretary to transmit a letter of appreciation to President Felmley of Normal for the splendid attitude towards the Academy and for the letters of invitation to meet in Bloomington and Normal and to state that the Academy contemplates meeting there in 1928.

Moved and carried that the date of the Joliet meeting be held on the week of the Chicago school spring vacation.

Mr. C. E. Spicer was elected Second Vice President.

The following committees were appointed:

Committee on Ecological Survey—W. G. Waterman, Chairman; G. D. Fuller; W. B. McDougall; Ruth Marshall; E. L. Stover; C. E. Montgomery; C. Bonnell; Mary M. Steagall; Samuel Eddy, and C. J. Telford.

Committee on Conservation—H. C. Cowles, chairman; M. M. Leighton; W. N. Clute; W. H. Haas.

Committee on High School Science and Clubs—E. R. Downing, Chairman. By vote the chairman was empowered to select other members of his committee.

Committee on Legislation and Finance—Don W. Deal, Chairman; Edward Payne; F. H. Colyer; Fred Jelliff; H. C. Cowles.

Moved and carried that the Chairman of the Committee on Ecological Survey be authorized to print 500 copies of the report for the use of the Committee.

The Secretary was appointed by vote as delegate to the American Association for the Advancement of Science with the power to appoint an alternate if unable to attend.

W. N. Clute and Stuart Weller were appointed delegates to the Conservation Council at Chicago by vote of the Council.

The Treasurer presented thirteen names to be passed on for membership. Moved and carried that the Council approve the names of these candidates for membership that they may be presented at the next meeting of the Academy.

Meeting adjourned.

LYELL J. THOMAS, *Secretary.*

Council Meeting, Joliet, December 11, 1926.

The members of the Council were introduced to the hospitality of Joliet by a luncheon at the Hotel Woodruff, given by President and Mrs. Clute. The two past presidents were unable to attend. By invitation past secretary Phipps attended the council meeting.

Following the luncheon the meeting was called to order by President Clute. The preliminary report of the Treasurer was given and accepted:

Cash balance April 3, 1926	$ 410.17
Receipts May 1 to December 10, 1926	650.22
Total	$1,060.39
Expenditures May 1, to December 11, 1926	551.37
Balance December 11, 1926	$ 509.02

The Treasurer also presented eight names which were approved by the Council for membership.

The following changes were recommended in the Constitution to be acted on at the Annual meeting:

(1) Amend by-law IX by adding the sentence, "The Secretary shall receive $150.00 to be paid semiannually."

(2) Amend by-law VIII by adding the sentences, "No paper shall be published unless the manuscript be handed in to the Secretary within thirty days after the Annual meeting. All papers are limited to twenty pages, additional pages are to be paid for by the author." Proposed by-law XI is to be made an ammendment to by-law VIII. See Council minutes of June 17, 1926.

(3) Insert in the paragraph *Life Members* etc. Article III, at the end of the first sentence the words, "at one time or complete payments before the annual meeting of 1928." Also add the sentence, "The dues from such a source are to be placed as a permanent fund and only the income is to be used." The paragraph will then read—"*Life members* shall be national or local members who have paid fees to the Academy to the amount of twenty dollars at one time or complete payments before the annual meeting of 1928. The dues from this source are to be placed as a permanent fund and only the income is to be used."

The Council authorized the Secretary to employ extra clerical help to ascertain the date on which each member joined the Academy and to print this after their favorite science in the list of members in the Transactions. The Secretary was also authorized to call in by wire if necessary all proof held up by authors so as not to delay the publication of the Transactions.

Dr. Mary M. Steagall was appointed alternate delegate to the A. A. A. S. meeting at Philadelphia.

It was voted by the Council to accept with very cordial thanks a gift to the Academy by Dr. W. S. Moffat of Wheaton, Illinois, consisting of a herbarium of flowering plants, some eight thousand sheets. These are now in the possession of Dr. A. R. Crook, the custodian of Academy property. The final acceptance of the gift is left for the action of the members at the Annual meeting.

By vote the following were appointed as a Program Committee for the Annual Meeting: President Clute, Mr. C. E. Spicer, and the Secretary. Plans for the Annual meeting were discussed with Mr. C. E. Spicer, chairman of the local committee of arrangements.

The date of the Joliet Meeting was set, by vote, for Friday, April 29, and Saturday, April 30, 1927. The Council approved a business meeting and general session for Friday forenoon; the afternoon to be given over to the section meetings. A popular lecture is to be given that evening. Field excursions are to be reserved for Saturday and Sunday for such of those who might care to stay.

The following names were submitted by the President for chairmen of the Sections at the 1927 Annual Meeting at Joliet:

Dr. H. S. Pepoon, Lake View High School, Chicago, chairman, Biology and Agriculture.

Professor Wm. C. Gould, State Teachers College, DeKalb, chairman, Geography and Geology.

Dr. G. D. Higginson, University of Illinois, Urbana, chairman, Psychology and Education.

Professor H. H. Radcliffe, 1346 W. Macon Street, Decatur, chairman, High School Science and Clubs.

Chairmen for the sections of Chemistry and Physics, and Medicine and Public Health are yet to be appointed.

Meeting adjourned.

L. J. THOMAS, *Secretary.*

Council Meeting, Joliet, April 29, 1927.

The Council met with the Local Committee of Arrangements and members of Affiliated Societies.

The Council by vote recommended that hereafter the approval of recommendations for membership be left to the Committee on Membership.

The continuation of the Committees on Ecological Survey, Conservation, and on High School Science and Clubs was discussed. Although the State Board has largely taken over the work of these Committees on Ecological Survey and the Committees on Conservation, it was considered wise to continue them so that they would be available to act in an emergency.

The Council recommended by vote that a uniform bill be adopted for the use of the Secretary and Treasurer.

The purchase of an Addressing Machine was discussed, and the Council recommended by vote that the decisions in such matters be left to the discretion of the Secretary, Treasurer, and President.

Meeting adjourned.

State Academy of Science Business Meeting, 11:00 A. M., Joliet, Ill., April 29, 1927.

The meeting was called to order by President Clute.

The Treasurer's report was first called for, and the following written report was submitted:

TREASURER'S REPORT, APRIL 29, 1927

RECEIPTS

Balance on hand April 30, 1926	$ 410.17	
Annual dues collected	544.15	
Life membership fees received	19.00	
A. A. A. S. dues received	10.00	
Received for reprints	199.82	
Received from sale of Transactions	111.00	
Received as annual grant from A. A. A. S.	162.50	
Total receipts	$1,456.64	

DISBURSEMENTS

Printer's bill for reprints	$ 197.59	
To postage for mailing Transactions	64.03	
A. A. A. S. dues for new members	10.00	
Expenses of Secretary's Office	291.24	
Expenses of Treasurer's Office	74.99	
Expenses of Council members	24.09	
Expenses of Membership committee	22.81	
Secretary's Salary	150.00	
		$834.75
Balance on hand April 29, 1927		$621.89

W. B. McDOUGALL, *Treasurer.*

The Secretary reported that Vol. 19, Transactions of the Harrisburg meeting, had been sent out to all members, and that the reprints ordered from this volume by authors had arrived and would be distributed in the near future.

The Librarian submitted the following written report:

Librarian's Report.

A larger number of the copies of the Transactions published by the Academy, which are for sale, have been sold this year than at any time previous.

From this sale, $111 have been turned over to the Treasurer, and $24 are still in the process of collection, making a total of $135.00 worth sold this year.

Of the following volumes, we have a few copies in excess of five hundred, and these may still be obtained by new members by sending postage: II, III, VII, IX and X. Of Volume VI, but 208 remain, and of Volume I, we have but about 30 remaining.

Respectfully submitted,

A. R. Crook, *Librarian.*

The Affiliation Committee submitted the following report: H. R. Geauque, Chairman, reported that an Affiliation Committee should be continued for more than one year in order to be of service to the Academy.

No report was turned in by the Ecological Survey Committee since the work of this committee has largely been taken over by the State, however, it was suggested that the Committee be retained to act in any emergency.

The Membership Committee did not turn in a formal report at this time.

The High School Science and Clubs Committee, H. H. Radcliffe, Chairman, reported as follows:

The meeting was unusually interesting, and it is a compliment to all who presented papers to be able to say that there was not a single "dry" moment, and that every one was followed by a lively discussion. Some who came to hear just one paper remained to the close. Some remarked that they had been attending the meetings for many years, but never one so interesting.

Personally I thought before the meeting it seemed useless to undertake to keep up the section, but the enthusiasm of this meeting was ample repay for the effort.

The Conservation Committee reported as follows:

One of the chief events of the year has been the appointment of Mr. R. B. Miller, one of our Academy members, as State Forester, under the new Department of Conservation. Mr. Miller has begun his service, and is inaugurating the purchase of lands for state forestry purposes. It is important that each legislative session make appropriations to further the forestry work of the state. Your committee was active in furthering Mr. Miller's appointment.

Another big event of the year is the continued development of the upper Mississippi wild life refuge under the able superintendency of W. T. Cox, of Winona, Minn. This refuge involves the Mississippi frontage of Illinois, north of Rock Island.

Little progress has been made or is in sight in regard to State Parks. Senator Hicks has offered a bill for the establishment of a Park to include the white pine woods of Ogle Co. The tax situation in the State is unfavorable to an immediate comprehensive State Park program.

The committee on Legislation at this meeting is presenting various matters touching on stream pollution, forestry, and other conservation matters.

Respectfully submitted,

H. C. COWLES, *Chairman.*

The Committee on Legislation and Finance reported that there are pending in the Legislature several bills of interest to the State Academy: The most important of these is Senate Bill No. 245, introduced by Senator W. S. Jewell of Lewistown on March 29, and referred to the committee on Canals and Waterways. This is an act to establish a Sanitary Water Board and to control, prevent, and abate objectionable pollution of the streams, lakes, ponds, and other water courses and surface bodies of water in the State. The Board consists of the Directors of the Departments of Agriculture, Public Health, Conservation, Purchases and Construction, who are to serve without additional compensation. An advisory council to the Sanitary Water Board and without salary is provided for.

A similar bill presented to the last Legislature passed the House, but was defeated in the Senate. Senator Jewell writes that there is considerable opposition to the measure, and it will need all the backing that this organization can give it.

It is recommended that each member of the Academy communicate with the Legislator from his district and urge them to give this bill their support.

It is further instructed that the Secretary respectfully request the two Illinois Houses to take favorable action on this bill.

Correspondence has been had on the subject of the State providing nurseries of our forest trees, from which land owners may procure trees for re-forestration purposes. Thirty-three states now maintain such nurseries. We have been informed by the State Forester that it is the purpose of the Department of Conservation to establish such nurseries, provided the Legislature approves of the appropriation asked by the Department.

It is recommended that the State Academy of Science approve the establishment of such nurseries, and that this action be communicated to the two Houses.

There is also pending in the House an act in relation to the acquisition and establishment of a State wide system of fishing and hunting grounds. The Department of Conservation would have charge of this system.

The Committee has also interested itself in the matter of procuring an appropriation for the printing of Transactions of the Illinois State Academy of Science. It is trusted that the officials of the organization have also had this in mind.

Respectfully submitted,

Dr. H. C. Cowles, *Chairman.*

The following changes in the Constitution, which had been approved of by the Council, were presented by the Secretary and passed by the members: Article V, insert in the first paragraph after "president," the words *First-Vice President, Second Vice-President.*

Amend By-law VIII by adding the sentences, *no paper shall be published unless the manuscript be handed to the Secretary within thirty days after the Annual Meeting. All papers are limited to twenty pages, additional pages are to be paid for by the author. Except by invitation of the Council, no paper may be accepted for the program unless the author is a member of the Academy or an applicant for membership.*

Insert in the paragraph Life Members, etc., Article III, at the end of the first sentence, the words, *at one time or complete payments before the annual meeting of 1928.* Also, add the sentence, *The dues from such a source are to be placed as a permanent fund and only the income is to be used.* The paragraph will then read—"Life members shall be national or local members who have paid fees to the Academy to the amount of twenty dollars at one time or complete payments before the annual meeting of 1928. The dues from such a source are to be placed as a permanent fund and only the income is to be used."

Adjournment to meet at 5:00 P. M.

Final Business Meeting, April 29, 5:00 P. M.

The Auditing Committee reported as follows: We, the committee appointed to audit the report of the Treasurer of the Illinois State Academy of Science have examined the accounts, have verified the entries of expenditures against approved vouchers or cancelled checks. We find the balance of $621.89, as reported on April 29, 1927, correct.

H. J. VAN CLEAVE,
FRANK H. COLYER,
J. C. HESSLER.
Committee.

The Nominating Committee reported the following candidates for offices: For President, H. J. Van Cleave, Urbana; First Vice-President, C. Frank Phipps, DeKalb; Treasurer, Geo. D. Fuller, Chicago; Secretary, L. J. Thomas, Urbana. The Secretary was instructed to cast a unanimous ballot for the above candidates.

Report of the Section Chairmen is as follows: No chairmen were elected by the following Sections for the ensuing year: Geology and Geography, Psychology and Education. The Chairman for the Chemistry and Physics Section is Dr. Fred H. Currens, Western Illinois State Teachers College, Macomb, Ill.; for the Medicine and Public Health Section, Dr. V. A. Latham, 1644 Morse Ave., Rogers Park, Chicago was elected, and the chairman for the High School Science Section is H. H. Radcliffe, Principal of Night School, 1346 W. Macon St., Decatur, Illinois. Prof. Wm. P. Hayes, Dept. of Entomology, University of Illinois, is appointed Chairman of the Section of Biology and Agriculture.

Due to the absence of the Chairman of the Membership Committee no formal report was given for the year, however, the total additions, withdrawals, and deaths for the year are as follows: 22 withdrawals, 4 deaths, 62 new members, giving a net gain for the year of 42.

The Committee on Resolutions made the following report:

I. *Resolved,* That we express our deep appreciation for the hospitality shown the State Academy during its sessions in Joliet, which has contributed greatly to our pleasure and comfort. We are especially grateful to the local committee on arrangements; to the Joliet Township Board of Education for the use of its beautiful and commodius High School building, and for the appetizing luncheon served at noon; to the High School Cadets for their courtesies; to those making such kind provisions for the field trips; to the press of the city for its favors, and, to all organizations of the city who have contributed to the success of the sessions, altogether making the meeting one of the most enjoyable in the history of the State Academy.

II. *Resolved,* That the Illinois State Academy of Science re-affirm its declaration of former years against the continued pollution of the streams, lakes and other bodies of water with sewage and factory waste, and again call the attention of the members to the recommendations of the Committee on Legislation pertaining to this subject; and, also, that we approve the recommendations regarding re-forestration, and the suggestions of the Committee on Conservation.

III. The Academy of Science accepts with much pleasure the generous gift of the Herbarium from Dr. and Mrs. Wm. S. Moffatt, now of California. We tender our grateful thanks to the donors.

IV. The Academy of Science wishes to record on the minutes its regrets and sympathy to the family of Dr. Erwin Smith, who recently died, and who has rendered such conspicuous service to the progress of plant pathology, and, also, its relation to cancer in the Department of Agriculture, Washington D. C., and to all the scientific workers of the world.

Also, the Academy expresses its regret over the death of Dr. Sargent of Howard University, and foremost man in the interest of culture. Dr. Sargent was the creator of the Arnold Arboretum. We wish to take this means of spreading recognition of his work on the minutes of the Academy of Science. It is with sorrow and regret that the Committee reports the deaths of James H. Ferris of Joliet; Charles H. Smith of Chicago, F. Kohl of Centralia, Dr. O. B. Thompson of Carbondale, and Frank M. Woodruff of Chicago.

FRED R. JELLIFF,
V. A. LATHAM,
C. F. PHIPPS,
Committee.

The Academy was informed that both Bloomington-Normal, and Decatur had extended invitations for the 1928 annual meeting. The council will decide at an early date which to accept.

Meeting adjourned.

L. J. THOMAS, *Secretary.*

PAPERS IN GENERAL SESSION, JOLIET.

ON POPULARIZING SCIENCE.

WILLARD N. CLUTE, JOLIET, ILLINOIS.

The Constitution of the Illinois State Academy of Science provides that it shall be one of the duties of the President to prepare an address to be delivered before the Academy at the Annual Meeting. This provision undoubtedly contemplates an eminently scientific paper on some subject of absorbing interest but since no penalties are provided for a failure to comply with this regulation, I feel that I may safely disregard the specifications in the present instance and spend a few minutes in discussing a matter which, though not strictly scientific, is, in large measure, a subject that concerns both the scientist and the public.

My thesis is that not enough is being done by the scientist to popularize science and the study of science. Of so-called popular science there is no end, but most of this is mere talk about science; information derived from others and passed on to third persons. Real students of science are rare. Every teacher knows how lamentably few of his students continue the subject after the course is finished unless, perchance, the information so secured may be used later in making a living. What is needed is to arouse an interest in, and a love for, scientific study at first hand.

The scientist carrying on investigations which he feels are sufficiently valuable in themselves, rarely feels called upon to make his problems intelligible to the general public. Frequently he has not the time or the opportunity even if he has the inclination to do so. In return the public is prone to think that science is the province of the super-individual and quite beyond ordinary comprehension. Though an occasional investigator may be attracted to scientific things, the majority do not know where or how to begin. Much as they would like to understand and enjoy, they can only wonder and speculate.

The stirring of the scientific instinct may often be observed in the collecting of shells, minerals, plants, bird's eggs, and even buttons and tobacco tags. This interest can, and should be, directed into useful channels before its possessor concludes that the only worth-while collection is a collection of the "coin of the realm." When I recall that one of our foremost conchologists was a grown man before he knew one shell from another, and that a certain excellent botanist was more than fifty years old before he began his studies, I can imagine that many an enthusiastic student has been lost to science for want of somebody to set his feet in the right path.

Nor is the attempt to spread a wider interest in science of benefit only to the beginner. A better informed public may be depended on to aid even the advanced scientist in his work. In all problems that depend on the securing of data from many and widely separated observers the co-operation of the public is invaluable. Such problems as the range of species, the migration of birds, the spread of the boll weevil, of the chestnut blight, and the corn borer, as well as extended phenological investigations must depend on help of this kind for solution. And if such considerations are not convincing, there is still the matter of funds for salaries and research, which aid, coming largely from an appreciative public, is likely to be proportionate to the interest aroused.

Practically all the advances toward a healthier and happier existence have come through the efforts and discoveries of the scientist but without support from an intelligent public such advances may be greatly delayed or even frustrated. We have not yet passed the stage in which our streams are polluted, our forests mismanaged, our timber wasted, and the range destroyed. Floods thus become increasingly destructive, disease may spread unchecked, and beautiful scenery, the heritage of every citizen, obscured by ugly bill-boards, or defaced by hot-dog stands and filling stations.

Unless one makes a special inquiry into the matter it is impossible to realize how abysmally ignorant of the fundamentals of science the average individual is. As a matter of fact, he rarely distinguishes between the real scientist and the adherents of a sect whose doctrines, however, worthy of admiration they may be, are, of all things, the least scientific. The public's knowledge of science is likely to be of the kind referred to by that homely philosopher, Josh Billings when he wrote: "It is better to know less than to know so much that ain't so."

So far as science is concerned, a large part of the public is still living in the Dark Ages. In spite of St. Paul's adjuration to "Prove all things and hold fast that which is good" it inclines to the other extreme and giving up its natural right to think, listens to the voice of "Authority" —that voice which, according to H. G. Wells, made itself so clearly heard in the early centuries of our era as to obfuscate practically all knowledge and intelligence for nearly a thousand years.

It is probably no exaggeration to state that fully half of the people still believe in miracles; not the miracles of Bible times, but present day miracles in which some natural law is contravened on special occasions or for special purposes. How else can one explain the custom of wearing a string of amber beads for the cure of goiter, the tying of a red thread around the neck to stop nosebleed or the various incantations for charming away warts?

It is true that we have pretty generally abandoned a belief in the power of fern-seed to make one invisible, or in the mandrake which was reputed to emit such shrieks on being pulled from the ground as to make everybody within hearing, mad. But Paracelsus' "Doctrine of Signatures" still has its votaries and in out-of-the-way places people still plant in the sign of the moon, believe in the power of a forked stick to locate underground streams and buried treasure, and assume that it is necessary to mutilate a crow's tongue in order to make him talk.

Even in less remote districts, people hold a respectful attitude toward ghosts, witches, fortune-tellers, charms, signs, mascots, and the revelations of the ouijaboard. And still more scientific folk have been known to carry a horse-chestnut or a small potato in the pocket as a charm against rheumatism and for all I know may still place absolute faith in a small bag of asafetida worn around the neck as a protection from any kind of an epidemic. We smile at the Hopi Indian's snake-dance for the purpose of making it rain and then raise a fund for some pretentious aviator to bombard the clouds on our own account.

The public is not entirely to blame for its beliefs, for it has been somewhat unfortunate in its guides and teachers. The modern agency from which most of us derive an idea of matters outside of our immediate cognizance—the newspaper—is, in matters of science, about of the time of Aristotle. Newspaper science is "fearfully and wonderfully made." Usually it is incorrect and frequently wilfully misleading. The callow reporter, an entire stranger to scientific method, and often others not so callow, is impressed by the marvellous or what appears to him to be the marvellous. Not satisfied with things as they are, he must ever dress them up in a garb of "human interest." Thus it happens that he places great stress on such horrendous things as man-eating trees, plants that have the power to foretell earthquakes, plants that cough, or get angry, or exhibit indications of cerebration that none but the higher animals possess.

It has often been said that if the daily press devoted as much space to science as it now devotes to sports, the scientist and all his works would come into their own—but not if the cub reporter conducted the science page. Though science should become as popular as short skirts and bobbed hair, it would still be the kind of science which we enclose in quotation marks so long as it concerns a fairyland in which the birds, flowers, trees and wind hold converse and the universe is pictured as an elderly dame called nature. It is perhaps too much to expect that the newspapers will do much for science of their own accord. The subject lacks the spectacular, offers no very definite field for exploitation, and does not contribute to the gate receipts.

For a time it was hoped that the introduction of science into high school curricula would largely increase the interest in things scientific, but this does not appear to be so at least in the case of the "natural sciences." The restriction on time and material necessitated by class-room study, the emphasis placed on drawing and note-book making, the disassociation of the objects studied from their natural environment, the use of pickled and preserved specimens and the insistence on the ability of the student to repeat the words of the text have all served to dampen enthusiasm and curb curiosity. It is no longer fashionable to know the animals and plants in their haunts. The science of biology has pressed on into new fields and the young student of the present frequently has a better knowledge of his specimen's interior than he does of its exterior.

Doubtless the scientist will concede without argument, most of the statements here made, but he may ask how matters can be remedied. To such a question I must answer that I do not know, else I would be talking of cures instead of symptoms. After trying to popularize science on my own account for more than a quarter of a century without very encouraging results, I hesitate even to make suggestions. I am convinced, however, that meetings such as these may be made to go a long way in arousing enthusiasm in the beginner. To accomplish this, it seems to me, we shall have to put greater efforts on making our scientific papers intelligible. Perhaps we shall have to divide the time between papers designed for the edification of the advanced scientist and others intended to attract the non-scientific, but if we do, it will be well to remember that we cannot make these latter too elementary.

In order to make better progress, the scientist, no matter what his field, will have to take the public more into his confidence. Even at the risk of seeming to court the limelight, he will be obliged to crowd the science reporter out of the local papers—or reform him. Publicity such as that which made the little town of Dayton famous is not desirable, but propaganda that will establish science in its rightful position before the public, is necessary. Not until a majority of the people in a given region attend the meetings of the Academy and similar societies will science have reached the prominence to which it is warranted in aspiring.

In recent years, the working people have been favored with greatly shortened hours of labor and thus an increased number of people have time to take up scientific studies. We should not let the auto, the radio, the movies, and sports, engross, entirely, the attention of this new aggregation of prospective investigators.

Nor does the desire to interest these and others in our work spring from any hope on the part of the scientist for additional honors or greater veneration. It is prompted solely by a sincere desire to bring to the masses a more worthy way of spending their leisure, to give them a deeper appreciation of the world we live in, and by advancing science promote a safer, saner, and more satisfactory existence.

GEOLOGY OF THE JOLIET DISTRICT.*

D. J. Fisher, University of Chicago.

Geology is a science which is of value to man from three points of view: (1) the economic, for it serves as an aid to the discovery and efficient recovery of valuable mineral resources, (2) the scientific, and (3) the cultural and philosophical. It is the last of these which is emphasized in this paper. In our every-day life it is a source of considerable satisfaction to have a distinct knowledge of the part that we in our little span as individuals are playing in the much greater scheme of the story of the earth. The treatment is historical, and leads up to the present; the story of the future can be interpreted from the story of the past.

No one limited area serves the geologist in deciphering the whole earth history; each district has its gaps or "lost intervals" which must be filled in by information from other places. The geologist in his search for the truth may be likened to the scholar of ancient history who searches among the ruins of Egypt for records of its past; but with the decline of Egyptian progress, the story and search are transferred to Greece, and then to Rome.

The rocks are the records used by the geologist. Their physical characteristics and relationships, as well as any remains of organisms or fossils found within them, serve as the "dead language" from which his story must be deciphered.

The rocks known in the Joliet area are all sedimentary in origin; that is, they were deposited by cool water, wind, and ice. They were laid down, one on top of the other, in orderly sequence. Thus the older rocks lie beneath the younger rocks—just like a house in which the oldest or lowest story is always the one built first; no one ever heard of building a house by first putting up the roof in the air, and then constructing the walls to support the roof.

The rocks of the Joliet area are of two types—consolidated and unconsolidated. In the main, the former or bed rocks were deposited from waters and the latter or mantle rocks were laid down by great masses of ice or glaciers which overrode the area relatively recently. Waters and winds were also important agents in the deposition of the incoherent material.

Imagine a cut straight down into the ground to a depth of 1000 feet below sea level along a line extending east from a point about five miles northeast of Morris through and beyond Elwood about two miles and thence N. 20° E. through a point 4 miles east of Joliet. (Fig. 1) An exaggerated diagram of the slice of earth revealed by the cut would look somewhat like figure 3. Figure 2 shows the details of the mantle rock deposits. Its vertical scale is larger than that of figure 3 in the proportion of 50: 13; i. e. the vertical scale of figure 3 is exaggerated 13 times, and of figure 2, 50 times. The horizontal scales are the same for both diagrams.

Figure 3 shows the various consolidated formations known to underlie the area. In the main these were laid down in relatively shallow seas that covered the district at different periods millions of years ago. Note the position of the Kankakee formation which outcrops in the southwest corner of the city of Joliet. A slab taken from this formation on Rock Run five miles west of Joliet is made up of a mass of petrified shells of animals somewhat resembling clams. They are not clams, however, but brachiopods, and are of a type that could live only in salt sea-water. It is thus known that this formation must have been deposited in a sea that covered the area long ago.

The several formations shown in figure 3 in the main originated in this same fashion. What the lowest formation (Cambrian) rests on in this area is unknown, as no well near Joliet has been drilled through it, though a well at Bensenville (30 miles north of Joliet) penetrated it nearly 1000 feet.

The contact between the Lower and Middle Ordovician strata at the base of the St. Peter sandstone is particularly uneven, though none of the contacts shown is smooth. Following the deposition of the Prairie du Chien series a relative rise of the submerged land surface caused the withdrawal of the sea, and for some time the area was subjected to the erosive action of ancient streams and winds. Later when the St. Peter sands were laid down, they filled old valleys. As a result of the rough surface developed during the "lost interval" between the times of deposition of the Prairie du Chien and St. Peter formations the thicknesses of the two vary notably in short distances. All the other contacts indicate "lost intervals" but during none was so uneven a surface developed, though the time interval may have been as long as or longer than that between Prairie du Chien and St. Peter depositions.

Following the deposition of the Niagaran dolomite all the older strata were tilted down in an easterly direction, as shown in figure 3, but the tilting was greater than the present dip of the rocks indicates.

At the extreme left edge of the diagram, Pennsylvanian rocks appear. These are much younger than the Niagaran dolomite; between these two is a great gap. The Pennsylvanian strata (or Coal Measures) dip to the west. They were presumably nearly horizontal when laid down; therefore it is obvious that following their deposition the region suffered a second tilt in a direction more or less opposite to the first one. This second tilt was smaller than the first one, but it was very important, for, without it Illinois would not have her present great coal resources.

The great "missing link" of the geologic section of the Joliet area is found in the essential absence of deposits younger than the Pennsylvanian and older than the glacial mantle rocks. For example, during this interval many thousands of feet of strata were laid down on the land and in a series of seas that covered the site of the present Rocky Mountains. Later these mountains were gradually formed by a succession of tremendous upheavals of the earth; still later much of the rock deposited was removed by erosive agents. The great niche of the Grand Canyon of the Colorado hardly represents a tithe of the rock thus removed; some of the debris collected in this fashion has accumulated at the head of the Gulf of California, partly filling in the gulf and adding thousands of square miles to the land area there. Equally important physical changes were taking place elsewhere and could be cited were the space available.

What happened in the Joliet area during these lost eras? All evidence points to the fact that erosive agents slowly removing the solid rock were moderately active. The result was the planation of the tilted formations which was completed during this interval. Much of the Niagaran dolomite and other soluble rock was removed by means of the dissolving action of water. The relatively insoluble siliceous materials in the dolomite tended to be left, however, and remnants of such materials may still be seen as bluish clay in old solution cavities. Near the southwest corner of the quarry of the National Stone Company half a mile south of Joliet, one of these cavities has been exposed which, according to Mr. George Langford of Joliet, formerly contained blue clay. Just west of the corner of Clinton and Scott Streets, only 1200 feet west of the Joliet High School building, an excavation showed a similar pocket filled with beautifully laminated bluish clay; the curved laminae lay parallel the bottom of the bowl-shaped cavity.

But these deposits are a most meagre record from which to piece the history of this long interval. Of the dinosaurs and other life forms that flourished here during different portions of this time, not so much as a footprint remains. Truly "the mighty have fallen".

* * *

The mantle rock of the area consists of a heterogeneous mass whose origin for a long time puzzled the early geologists. A characteristic exposure of this material, which is found both on hills and in valleys, would show pebbles and boulders surrounded by yellow clay. The boulders are of rock not belonging to any formation outcropping within 200 to 300 miles of Joliet. What could have brought them here? Were they blown south by the wind, or carried by some stream long since extinct? The only feasible transporting agent is moving ice. The conception that a great ice-sheet formerly covered this district is a stupendous one. Picture a mass of ice, probably half a mile or more in thickness, extending south some thousands of miles from the vicinity of Labrador, and covering a large part of the northeastern portion of the United States. Think how such a mass of ice, sliding over the solid rock, would scratch it, break off chunks, and grind them to bits like a giant crusher. Such an ice-cap still covers all but the fringe of Greenland. It and its deposits there have been studied, and substantiate this conception.

Ice-caps near the pole are easily visualized, but ice-caps near Joliet, which is much nearer to the equator, are incongruous. But consider the large portion of North America that was covered by the sea in which the Niagaran dolomite formed. Outcrops of this formation are found near the north tip of Greenland as well as near Joliet. At Joliet and also in Greenland this formation carries among other forms fossil corals. Corals are now limited to warm, clear, shallow seas. The only explanation is that during the Niagaran epoch it was warmer here and in Greenland than it is now. In short, we know that at different times and in different places greatly different temperatures have prevailed.

Regional study leads to the conclusion that the ice moved out from two or three main centers, although the Labrador ice-sheet is the only one known to have covered the area about Joliet. Regional studies have also shown that four or five ice-sheets covered parts of the United States at different times, but the deposits of the last, or so-called Wisconsin sheet, are the only ones commonly recognized in this area.

Along Kankakee River, however, remnants of an earlier glaciation are well exposed. These were probably deposited by the Illinoian ice-sheet; they are separated from the Wisconsin deposits by an old soil buried under loess (fine, silty material) and lying on lake clays and gravel-sand deposits.

The Wisconsin ice-sheet advanced as far south as Cumberland County in Illinois. Its front remained there long enough so that a notable deposit of material—the Shelbyville moraine—was laid down. The edge of an ice-sheet, although it may temporarily hold a constant position, is far from static. Melting and evaporation cause a notable loss all the time, and it is only by the continued outward movement of the ice that its edge remains more or less fixed. If melting and evaporation are less important than outward movement, the ice edge advances; if more important, it retreats. But even while the ice edge is retreating, the movement of the ice itself is always outward, and thus materials scraped up within constantly tend to be shifted out to the edge of the ice.

Following the deposition of the Shelbyville and two minor moraines, the ice edge next assumed a constant position over the site of the Bloomington moraine. At the time this moraine was forming at the ice edge, minor deposits were laid down here and there under the ice well back from its edge. One such deposit exists seven miles west of Joliet along a minor tributary of Du Page River. This is protected by later glacial deposits and is fifteen miles southeast of the nearest large body of Bloomington drift. It was recognized by its characteristic pink color.

Later the ice retreated to the position of the Marseilles moraine where its edge again remained constant for probably a few centuries while this moraine was built.

Following the building of the Marseilles moraine, the ice edge suffered great changes, and when it again became temporarily constant its shape in Illinois was fundamentally different, since it lacked the bulge so marked in it at an earlier date. The diminutive Minooka moraine next formed can be traced from Elgin to the head of Illinois River where it has been cut off. Its extension was probably to the southeast under younger moraines.

The retreat to this position first uncovered the general course of Kankakee River, and the present stream presumably had its inception at this time from the waters formed by the melting ice. But the present course of the river was dammed by the massive Marseilles moraine. As a result, a large lake formed. Its surface rose until it reached the level of the lowest gap in the Marseilles moraine. At different times when the flow of water was great several low gaps may have been in use, but finally all the waters were concentrated in the present outlet. The lake lasted a long time—probably until after the ice-sheet had retreated some distance from Illinois—but its level in general dropped (except during two temporary halting stages) as the outlet was cut down, and finally it was completly drained.

Following the Minooka stage, there was pronounced retreat of the ice and the country at least as far as five miles east of Joliet was uncovered. An extensive gravel sheet (the Joliet outwash plain) sweeping out from the ice edge was formed; then the glacier advanced and the Rockdale moraine was deposited. This sequence of events is indicated by the buried gravel sheet seen at many places near Joliet.

During the retreat from the Rockdale moraine the minor Manhattan ridge was formed. Later the extensive Valparaiso morainic system was built, and then the ice-sheet receded in an irregular fashion into the Lake Michigan basin. Figure 2 shows the general sequence in cross-section.

Following the retreat into the Lake Michigan basin, a large lake known as Lake Chicago developed between the edge of the ice-sheet and the Valparaiso moraine, which acted as a dam. The waters thus impounded rose to the level of the lowest gap in the Valparaiso moraine, which was near Lemont. Here they overflowed and followed valleys already established by the outwash waters from the Valparaiso ice-sheet. They wore away the materials of the moraine, and lowered the outlet. These materials, with those formed as outwash from the Valparaiso ice-sheet, were spread out downstream, and now constitute the great gravel deposits near Plainfield and between Joliet and Channahon.

By the time the Lake Chicago outlet was formed, the Kankakee flood had subsided, for the Erie basin waters were diverted into Lake Chicago. Since then the Kankakee has been a little river in a big valley. As the ice retreated farther northward the present St. Lawrence drainage was established and the diminutive Des Plaines River inherited the broad valley of the old outlet of Lake Chicago. Thus two mighty rivers had their rise and decline during minor stages of the last continental glaciation. Recently man has attempted to improve his condition by digging a ditch down the old Lake Chicago outet valley, and endeavoring to bring back the old drainage in a very small way—but there has been opposition to this "reversion to nature".

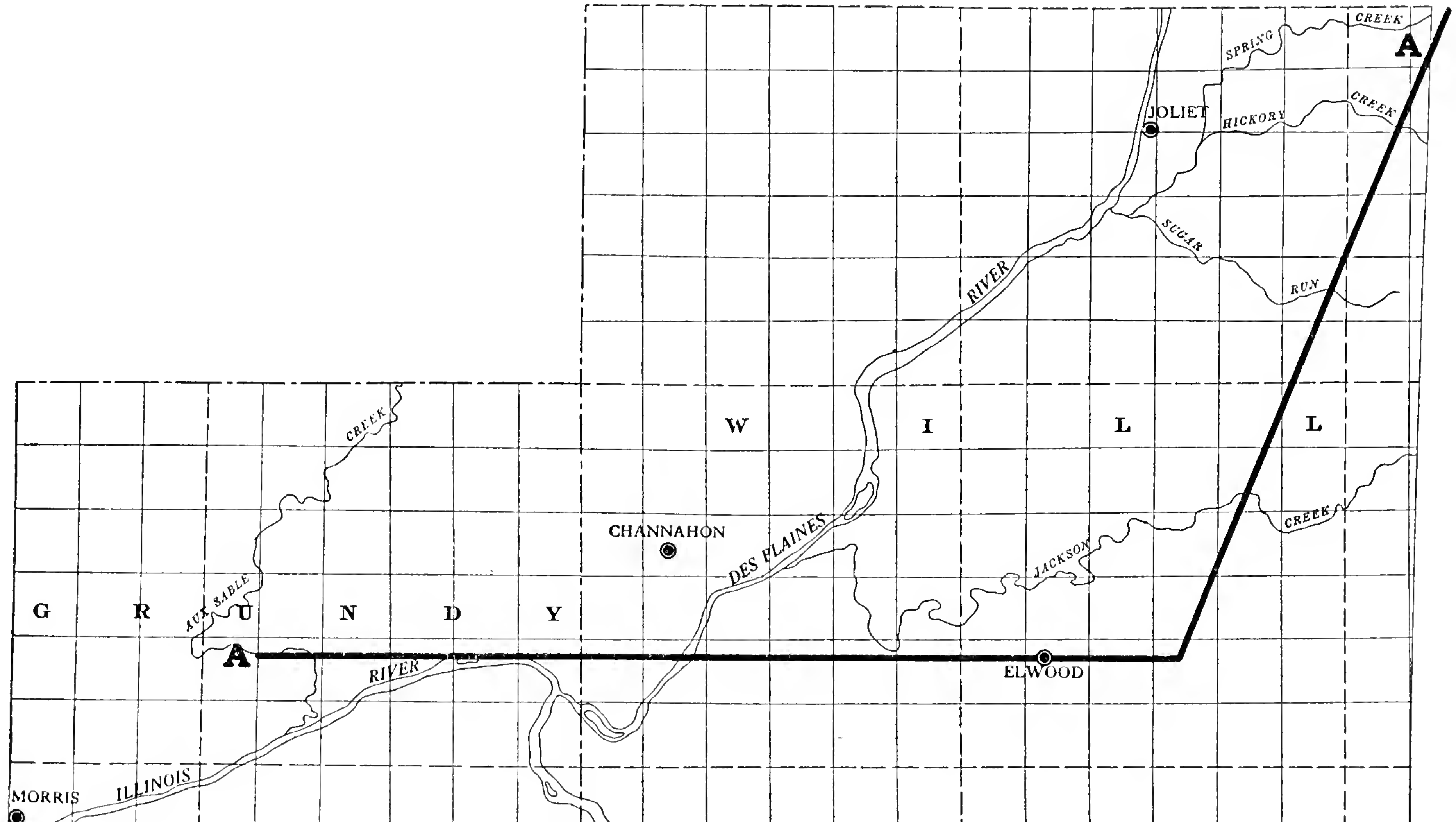

Fig. No. 1—Index map showing line of cross sections in Figs. 2 and 3 (A-A).

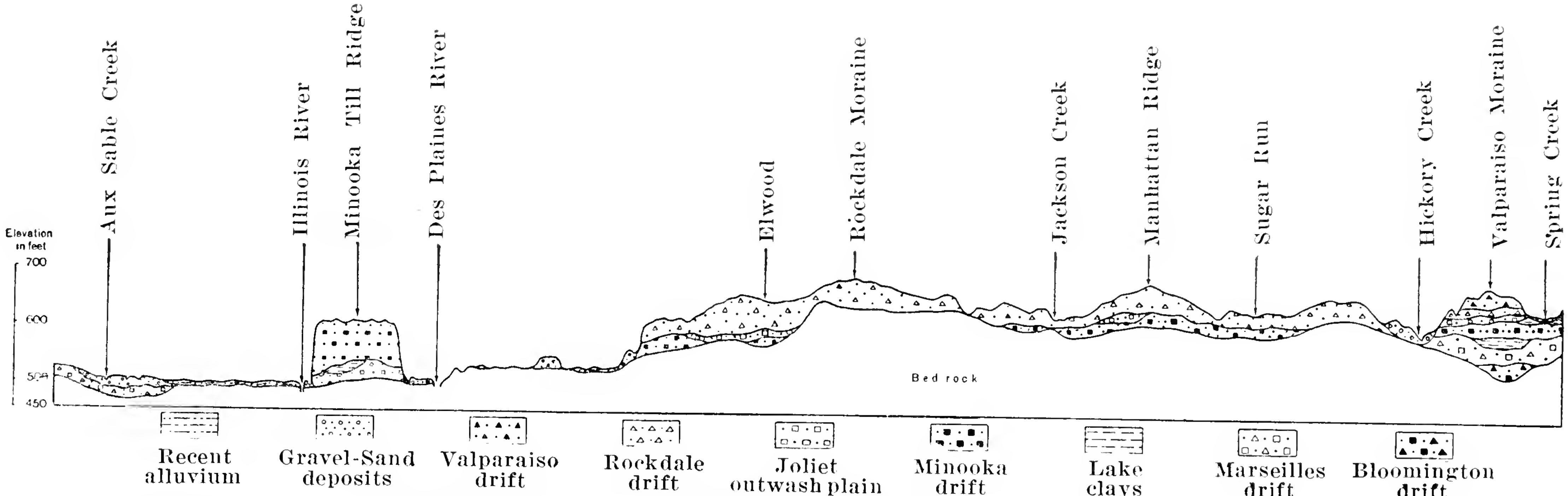

Fig. No. 2—Details of mantle rock deposits of Fig. No. 3.

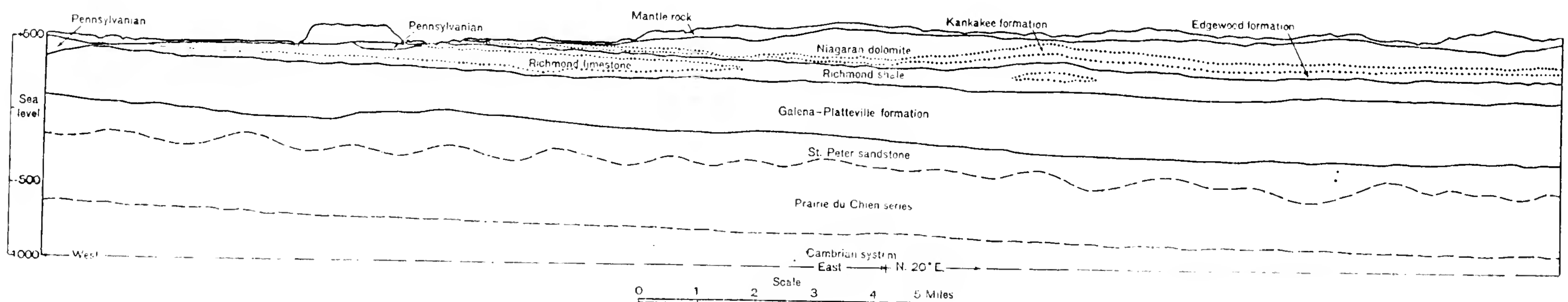

Fig. No. 3—Diagrammatic cross-section along line A-A (Fig. 1) showing strata of the Joliet District.

In summary—the area has had a long history; this paper skims over only a little of it. And the life side has been sadly neglected in favor of the physical side. But one can be sure that each physical change—and geologic history is replete with such changes—has had its effect on whatever forms of life were existing, and these had to meet the new environment imposed on them. Whole tribes have been driven out, suffered changes, and re-invaded the area. And now man is here. Perhaps we are living in an interglacial epoch. Another ice-advance may drive our remote descendants south, just as the last one forced primitive man in Europe to seek regions of warmer climates. But we are far more able to cope with new physical conditions imposed on us than has been any form of life known to have existed in the past. We owe much of our present condition to the striving of life down the long ages. Let us constantly aim to deserve that which we now have by contributing our share to the needs of the future.

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PAPERS IN BIOLOGY AND AGRICULTURE SECTION, JOLIET.

THE GENUS PEPEROMIA IN NORTHEASTERN SOUTH AMERICA.*

CLARA MAURIE BAILEY, UNIVERSITY OF ILLINOIS.

I. Introduction.

In 1775, nineteen years before Ruiz and Pavon established the genus *Peperomia,* Aublet reported fourteen species of *Piper* from Cayenne. Later, eight of these were transferred to the genus *Peperomia.* Richard Schomburgk published a flora of British Guiana in 1848, and included in this were fourteen Peperomias. Fifty-eight years afterward, in 1906, Pulle enumerated fourteen species of this genus as known from Surinam. The Peperomias of the Guianas were also included by Miquel in his monographic study of the Piperaceae and by Casimir de Candolle in the Candollean Prodromus and post-humously in volume one of Candollea. In 1900 Dahlstedt published a comprehensive study of the genus in which most of the species occurring in the Guianas were reported. Other authors dealing with this group of plants are indicated by the references in connection with the synonyms of each species.

There are twenty species included in the present study and these account for all the Peperomias reported for the Guianas in the above-mentioned works. In addition to the twenty, *Peperomia piperea,* reported by Casimer de Candolle in Seemann's Journal of Botany on a Parker specimen at Kew, requires mention. However, the type specimen does not represent a *Peperomia* but consists of foliage apparently of some aroid and an isolated spike of some *Piper.*

Of the twenty known species from the Guianas two are reported as common to the three countries, five from Cayenne and Surinam, three from Cayenne and British Guiana, two from Cayenne, three from Surinam, and five from British Guiana.

The Guianas have low alluvial coast-lands which average about twenty miles in width. These are only a few feet

*The substance of a Thesis in candidacy for the Master's degree at the University of Illinois, in 1926.

above high-water level and back of them is the old marine beach which averages about 100 feet in height. This gradually rises toward the mountain ranges and elevated plateaux where large expanses of open savannas are found. Almost the entire seaward slope is covered with dense primeval forests as would be expected in a country where heat and moisture prevail throughout the year. The mean temperature is about 80 F. and the mean annual rainfall in the coast-lands exceeds 100 inches.

The Peperomias are for the most part endemic to the Guianas due to the fact that these countries are more or less isolated by geographic barriers. They are bounded on the West by the Orinoco River valley, on the south by the Amazon valley, and on the north by the Atlantic Ocean. The Tumuchumac Mountain Range, which lies between the Guianas on the south and the Amazon valley, has an arid region on the Brazilian slope which forms an effective ecological barrier. A few Peperomias are quite wide spread, appearing as weeds in many countries. It is entirely possible that these have crept in along the valleys of the tributaries to the Orinoco and Amazon Rivers.

This study was made from dried herbarium specimens and from drawings and notes of plants in European herbaria made by Dr. William Trelease, to whom the author wishes to acknowledge her great indebtedness not only for the use of his manuscripts but also for the suggestion of the problem and for aid and criticism while the work was being done.

All published references to collections of Peperomias from the Guianas and all specimens which Dr. Trelease or the author have seen are included in the account.

As furnishing the simplest method of determining the species they have been keyed out on the vegetative characters. Following this is a key based on the more fundamentally important fruit characters. The species are arranged under the subgeneric names employed by Dahlstedt.

II. Key Based on Vegetative Characters.

1. Leaves opposite or whorled. 2.
   Leaves alternate. 5.
2. Leaves whorled. — 19. P. Schomburgkii.
   Leaves opposite. 3.
3. Stem 4-angled: plant glabrous. — 18. P. angulata.

Stem not 4-angled: plant sparsely puberulent. 4.
4. Leaves orbicular. 21. P. circinata.*
Leaves obovate or elliptic-rhomboid. 10. P. blanda.
5. Leaves pinnately nerved. 6.
Leaves palmately nerved. 13.
6. Leaves peltate. 1. P. variegata.
Leaves not peltate. 7.
7. Plants at least slightly pubescent. 8.
Plants glabrous. 9.
8. Leaves ovate-lanceolate, pellucid dotted. 4. P. surinamensis.
Leaves lance-elliptic, not pellucid dotted. 8. P. longemucronata.
9. Leaves more than 10 cm. long. 10.
Leaves 10 cm. or less long. 11.
10. Leaves ovate- or elliptic-oblong: blade decurrent on petiole. 2. P. Parkeriana.
Leaves oblanceolate: blade not decurrent on petiole. 3. P. longifolia.
11. Leaves usually with dendritic exudate or pellucid. 5. P. macrostachya.
Leaves without dendritic exudate or pellucidness. 12.
12. Leaves obovate-oblong or obovate-elliptic: 5-6 cm. wide. 7. P. magnoliaefolia vr. grandifolia.
Leaves obovate-oblong or oblong-spatulate: 2. 5-3. 5 cm. wide. 6. P. obtusifolia var. macropoda.
13. Plants glabrous. 14.
Plants pubescent. 15.
14. Leaves with cordate base. 17. P. pellucida.
Leaves with acute base: blade decurrent on petiole. 11. P. acuminata.
15. Leaves 1.5 cm. or more long. 16.
Leaves less than 1.5 cm. long. 18.
16. Leaves round-ovate. 14. P. roraimana.
Leaves lanceolate or elliptic. 17.
17. Apex of leaves acuminate or acute: leaves 2-6 cm. long. 12. P. melanostigma.
Apex of leaves bluntish: leaves about 2.8 cm. long. 16. P. purpurinervis.
18. Leaves dark-punctulate. 13. P. rotundifolia.
Leaves not dark-punctulate. 19.
19. Leaves elliptic. 15. P. Bartletti.
Leaves reinform or rounded. 9. P. repens.

III. Key Based on Fruit Characters.

1. Berries without a pseudocupule. 2.
Berries with a distinct pseudocupule. 18. (Subgenus *Micropiper*).
2. Stigma at base of an oblique beak. 3.
Stigma terminal on a conic appendage. (Subgenus *Ogmocarpidium*) 17. P. pellucida.
3. Berries cylindric-ovoid: beak mostly elongated. 4. (Subgenus *Rhyncophorum*).
Berries subglobose: obliquely short beaked. 12. (Subgenus *Sphaerocarpidium*)
4. Leaves peltate. 1. P. variegata.
Leaves not peltate. 5.
5. Blade decurrent on the petiole. 6.
Blade not decurrent on the petiole. 7.
6. Spikes opposite the leaves: leaves about 11 cm. long. 2. P. Parkeriana.

*Not known from the Guianas.

Spikes in terminal panicle: leaves about 20 cm. long. 3. P. longifolia.
7. Leaves usually with dendritic exudate or pellucid. 8.
Leaves without dendritic exudate and not pellucid. 9.
8. Leaves pellucid: petiole ciliolate: berries 1 cm. long. 4. P. surinamensis.
Leaves often with dendritic exudate: petiole glabrous: berry 2 cm. long. 5. P. macrostachya.
9. Leaves pubescent. 10.
Leaves glabrous. 11.
10. Leaves small (5-14 mm. long). 9. P. repens.
Leaves moderate (about 7.5 cm. long). 8. P. longemucronata.
11. Leaves 2.5-3.5 cm. wide: berries ellipsoid. 6. P. obtusifolia var. macropoda.
Leaves 5-6 cm. wide: berries ovate-globose. 7. P. magnoliaefolia var. grandifolia.
12. Leaves opposite. 10. P. blanda.
Leaves alternate. 13.
13. Leaves at least sparsely black-punctulate or black-granular. 14.
Leaves not black-punctulate. 17.
14. Blade decurrent on petiole. 11. P. acuminata.
Blade not decurrent on petiole. 15.
15. Leaves round, round-ovate, or obovate-elliptic. 16.
Leaves lanceolate or elliptic. 12. P. melanostigma.
16. Leaves very small (5-10 mm. long). 13. P. rotundifolia.
Leaves a little larger (15-25 mm. long). 14. P. roraimana.
17. Leaves less than 15 mm. long. 15. P. Bartletti.*
Leaves more than 20 mm. long. 16. P. purpurinervis.*
18. Spikes axillary. 18. P. angulata.
Spikes terminal. 19.
19. Leaves opposite. 21. P. circinata.†
Leaves whorled. 19. P. Schomburgkii.

IV. Classified Enumeration, With Descriptions.

SUBGENUS RHYNCOPHORUM

1. Peperomia variegata. R. & P.

Peperomia variegata R. & P. Fl. Peruv. 1:33, 1798.—C. DC. in Cand. 1:375, 1923.

Peperomia maculosa Auct. as to Cayenne.

A short, glabrous herb; stem stout (5-7 mm.), smoky- or violet-spotted; leaves alternate, broadly ovate-elliptic, short acuminate, peltate scarcely 2 cm. above the round or sub-cordate base, very large (8.5-10×10-15 cm.), multiple nerved; petiole very long (8-10 cm.); spikes terminal, one or two on a common peduncle (about 2 cm. long), thick and very long (.5×15-18 cm.); individual peduncles long (1.5-2 cm.); bracts round-peltate; ovary ovoid, obliquely long-beaked; stigma nearly in center of beak.

Type locality: Pillao at Chacabuossi, Peru.

Collections: *Cayenne* (fide Aublet, Hist. p. 22).

2. Peperomia Parkeriana Miq.

Peperomia Parkeriana Miq. in Hook. Lond. Journ. Bot.

*Placed in Sphaerocarpidium although the stigma is described as apical.
†Not known from the Guianas.

4:427, 1845.—C. DC. in DC. Prod. 16′:425, 1869.—C. DC. in Cand. 1:370, 1923.

A terete, glabrous herb; leaves alternate, ovate- or elliptic-oblong, acuminate, decurrent on petiole, very large (5×11 cm.), pinnately nerved from below the middle, the nerves 3-4×2; petiole moderate (1.5 cm.); spikes filiform, opposite the leaves, closely flowered; peduncle moderate (1.5 cm.); ovary beaked; stigma in middle of beak.

Type locality: Lower Surinam River, near Geyersvlyt, Surinam.

Collections: *Surinam* (Kegel 1005 at Göttingen) Miquel. *British Guiana* (Parker at Kew) C. DC.

3. PEPEROMIA LONGIFOLIA C. DC.

Peperomia longifolia C. DC. in DC. Prod. 16′:405, 1869.—C. DC. in Cand. 1:289, 1923.

A shortly caulescent, erect, glabrous herb; leaves alternate, oblanceolate, acuminate, mucronulate, decurrent on petiole, very large (4.5×20 cm.), pinnately nerved; petiole long (4 cm.); spikes short (10-15 mm.), in terminal panicle, closely flowered; peduncle short (4 mm.); bracts round-peltate, glandular; ovary compressed, ovoid; berries cylindric-ovoid, obliquely short beaked.

Type locality: *Cayenne* (apparently near the city Cayenne)

Collections: *Cayenne* (Richard at Paris) Trelease; (Le Prieur at Paris) Trelease.

Also reported from Costa Rica presumably on a different species.

4. PEPEROMIA SURINAMENSIS C. DC.

Peperomia surinamensis C. DC. in DC. Prod. 16′:408, 1869.—C. DC. in Cand. 1:353, 1923.

A suffruticose, scandent plant, rooting at the nodes; stem ciliolate near the end; leaves alternate, ovate-lanceolate, acuminate, ciliolate near the end, membranaceous, pellucid, large (2-5×6-9 cm.), (Kappler specimen 2-2.5×4.5-6 cm.), pinnately 7-nerved from below the middle; petiole moderate (1.5 cm.), ciliolate above; spikes longer than the leaf, (Kappler specimen shorter than leaf, 3.5 cm.), solitary at the end of stem, closely flowered; peduncle long (3 cm.); bracts round-peltate; ovary half-immersed; berries cylindric-ovoid, 1 mm. long, black, obliquely subacute.

Type locality: Paramaribo, Surinam.

Collections: *Surinam* (Kappler 1577 in Hb. DC. at Geneva) Trelease. *Cayenne* (Sagot 538 in Hb. Lenormand at Caen) C. DC. *British Guiana* (de la Cruz 1304 at N.Y. B. G.) Bailey; (de la Cruz 1365 at N.Y.B.G.) Bailey; (de la Cruz 1520 at N.Y.B.G.) Bailey.

5. Peperomia macrostachya (Vahl) Dietr.

Peperomia macrostachya (Vahl) Dietr. Sp. 1:149, 1831.—C. DC. in DC. Prod. 16′:439, 1869.—Dahlst. Stud. 88, 1900.

Piper macrostachyon Vahl Enum. 1:341, 1804.

Piper myosuroides Rudge Pl. Guian. Rar. pl. 5, London, 1805.

Peperomia myosuroides (Rudge) Dietr. Sp. 1:157, 1831.—C. DC. in DC. Prod. 16′:407, 1869.—C. DC. in Cand. 1:365, 1923.—Miq. Syst. Pip. 184, 1843.

Peperomia rupestris HBK. in Nov. Gen. 1:62, 1815 as to collections of Seeman (608) and Kegel (1037) from Surinam.

Peperomia myriocarpa Auct. as to Cayenne.

Peperomia distachya as to collections of Poiteau, Focke, and Miquel from the Guianas.

Peperomia nematostachya Auct. as to the Guianas.

A trailing, essentially glabrous herb; leaves alternate, subovate-elliptic, acuminate, base rounded, moderate (1.5-3.5×6-9 cm.), lepidote above with dendritic exudate*, pinnately nerved; petiole short to moderate (3-20 mm.); spikes filliform (10-30 cm.), subpanicled on bracted branches opposite the leaves or apical, closely flowered; peduncle short to long (5-20 mm.); bracts round-subquadrangular, peltate, fringed; berries cylindric, 2 mm. long, scutulate; stigma subapical.

Type locality: Cayenne.

Collections: *Cayenne* (Rich. at Paris) Trelease; (Sagot 538 at Kew) C. DC.; (Martin in Hb. Rudge in Brit. Mus. at London) C. DC.; (Poiteau in Hb. Delessert at Geneva) Trelease; (Sagot at Stockholm) Dahlst. *Surinam* (Humb. in Hb. Willdenow at Berlin) Dahlst; (Near Kangaruma, Potaro R., Bartlett 8741 at N.Y.B.G.) Bailey; (Seemann 608 at Kew) C. DC. *British Guiana* (de la Cruz 3615 at N.Y.B.G.) Trelease; (Macbride 6001 in Hb. U. of Ill. at Urbana) Bailey; (Kabakaburi, Pomeroon District, de la Cruz 3240 at N.Y.B.G.) Bailey; (Dense upland forest, Rockstone, Gleason 564 at N.Y.B.G.) Bailey; (dry sandhills, east of Rockstone, Gleason 810 at N. Y. B. G.) Bailey.

Also reported from Brazil.

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*The original description of Piper myosuroides by Rudge included mention of stellate scurfiness which is frequently seen but consists of dendritically divided exudate from the leaf rather than pubescence.

6. Peperomia obtusifolia (L.) A. Dietr. var. macropoda (Miq.) Dahlst.

Peperomia obtusifolia (L.) A. Dietr. var. macropoda (Miq.) Dahlst. Stud. 65, 1900.

Peperomia macropoda Miq. in Linn. 20:128, 1844.—C. DC. in DC. Prod. 16′:428, 1869.

A creeping, glabrous herb; stem thick, rooting at the nodes, apex and branches ascending; leaves alternate, obovate-oblong, or oblong-spatulate, base attenuate or cuneate, large (2.5-3.5×6-9 cm.), pinnately nerved; petiole usually long (1-7 cm.); spikes long (11-14 cm.), terminal or axillary, closely flowered; peduncle long (7 cm.); bracts round-peltate; berries ellipsoid with beak (about 2 mm. long); stigma anterior on the beak.

Type locality: Brazil.

Collections: *Surinam* (Kegel 1252a and b at Göttingen) Dahlst. *Cayenne* (Richard at Paris) Trelease; (Le Prieur at Paris) Trelease.

Also reported from St. Vincent, St. Domingo, Porto Rico, Mexico, and Nicaragua presumably on different species.

7. Peperomia magnoliaefolia (Jacq.) A. Dietr. var. grandifolia Miq.

Peperomia obtusifolia Miq. Syst. Pip. 194, 1843 (in part).

Peperomia obtusifolia Dietr. var. *grandifolia* Miq. Syst. Pip. 196, 1843.

Peperomia magnoliaefolia (Jacq.) A. Dietr. var. *Sintenisiana* Dahlst. Stud. 59, 1900, as to Surinam.

An erect or ascending, branched, glabrous herb, often rooting at the nodes; leaves alternate, obovate-oblong, or obovate-elliptic, apex rounded or obtuse, fleshy with thin margins, large (5-6×9-10 cm.), pinnately nerved, middle nerve thick below; petiole long (2-4 cm.); spikes very long (19-20 cm.), terminal or terminating lateral branches, closely flowered; peduncle very long (5-10 cm.); bracts round-peltate; berries ovate-globose.

Type locality: Caracas, Venezuela.

Collections: *Surinam* (Hostmann 260 in Hb. Delessert at Paris) Trelease; (Hostmann 260 at Berlin) C. DC.; (Kegel 806 at Göttingen) Dahlst.; (Kegel 619 at Göttingen) Dahlst.; (Wullschaegel 480 at Munich and in Hb. Grisebach at Göttingen) Dahlst.; (R. F. Hohenacker 401a at Stockholm) Dahlst.

Also reported from Brazil, Porto Rico, and Grenada.

8. Peperomia longemucronata C. DC.

Peperomia longemucronata C. DC. in Notizbl. Berlin 7:497, 1917.—C. DC. in Cand. 1:364, 1923.

A slightly pubescent herb; leaves alternate, lance-elliptic, acute at both ends, moderate (4×7.5 cm.), pinnately nerved, pubescent on nerves on upper face, paler beneath; petiole moderate (2 cm.); spikes long (10 cm.), paired, terminal, loosely flowered; peduncle long (1.5 cm.); peduncle-bearing branches 5.5 cm. long; bracts large (¾ mm.), round-peltate; berries thick-ellipsoid; scutulem acuminate; stigma median, sessile.

Type locality: Roraima, Britsh Guiana.

Collections: *British Guiana* (Ule 8594 in Hb. DC. at Geneva) Trelease.

9. Peperomia repens HBK.

Peperomia repens HBK. in Nov. Gen. 1:65, 1815.—Dahlst. Stud. 79, 1900 (in part).

Peperomia scandens Auct. as to the Guianas.

A small creeping, somewhat crisply pubescent herb, rooting from the nodes; leaves alternate, reniform or rounded, apex sometimes subacute, small (.5-1.5×.7-1.4 cm.), palmately 3- or obscurely 5-nerved; petiole moderate (3-10 mm.); spikes short (10-15 mm.), terminal; peduncle long (2 cm.), commonly bracted in the middle; berries cylindric, beaked; stigma anterior at base of beak.

Type locality: near Cumanacoa, Venezuela.

Collections: *Surinam* (Focke in his personal herbarium) Miq.; (Hostmann and Kappler 117 at Munich) Dahlst.; (Hostmann 629 at Stockholm) Dahlst.; (Wullschaegel in Hb. Grisebach at Göttingen) Dahlst. *Cayenne* (Le Prieur in Hb. Delessert at Geneva) C. DC.; (Martin in Hb. British Museum at London) C. DC.

Also reported from Brazil.

SUBGENUS SPHAEROCARPIDIUM

10. Peperomia blanda

Peperomia blanda HBK. in Nov. Gen. 1:67, 1815.—Miq. Syst. Pip. 115, 1847.—C. DC. in DC. Prod. 16′:458, 1869.—Dahlst. Stud. 131, 1900.

Peperomia Langsdorffii Miq. Syst. Pip. 116, 1843.—Miq. in Linn. 20:124, 1847.—C. DC. in DC. Prod. 16′:443, 1869.

Micropiper Langsdorffii Miq. in Comm. Phyt. 2:52, 1840.

Peperomia polystachya Auct. as to the Guianas.

A branched, erect, slightly suffruticose, pubescent herb, scarcely a foot high; leaves opposite or whorled, upper ones alternate, obovate- or elliptic-rhomboid, apex acute, base cuneate, pubescent on both faces, moderate (1.5-3×2.5-8 cm.), upper ones smaller, palmately 3-nerved; petiole moderate (.5-1.5 cm.); spikes long (8-12 cm. long), terminal in twos, threes, or more, or in axils of terminal leaves; peduncle moderate (1-1.5 cm.); bracts oblong, truncate, peltate; ovary emersed-impressed; berries obliquely ovoid, short-beaked.

Type locality: Venezuela.

Collections: Reported by Schomburgk from *British Guiana* as *Peperomia polystachya* A. Dietr.

Also reported from Colombia, Educador, Brazil, and Bolivia. Also from the West Indies presumably on a different species.

11. Peperomia acuminata (L.) Dahlst.

Peperomia acuminata (L.) Dahlst. Stud. 123, 1900.

Piper acuminatum L. Sp. Plant. ed. 2:42, 1762.

Peperomia acuminata (L.) Dietr. Sp. 1:148, 1831 (in part).—Miq. Syst. Pip. 95, 1843 (in part).

Peperomia nemorosa (Vahl) C. DC. in DC. Prod. 16′:415, 1869 (in part).

Peperomia obliqua Auct. as to British Guiana.

An erect, glabrous herb; leaves alternate, lower ones often obovate-elliptic, upper ovate-elliptic, apex acuminate, base acute, decurrent on petiole, moderate (3.5×7 cm.), membranaceous, pellucid-punctate, sparsely black-punctulate below, palmately 3-5-nerved; petiole moderate (12 mm.); spikes almost twice surpassing the leaves, axillary and terminal; bracts round-peltate; ovary half-immersed; berries subrotund-acute, apex with small beak.

Type locality: Based on Plumier's plate 71 from West Indies.

Collections: *Cayenne* (fide Aublet, Hist. p. 21) *British Guiana* (fide Schomburgk, Fauna und Flora p. 18).

Also reported from Jamaica, Porto Rico, St. Bartholomew, St. John, Antigua, Dominica, Martinique, and St. Vincent.

12. Peperomia melanostigma Miq.

Peperomia melanostigma Miq. Syst. Pip. 90, 1843.—C. DC. in DC. Prod. 16′:408, 1869 and varieties.

Peperomia velloziana polystica Miq. in Linn. 18:226, 1844. —C. DC. in DC. Prod. 16′:408, 1869.

Peperomia glabella melanostigma C. DC. in Cand. 1:326, 1923.

A suffruticose, branched, puberulent herb, rooting at the nodes; leaves alternate, petioled, lanceolate or elliptic, acuminate or acute, black punctulate, moderate (1-2×2-6 cm.), obscurely palmately 3-5-nerved; petiole moderate (.5-1 cm.); spikes 7-20 cm. long, axillary or terminal, loosely flowered; peduncle long (1.5-2 cm.); berries ovate, beaked.

Type locality: near Paramaribo, Surinam.

Collections: *Surinam* (Hostmann 437 at Berlin) Miq.; (Focke in his own personal herbarium) Miq.; (Hostmann 437 at Paris) Trelease; (Hostmann-Hohenacken 799a at Paris) Trelease; (Kegel 437 at Paris) Trelease. *Cayenne* (Melinon 171 at Paris) Trelease; (Le Prieur at Paris) Trelease.

13. Peperomia rotundifolia (L.) HBK.

Peperomia rotundifolia (L.) HBK. in Nov. Gen. 1:65, 1815.

Peperomia rotundifolia (L.) Dahlst. Stud. 99, 1900 and varieties.

Piper rotundifolium L. Sp. Plant. 30, 1753.

Piper nummularifolium Sw. Prod. 16, 1788.

Peperomia nummularifolia HBK. in Pl. Aeq. 1:66, 1808.—HBK in Nov. Gen. 1:66, 1815.—C. DC. in DC. Prod. 16′:420, 1869.

Acrocarpidium nummularifolium Miq. Syst. Pip. 52, 1843.

Peperomia metapalcoensis Auct. as to the Guianas.

A small, delicate, slightly pubescent herb, rooting at the nodes; leaves alternate, round to obovate-elliptic, small (5-6×5-10 mm.), obscurely palmately 3-nerved, more or less hairy on both sides or glabrous, somewhat dark-punctulate; petiole short (1-3 mm.); spikes short (10-20 mm.), terminal, subverticillately and remotely flowered; peduncle short (2-5 mm.); bracts round-peltate; berries round-ellipsoid; stigma slightly anterior.

Type locality: Martinique.

Collections: *Surinam* (Weigalt at Berlin and Munich) Dahlst.; (Hb. Krug and Urban at Berlin) Dahlst.; (Weigelt in Hb. DC. at Geneva) Trelease; (Hostmann 117 at Berlin and Stockholm) Dahlst.; (Wullschlaegel 485 in Hb. Grisebach at Göttingen and Hb. Krug and Urban at Berlin) Dahlst.; (Kappler 672 at Stockholm) Dahlst. *Cayenne* (fide Aublet, Hist. p. 21.); (Sagot 903 at Berlin) Dahlst.; (Le Prieur in Hb. Franqueville at Paris) C. DC.

Also reported on various scarcely separable forms from Paraguay, Brazil, Venezuela, Ecuador, Colombia, Costa Rica, Guatemala, Mexico, Cuba, Jamaica, St. Domingo, Porto Rico, St. Bartholomew, Antigua, Guadeloupe, Dominica, Martinique, St. Lucia, Grenada, and Trinidad.

14. PEPEROMIA RORAIMANA C. DC.

Peperomia roraimana C. DC. in Notizbl. Berlin 7:493, 1917.*—C. DC. in Cand. 1:328, 1923.

A branched, erect, crisply pubescent herb; leaves alternate, round-ovate, obtuse or acutish, round-based, sparsely pubescent on both faces, black-granular, small (1.5-2×1.5-2.5 cm.), palmately 3-5-nerved; petiole short (.5 cm.), crisply pubescent; young spikes short (1.5 cm.), terminal and axillary; young peduncle short (3 mm.) glabrate; berries sessile, stigma oblique.

Type locality: Roraima, British Guiana.

Collections: *British Guiana* (Ule 8593 at Berlin) C. DC.; (Ule 8593 in Hb. DC. at Geneva) Trelease.

15. PEPEROMIA BARTLETTI *C. DC.*

Peperomia Bartletti C. DC. in Notizbl. Berlin 7:470, 1917*. —C. DC. in Cand. 1:334, 1923.

A small, delicate, arboricolous, sparsely hairy herb; leaves alternate, elliptic, rounded above, acute based, small (7×13 mm.), palmately 3-nerved, pubescent above, ciliate; petiole short (2 mm.); spikes (2 cm.), solitary, terminal, filiform; peduncle moderate (5 mm.); stigma not lobed, sessile, apical.

Type locality: Conanaruk river, British Guiana.

Collections: Conanaruk river, *British Guiana* (H. H. Bartlett 8233, from Berlin, in Hb. DC. at Geneva) Trelease.

16. PEPEROMIA PURPURINERVIA C. DC.

Peperomia purpurinervia C. DC. in Notizbl. Berlin 7:496, 1917*.—C. DC. in Cand. 1:345, 1923.

An epiphytic herb with stem minutely puberulous upwards; leaves alternate, elliptic, bluntish, acute-based, minutely ciliate upwards, small (1.7×2.8 cm.), palmately 3-nerved; petiole short (5 mm.), purplish; spikes short (5.5 cm.), terminal, closely flowered; peduncle moderate (1.5 cm.); stigma apical, sessile.

Type locality: Roraima, British Guiana.

Collections: *British Guiana* (Ule 8592 at Berlin) C. DC.

SUBGENUS OGMOCARPIDIUM.

17. PEPEROMIA PELLUCIDA (L.) HBK.

Peperomia pellucida HBK in Nov. Gen. 1:64, 1815.—Miq. Syst. Pip. 79, 1843.—C. DC. in DC. Prod. 16′:402, 1869.—Dahlst. Stud. 16, 1900.

Piper pellucidum L. Sp. Plant. 21, 1753.

An erect, glabrous herb; leaves alternate, deltoid-cordate to ovate-cordate, apex acuminate, pellucid-punctate, leaves small (1.5-

*The volume number 7 of Notizbl. as given in Clavis is correct although the number of Notizbl. containing the article and separates of the article made from it were erroneously marked as of distributed volume 6.

2.5×1.5-2.5 cm.), palmately nerved; petiole moderate (1.5 cm.); spikes moderate (2-5 cm.), opposite the leaves (Miquel gives them as axillary or terminal), loosely flowered; bracts round-peltate, shortly pedicelled; ovary oblong-cylindrical; berries ovoid; stigma on a conic appendage.

Type locality: Based on Plumier's plate 72 from Martinique.

Collections: *Surinam* (Hostmann 65 in Hb. Boissier at Geneva) C. DC.; (Hostmann and Kappler 65 at Stockholm and Hb. Grisebach) Dahlst.; (Kegel 476) fide Miq. in Linn. 22:76, 1849. *Cayenne* (Sagot in Hb. Franqueville at Paris) C. DC.; Sagot 523 at Stockholm) Dahlst. *British Guiana* (Schomburgk 939 at Kew) C. DC.; (Schomburgk 939 at Berlin) Dahlst.

Also reported from Jamaica, Hispaniola, St. Croix, St. Thomas, Guadeloupe, St. Vincent, Barbados, Grenada, Tobago, Colombia to Peru, Venezuela to Brazil, and Africa.

SUBGENUS MICROPIPER.

18. PEPEROMIA ANGULATA (R. & S.) HBK.

Peperomia angulata (R. & S.) HBK. in Nov. Gen. 1:66, 1815.—Miq. Syst. Pip. 180, 1843.—C. DC. in DC. Prod. 16′:446, 1869.—C. DC. in Cand. 1:317, 1923.—Dahlst. Stud. 156, 1900 and variety.

Piper angulatum R. & S. Mant. 1:332, 1822.

Peperomia trifolia Auct. as to Cayenne.

A repent, glabrous herb; stem 4-angled; leaves opposite, obovate, obtuse, base cuneate, small (15×25 mm.), palmately 3-nerved, the nerves prominent beneath; petiole short (3 mm.); spikes short (about 30 mm.) axillary, closely flowered, filiform; peduncle very long (30 mm.), scaly; bracts round-peltate, glandular-punctate; ovary immersed, oblong; stigma apical.

Type locality: Cumana, Venezuela.

Collections: *Surinam* (Hostmann 784 in Hb. Boissier at Geneva) Trelease; (Wullschlaegel in Hb. Grisebach at Göttingen) Dahlst. *Cayenne* (fide Aublet, Hist. p. 22.)

Also reported from Brazil.

19. PEPEROMIA SCHOMBURGKII C. DC.

Peperomia Schomburgkii C. DC. in DC. Prod. 16′:395, 1869.—Dahlst. Stud. 182, 1900.—C. DC. in Cand. 1:294, 1923.

Peperomia quadrifolia Aublet, Hist. 1:21, 1775.

A branched, creeping, nearly glabrous herb; leaves in whorls of four, sub-orbicular, ciliolate, emarginate, drying thick and dull, small

(10×12 mm.), obscurely 3-nerved; petiole short (6 mm.), slightly velvety; spikes much surpassing the leaves, terminal, closely flowered; peduncle moderate (15 mm.); bracts round-peltate, short-stalked; ovary ovoid, short-styled.

Type locality: British Guiana.

Collections: *British Guiana* (Schomburgk 406 at Berlin) C. DC.; (Schomburgk in Hb. D. C. at Geneva) Trelease. *Cayenne* (fide Aublet, Hist. p. 21.)

EXCLUDED FROM THE GUIANA FLORA.

20. Peperomia piperea C. DC.

Peperomia piperea C. DC. in Seem. Journ. 4:143, 1866.

Spike of a Piper and leaf of an aroid.

21. Peperomia circinata Link.

Peperomia circinata Link in Spreng., Schrader and Link, Jahrb. 1. 3:64, 1820.—C. DC. in DC. Prod. 16:444, 1869.

This species is reported by C. D.C. from Surinam on a Pohl specimen (number 1217 at Vienna). However it was collected at Parnahyba, Brazil (the label on the specimen which reads Paranahyba was probably misread as Paramaribo).

V. Bibliography.

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VI.—Index to Species.

THE AMERICAN BITHYNIA NOT WHOLLY AN INTRODUCED SPECIES.*

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One of the most abundant species of gastropod mollusks in the United States is the little snail known as *Bithynia tentaculata* first described by the great Linnaeus. Its late appearance in American molluscan literature (1880) and its later appearance in different parts of the Great Lakes area has led to the conclusion that it was introduced from Europe with some sort of cargo. Walker (1918, p. 132) remarks that "This well known European species has been introduced from Europe by commerce and has spread from the Hudson west to Lake Michigan". In a letter to the writer Dr. Walker says "There is no doubt but that this common European species was introduced into America from Europe in the ballast of the timber ships that used to carry long, squared timber from Holland, Saginaw and other Lake Michigan ports, directly to Europe. The species was detected at these points as early as 1891".

The present wide-spread distribution of *Bithynia tentaculata,* now found in all the Great Lakes excepting Lake Superior, in such lakes as Oneida and Cayuga, in New York, Winnebago in Wisconsin, and Black Lake and other inland points in Michigan, in addition to other places in New York State, Erie Canal and Hudson River, taken in connection with its great abundance wherever found, raises the question as to whether it is not another species inhabiting both Europe and America., as *Stagnicola palustris* and *Margaritana margaritifera.* Until recently, its numbers and wide distribution (it seems doubtful that it could spread so far in 48 years, 1879 to 1927) have been the only factors that could be urged for the acceptance of a two continent distribution theory.

Two years ago Dr. Alvin R. Cahn, of the Department of Zoology, University of Illinois, collected a number of

*Contribution from the Museum of Natural History, University of Illinois, No. 46.

Pleistocene fossils from Chicago deposits which included a number of *Bithynia tentaculata*. This material with the associated species, is tabulated below:

I. Southwest corner Michigan Boulevard and Walton Place, nine feet below level of Lake Michigan.

Lampsilis siliquoidea rosacea	*Pleurocera acuta*
Elliptio dilatata	*Goniobasis livescens*
Sphaerium simile	*Campeloma rufum*
Sphaerium solidulum	*Amnicola limosa porata*
Sphaerium flavum	*Valvata bicarinata perdepressa*
Pisidium virginicum	*Bithynia tentaculata*
Pisidium compressum pellucidum	

II. Southwest corner Tower Court and Pearson Street, about 15 feet below street level.

Sphaerium solidulum	*Pleurocera acuta*
Sphaerium flavum	*Bithynia tentaculata*
Goniobasis livescens	

III. Pearson Street, west of Michigan Avenue, about half a mile west of the lake, 25 feet below street level.

Fusconaia undata	*Pleurocera acuta*
Sphaerium solidulum	*Planorbis trivolvis, var.*
Sphaerium flavum	*Amnicola limosa porata*
Goniobasis livescens	*Bithynia tentaculata*

In the above lists, *Elliptio dilatata* and *Fusconaia undata* are not found in Lake Michigan at the present time, and the latter species is only known as a fossil in the Chicago area, *Fusconaia flava* being the species found in the streams in the vicinity.

The location of the fossil deposits is about a fourth of a mile west of Lake Michigan and half a mile north of the Chicago River, not far from the Chicago Avenue water works. The surface at this point is 10 feet above Lake Michigan level, so that the depths at which fossils were found are from five to 15 feet below lake level, in undisturbed strata. The localities are also about 2000 feet south of the south end of the old Graceland bar and the geological time of the formation was probably the Toleston stage of Glacial Lake Chicago (see Baker, 1920, p. 79, pl. 37, 38).

That this species of *Bithynia* was not found in any of the Wilmette Bay deposits studied in 1910-1912 is perhaps not strange since the portion of the old bay studied did not extend south of Bowmanville, which is about five miles north of the location under discussion.

The present habitat of *Bithynia tentaculata,* in America, is in fairly open water in more or less exposed situations where there is good wave motion (see Baker, 1916, 1924 for habitats in lakes Oneida and Winnebago). It is preëminently a mollusk of vegetation and is seldom found away from it. It is a vegetable eater, being particularly fond of filamentous algae, among which it is usually found in abundance. It is also found on the stems of *Scirpus* and *Elodea,* plants that were common in old Wilmette Bay during Pleistocene times. The lower part of Wilmette Bay was not unlike Winnebago Lake in some respects, being 10 miles long and two miles wide, and rather shallow.

The present American distribution of *Bithynia tentaculata* is as follows, as far as available records have determined.

Wisconsin: Winnebago and Butte des Morts lakes, Calumet and Winnebago counties; Sturgeon Bay, Door Co.; Kenosha Co., Lake Michigan (Baker); Green Bay (Pearse).

Michigan: Black Lake, near Holland, Ottawa Co.; Bay City; Winona Beach, Bay Co.; Muskegon Lake, Muskegon Co.; Lake Michigan, New Buffalo, Berrien Co.; La Plaisance, Monroe Co.; Manistee River, Manistee Co.; Detroit River, Gibraltar, Wayne Co.; Lake Huron, Harbor Beach and Sandusky, Huron Co. (Walker).

Pennsylvania: Erie Harbor, Erie Co. (Walker).

Ohio: Ohio Canal, Stark Co. (Sterki); Ashtabula Harbor, Ashtabula Co. (Streator); mud flats near Toledo, near Maumee Bay, Lucas Co. (Goodrich).

Illinois: Shore of Lake Michigan (Baker).

Indiana: Shore of Lake Michigan (Baker, Daniels).

New York: Oswego, Lake Ontario, Oswego Co.; Erie Canal, Syracuse, Onondaga Co. (Beauchamp); Erie Canal, Rochester, Ontario Co. (Walton); Genessee River, near Rochester and Lake Ontario, Ontario Co.; Thousand Islands, St. Lawrence River; Oneida Lake (Baker); Seneca

River at Waterloo and Cayuga Lake (Maury); Lake Champlain and Niagara Falls (Walker).

Canada: Cornwall and Toronto Bay, Ontario; Duck Island, Ottawa River; Bay of Quinte, near Belleville, Toronto (Latchford).

The fossil *Bithynia* are like the form now living in Lake Michigan. This would suggest that it may be another species of a circumboreal nature, like *Aplexa hypnorum*. It might have been a migrant by way of the northeast land connection and could have reached our shores at the same time as the land snail *Helix nemoralis* which was for a long time thought to be an introduced species until it was finally found in Pleistocene deposits. There seems no question concerning the authentic character of the material from the Chicago deposits as being of Pleistocene age, and representing life that lived at the entrance to Wilmette Bay during the later stages of Glacial Lake Chicago.

A critical examination of specimens from Europe and America seems to indicate that they are not exactly alike, the lake form being heavier, the whorls more rotund, the spire usually shorter and the sutures less deeply impressed than in ditch forms from England. The columellar callus is also usually thicker, forming a rather heavy deposit in the lake shells. These differences reflect a response to a lake environment, the European form living in ditches, small rivers and relatively quiet bodies of water. The American localities, on the other hand, are subject to more or less violent wave action. There also appear to be some differences between the published figures of the radulae of the American and the European form, but whether this is due to differences in drawing the teeth or are real distinctions in the radulae is not at present determinable. It is possible that the American form should be separated as a distinct variety.

It should be noted, however, that it is doubtless true that European specimens of *Bithynia tentaculata* were introduced into American Localities as described by Walker and others. These may have interbred with the native form and produced the heavy lake species now found in the lake. There is also the possibility that *Bithynia* became extinct in Wilmette Bay and that the lake was populated by the introduced form. There is more variation among the recent than among the fossil forms, some of the former approaching the long-spired forms so characteristic of the European Bythinia. More fossil examples are needed for comparison and the form should be found in additional strata near Chicago and elsewhere.

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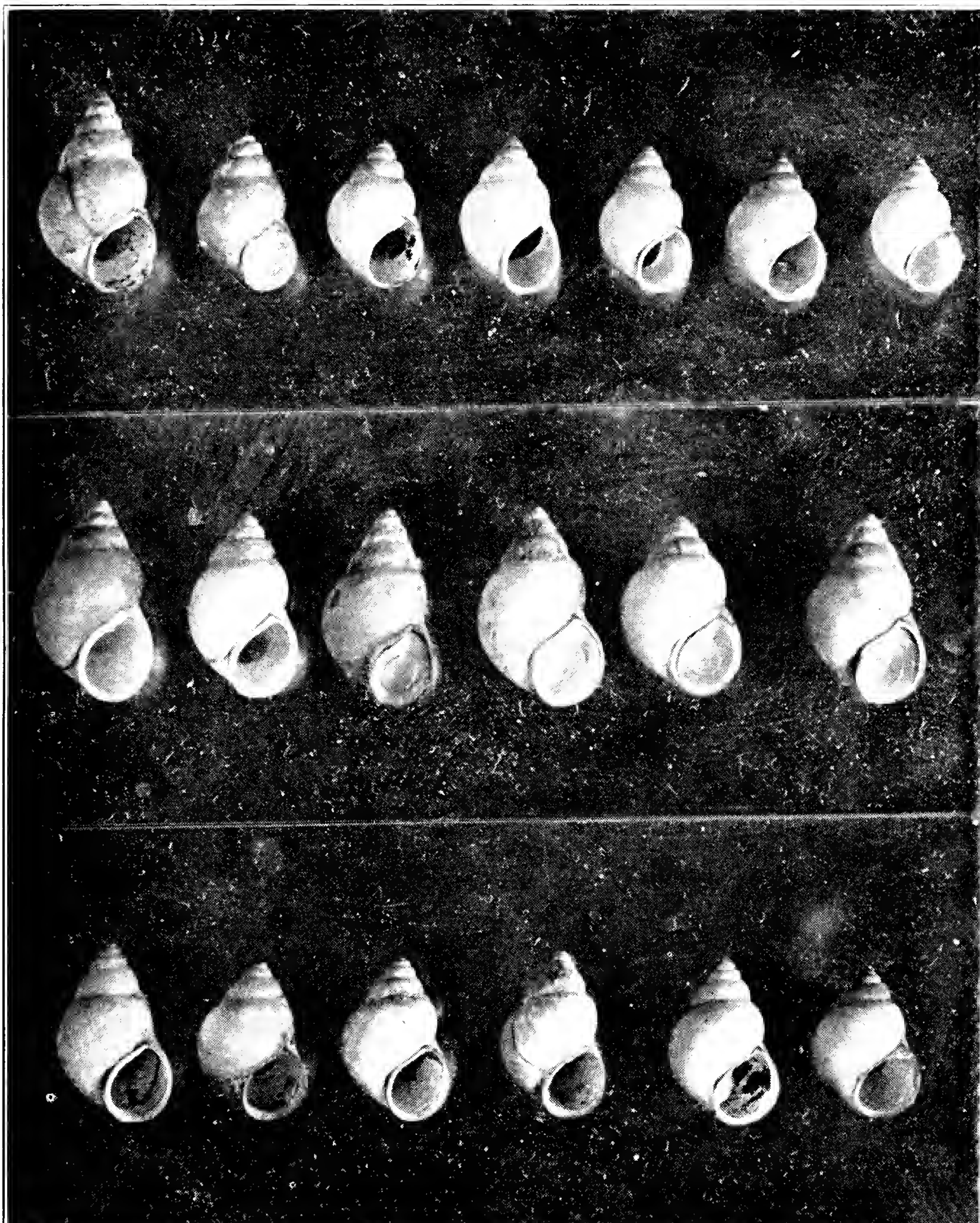

DESCRIPTION OF PLATE

Upper row: Bithynia tentaculata (Linn.). Ditch, Scarborough, England.
Middle row: Bithynia tentaculata (Linn.), Variety. Lake Winnebago, near Oshkosh, Wis.
Lower row: Bithynia tentaculata (Linn.), Variety. Chicago, fossil deposit No. 1. Figures enlarged about two diameters.

GROWTH OF DIATOMS IN RELATION TO DISSOLVED GASES.

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Periods of diatom abundance have been long known to occur during the colder months of the autumn and spring. Kofoid (1904) found this to be true of the diatoms of the plankton of the Illinois river with the exception of *Melosira granulata.* The latter reaches its greatest abundance during the summer months. Temperature was advanced by the earlier writers as an explanation for the greater growth during the colder months. Allen (1925) considered temperature to be an important factor in relation to the abundance of marine diatoms. Kofoid indicated that the spring and autumn floods were important factors as the heaviest abundance appeared after the overflows and did not occur when the floods did not appear at their usual season.

An increase in nitrates was noted by Whipple (1894) as an important factor in the increase of diatoms in reservoir waters. Whipple and Parker (1901) pointed out that while diatom abundance had been previously explained by an increase in the soluble nitrates, their occurrence in waters containing a large carbon dioxide content indicated a response to this gas. Diatoms have been shown by Palmer (1897) to produce oxygen and by Whipple and Parker to be carbon dioxide consumers. The latter also indicated that the autumn and spring growths of diatoms may be due to the increased circulation of the carbon dioxide as well as of the nitrates brought to the surface by the overturning of the larger bodies of waters. Pearsall (1923) advanced the theory that this semi-annual abundance was largely due to an increase in the dissolved oxygen content caused by the excessive rainfall. Pearsall further states that a deficiency of oxygen, nitrates, silica, or calcium is usually the limiting factor of diatom distribution.

Circulation caused by autumnal and vernal overturns and floods no doubt increases the mineral content of the water and adds to the dissolved gaseous content. The writer, however, has often observed periods of maximum abundance of diatoms which could not be attributed to either of these causes. The majority of the periods of abundance of diatoms have been observed in the colder months, but periods of equal abundance have been noted in the warmer months when conditions were at the opposite extreme. Whipple and Parker have shown that the waters of ponds and streams dissolve a much greater amount of carbon dioxide during the winter months than during the summer months. During the colder season the bottoms of the shallow streams of Illinois are covered with a thick brown scum of Gomphonema which disappears during the spring floods. In the latter part of the summer during the period of low water and drouth, when the earlier aquatic vegetation begins to die and decompose, the carbon dioxide content of the waters is often high. During this season the great growths of Melosira and some Synedra often appear. This would indicate that carbon dioxide is a probable factor influencing the growth of diatoms.

With this factor in mind the writer conducted a series of experiments to determine the response of diatoms to carbon dioxide. Rich cultures of diatoms (mostly Synedra) were secured from scrapings of the bottoms of some laboratory tanks at the University of Illinois. In the following series, each of two cultures of diatoms were subjected to various amounts of carbon dioxide and oxygen for a period of several weeks.

Series 1—Cultures of diatoms through which CO_2 was allowed to bubble for twenty minutes every twenty-four hours.

Series 2—Cultures of diatoms through which a slow stream of air bubbled continually.

Series 3—Cultures of diatoms undisturbed.

Series 4—Cultures of diatoms into which water dripped, creating considerable aeration.

All cultures were placed side by side under the same conditions of light and temperature. Observations were made at the beginning and at the following intervals as described in the following table. The collections were made by stirring the contents of the culture and removing one cubic centimeter with a pipette. This collection was placed in a Sedwick-Rafter slide and the diatoms of a known area were counted, giving sufficient data for an estimate per cubic centimeter. The results per cubic centimeter for the cultures of each series at the different periods of observation are as follows:

Days		1	2	8	12
Series 1	A	131,250	167,600	373,000	1,560,000
	B	120,750	147,000	2,100,000	24,000,000
Series 2	A	168,000	78,750	525,000	575,000
	B	210,000	184,800	630,000	627,000
Series 3	A	187,350	210,000	2,572,500	15,000,000
	B	210,000	210,000	3,202,500	25,000,000
Series 4	A	199.500	157,500	105,000	75,000
	B	131,250	52,500	26,250	30,500

A repetition of the experiments gave practically the same results. The diatoms of the cultures subjected to carbon dioxide (Series 1) showed an increase over those of all the other cultures except those of Series 3. The diatoms of the air cultures, (Series 2) showed only a slight increase during the first eight days, while those of the running water cultures (Series 4) decreased. This decrease may have been due to the removal of some of the diatoms by the water currents, but as the current was maintained at a very low rate, this probability was rather slight. The diatoms of the cultures (Series 3) which were undisturbed showed considerable increase in eight days. In these cultures there was evidence of decomposition of the organic matter, resulting in a high acidity and hydrogen-ion concentration. This indicating an abundance of carbon dioxide. The cultures showing the greatest increase in diatom growth were those of the series containing the greater abundance of carbon dioxide. The diatoms showed a greater growth response under the influence of the carbon dioxide than under the influence of oxygen. In the series containing the most diatoms the water was opaque. The diatoms were immotile and clustered together in large masses, especially on the twelfth day. Apparently their only reaction was that of growth. In the cultures of the air series the water remained clear, and the diatoms were quite active. In these cultures the diatoms exhibited general activity, but less growth response. In the cultures of the carbon dioxide series the accompanying Protozoa disappeared probably because of the toxic effect of the carbon dioxide, but were quite abundant in the cultures of the other series.

They probably destroyed some of the diatoms, but not enough to cause the resulting differences.

In the natural waters of Illinois the mineral content is probably sufficient for abundant diatom growth at all times. Turbidity, light, temperature, and dissolved gases are the more important factors involved in diatom distribution. In the spring following the melting of the ice, more light penetrates the water. The rising temperature increases the bacterial action upon the accumulated bottom debris, resulting in a greater carbon dioxide content. An abundance of carbon dioxide is an important factor for the growth of most diatoms. Not all diatoms react to the same factors or with the same degree of response. As with most organisms not one, but a combination of factors in the right ratio are responsible for the maximum development.

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BIOLOGY AND HIGHER EDUCATION.

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My purpose is not to give reasons for the changes in courses of study relating to the biological sciences in high schools or to explain why higher education has neglected to keep pace with the demand brought by these changes but rather to give facts, whether liked or disliked, concerning the teaching of biology, botany, zoology, and physiology in high schools in the United States and call attention to the atttitude of universities, state normals, and teachers' colleges toward preparing teachers for the very popular subject, biology.

We shall first see just what changes have taken place in courses of study in the biological sciences in high schools within the last few years. G. W. Hunter, of Knox College, Galesburg, Ill., found in his study of secondary sciences for 1908 and 1923 that in 1908 there were 225 high schools teaching botany, while in 1923 there were 107 schools teaching botany; in 1908 there were 150 schools teaching zoology, while in 1923 there were 66 teaching zoology; in 1908 there were 193 schools teaching physiology, while in 1923 there were 73 schools teaching physiology; in 1908 there were 73 schools teaching biology, while in 1923 there were 299 schools teaching biology. The first three show a loss of from 30 to 50 per cent, while biology made a gain of 57 per cent. (See plate No. 1.)

Number Concerned			Per Cent Concerned		
Subject	1908	1923	1908	1923	% of gain or loss
Botany	225	107	81.5	29.9	-51.6
Zoology	150	66	52.2	1.8	-50.4
Physiology	193	158	69	34.3	-35.6
Biology	73	299	26.5	83.5	-57.6

PLATE 1. Based on G. W. Hunter's study of secondary sciences in 1908 and 1923.

A study of Indiana high schools shows the following: In 1921 there were 80 high schools teaching botany, while in 1926 there were 182 teaching botany; in 1921 there were no high schools teaching zoology, while in 1926 there were 18 schools teaching zoology; in 1921 there were 22 high schools teaching physiology, while in 1926 there were 83 schools teaching physiology; in 1921 there was 1 high school teaching biology, while in 1926 there were 290 schools teaching biology. (See plate No. 2.)

Subject	1921	1926	% of 646 schools 1921	% of 759 schools 1926
Botany	80	182	12.3	24
Zoology	0	18	0	2.3
Physiology	22	83	3.4	11.
Biology	1	290	.15	38.2

PLATE 2. Changes in five years in Indiana high schools.

The number of high schools in Illinois during 1926 teaching biological sciences were as follows: 63 teaching botany; 77 teaching zoology; 53 teaching physiology; 136 teaching biology. (See plate No. 3.)

Subject	Schools Teaching 1926	% of 663 Schools
Botany	63	9.5
Zoology	77	11.6
Physiology	53	8.
Biology	136	20.5

PLATE 3. High schools of Illinois in 1926.

In Ohio during 1926 there were 40 high schools teaching botany, a small number teaching zoology, and 1100 teaching biology. (See Plate No. 4.)

Subject	Schools Teaching 1926	% of 1375 Schools
Botany	40	3.
Zoology	Less than 40	?
General Science	?	75.
Biology	1100	80.

PLATE 4. High schools in Ohio, 1926.

In the high schools of Massachusetts, in 1925, we find few schools teaching botany; none teaching zoology; 250

or all teaching physiology; 165 schools teaching biology. (See Plate No. 5.)

Subject	Schools Teaching 1925	% of all schools
Botany	Few	?
Zoology	None	0
Physiology	250	100.
Biology	165	66.

PLATE 5. High schools in Massachusetts.

In our study of the courses of study of twenty states we find the % of biology taught in all high schools to be as follows: Ohio, 80%; Indiana, 38%; Illinois, 21%; New York, 95%; Pennsylvania, 76%; Delaware, 100%; Michigan, 90%; Kansas, 20%; Georgia, 90%; Wisconsin, 70%; Minnesota, 75%; California, 62%; New Jersey, 90%; Utah, 99%; Massachusetts, 66%; Florida, 60%; Nebraska, 20%; Arkansas, 80%; Oregon, 70%; Virginia, 100%. (See plate No. 6.)

State	% of Schools Teaching Biology
Ohio	80.
Indiana	38.2
Illinois	20.5
New York	95.
Pennsylvania	76.
Delaware	100.
Michigan	90.
Kansas	20.
Georgia	90.
Wisconsin	70.
Minnesota	75.
California	62.
New Jersey	90.
Utah	99.
Massachusetts	66.
Florida	60.
Nebraska	20.
Arkansas	80.
Oregon	70.
Virginia	100.

PLATE 6. Number of high schools teaching biology in twenty states, 1925 and 1926.

From the foregoing facts it is evident that biology is the most popular of all biological sciences; that biology has been a part of the course of study of some states for many years and that biology is rapidly becoming a part of the course of study of other states such as Indiana and Illinois.

Certainly, the Universities, State Normal Schools, and Teachers' Colleges face the problem of training high school teachers in biology.

The author asked twelve representative institutions the following direct questions: first, does your school give a course or courses in general biology; second, does your school give a methods or a teacher's course in biology; third does your school give a major in biology. Plate 9 below is the reply:

Institutions	Courses in General Biology	Methods Course	Major
1. Stanford University	Yes	No	Yes
2. Northwestern University	No	No	No
3. Harvard	Yes	No	No
4. Cornell	Yes	No	No
5. Indiana University	Yes	Yes	No
6. Purdue University	Yes	No	No
7. Teachers' College, Macomb, Ill.	Yes	Yes	No
8. Ball Teachers' College, Muncie, Ind.	Yes	Yes	Yes
9. Chicago University	No	No	Yes
10. University of Illinois	No	Yes	No
11. De Pauw University	No	Yes	Yes
12. Yale	Yes	Yes	No

Eight of twelve higher institutions give a course or courses in general biology. From their catalog statement, they purpose to acquaint the student with fundamentals of living things. Six institutions out of twelve give the future teacher of biology a methods or teacher's course dealing with text books, courses of study, lesson plans, laboratory practice, laboratory equipment, etc. Four out of twelve offer a major in biology. That is, thirty-six term hours or twenty four semester hours consisting of varied combinations. Some have the major made up of botany and zoology; others have the major made up of general biology, a method course, botany, zoology and physiology. About one-half are neglecting to train in the most effective way a biology teacher. Too many students who are majors in botany or who are majors in zoology are going into high schools where they will face a course in biology. They may not often know the biology of the house fly or may not know the biology of milk or biology of a hen's egg. They know little as to course of study, electing text books and biology outlook. A little modernism must come into the courses of study of many of our higher institutions. A few have taken the step.

Were I to suggest a course of study for a major in biology it would consist of a few courses in general biology, courses in botany, courses in zoology, a course in bacteriology, courses in human physiology, and a course in methods or the teaching of biology.

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COMMUNITIES OF MUSHROOMS.

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One that has observed the newspaper accounts of mushroom poisoning may have wondered why certain localities should have a great number of casualties while other localities are practically free from cases of mushroom poisoning. The reason for this is to be found in the study of the relationship between the topography of the land and the plant associations. Many of the cases of mushroom poisoning that come to our notice in the Chicago area occur from specimens gathered in the dune region. It is here that the Quercus velutina (Black oak) predominates and associated with this tree is a member of the Quercus velutina (Black oak) mushroom community called the Destroying Angel or Death Cup (Amanita phalloides). Nearly all of our very serious cases of poisoning in this area are the result of eating this one species.

Mushrooms may be classified into communities which are related to a corresponding association of higher plants. The dunes region, located adjacent to Lake Michigan, contains a succession of associations from the most xerophytic to the climax forest. Each of these has in it a community of mushrooms. The successional stages on the beach contain no mushrooms as the exposure is too great and the change too rapid to permit successful growth and reproduction. The higher plants are successful on the upper beach where the presence of Calamovilfa longifolia and Ammophila arenaria cause the moving sand to pile up and produce fore dunes. On these fore dunes along with these grasses is to be found a gregarious mushroom commonly spoken of as the "Lover of the Sand Binding Grass" (Psilocybe ammophila) and another called "Lover of the Sand" (Psilocybe arenulina). The presence of these mushrooms apparently in the midst of bare sand indicates that some organic material is present in the sand. By moving back farther into the dunes to a place where the sand has stopped moving and pine trees have established themselves another community composed of four or five species is to be found. This community is generally dominated by the Clavaria muscoides (Dingy coral), Lepiota cristata (Small Scaly Mushroom) and Clitocybe pinophila (the Pine Loving Mushroom). Among these may often be observed the American Boletus (Boletus americanum), Granulated pored Boletus (B. granulatus) and rarely Lepiota cinnabarinus. If the pines have stood for a very long time Marasmius androsaceus (Pine needle Marasmius) and Mycena vulgaris will be found to have joined the community.

As pines do not succeed themselves the time eventually comes when they are replaced by an association of Black oak (Quercus velutina). Places where this has already happened may be found a little farther back from the lake. Here may be recognized a sandy soil with but little covering or in a very much protected spot a sandy soil with a thick covering of dead leaves. The communities of fungi are variable due to the differences in the amount of leaf covering present. The less protected locality where the leaf covering is very thin has a community composed of Geaster hygrometricus (Earth star), Tylostoma campestris (the Stalked Puff Ball), Scleroderma flavidum (Tough skinned Puff Ball), and Polyporus cinnamomeus (Silky Central Stemmed Polypore). Here areas become stabilized, but the protecting dune which by sheltering the area from the wind made possible the stabilization, shifts and the surface is again subject to wind action. The community that can live here is able to find subsistence in changing conditions. Stabilization becomes more permanent, gradually the leaf mould accumulates, and the humus is plentiful. The community of mushrooms increases in number and kind until the former community can no longer be recognized as a component part of the new community. This advanced stage, Black Oak community of mushrooms contains that beautiful yet dangerous monarch of mushrooms, the Destroying Angel or Death Cup (Amanita phalloides). This one species has been responsible for more human trouble than all of the other species combined and has claimed its toll of human life wherever the Black oak, Chestnut or other oaks that occupy the corresponding physiographic landscape exist. Others in this community are Hydnum zonatum (The zoned Toothed Mushroom), Tricholoma acre, T. transmutans, T. terriferum, Clitocybe ochropurpurea, T. personatum, Boletus felleus and B. edulis. In the protected ravines away from the moving dunes where stabilization has long existed the association of trees is dominated by the Red Oak (Q. rubra) with an occasional Sugar Maple present to indicate that the next association is in the initial stage. Here the leaf mould is abundant and the herb life is an association of climax species. The community of mushrooms here found is exceedingly large. The sandy subsoil tends to insure an ever present supply of abundant moisture. Moisture and humus supply operate together as determining factors to augment the development of abundant carpophores. The number of fungi during a rainy autumn is tremendous. Among these may be enumerated Clitocybe maxima, C. caespitosa, Entoloma jubatum, Hydnum aurantiacum, H. repandum, Geaster rufescens and Inocybe repandum (Fiber head).

In either the xerarch or the hydrarch succession the number of fungi increases as the succession advances toward the climax stage. The dune succession presents the xerarch in which it may be noted that the humus supply becomes greater as we advance from one community to another of the series. A similar series of facts is in evidence in other xerarch successions such as the rock series or the change from a very open to a dense forest.

The bog succession is much richer in fungi than the swamp. The succession of vascular plant associations consists of a fringe of Decodon verticillatus (Whorled Loosestrife); Sphagnum, with other plants such as sundew and the pitcher plant; bog shrubs; Tamarack trees; Yellow Birch, Red Maple; and the climax Sugar Maple. These associations come in succession in time and quite often are arranged in place order due to the different degree of advancement of the habitats. In Cedar lake, Lake Villa, Ill., for instance the zonation of associations is quite distinct composed of the fringe of Loosestrife well out in the lake perhaps 200 feet from shore. The next association forming a zone perhaps 100 feet wide is composed of sphagnum with other plants growing on the mat formed by the sphagnum. The entrance of shrubs on the sphagnum mat marks a third association. The communities of fungi do not here separate from each other with the same sharp zonation as is true of the vascular plants, in fact they seem to be determined more by the presence of the factors produced by the growth of the sphagnum rather than to the advance of conditions to a place where another vascular plant association may develop. On this mat of sphagnum is found a community of fungi composed of Omphalia fibula, Galera hypnorum, Hygrophorus miniatus variety sphagnophilus, Entoloma nidorosum, Hebeloma crustiliniforme form sphagnophilum and that most beautiful and colorful plant the Boletus spectabilis with its red and golden colors. All these seem to be related to the mat of sphagnum which forms most of the soil material for the growth of plants both vascular and nonvascular. The succeeding zone which contains Tamaracks (Larex laricina) contains two other fungi, Russula fallax and Lactarius sp. Cedar lake bog contains young tamaracks only. The indications here are that many years must elapse before the filling in of the lake by the accumulation of sphagnum in the form of peat will be sufficient for the advance to the Red Maple-Yellow Birch association. This stage of the successional advance has been reached in the Mineral Springs bog and with it has come a community of mushrooms containing some that belong in the preceding group and are to be associated with the Tamarack such as Boletus spectabilis, and the Vermilion Wax Gill (Hygrophorus miniatus) and in addition to these that have continued from the former community are Lactarius helvus, Cantharellus aurantiacus (Golden Vase), Calvatia saccatus (Bog Puff Ball), Hygrophorus speciosus (Beautiful Wax Cap) Collybia aquosa, Mycena sanguinolenta (Red milk Mycena), Gomphidius maculatus (Spotted Bolt) Lactarius camphoratus (Camphor Mushroom), and Hygrophorus chlorophanus (Yellow Wax Mushroom). The advance to the climax community finds a tremendous number of fungi as well as the remnants of bygone communities. These remnants furnish a most interesting means for the estimation of the past history of a habitat. If for instance we find in a climax forest the Yellow Wax Mushroom, Camphor Mushroom and Golden Vase, along with the usually expected climax forms. It seems justifiable to believe that they are remnants of a habitat that is different from the present one and that the habitat has developed to the climax through the bog series (hydrarch) rather than through a xerarch series.

A listing of the climax community shows the species of mushrooms to be much the same regardless of whether the climax has come through the one (xerarch) or the other (hydrarch) series. The percentage is doubtless as high as 80% but the differences between the two communities, the other 20% is of great interest from the standpoint of ecological development. Too little has been done on the problem of the estimation of past development from the differences to make any very sweeping conclusions. A few years further study of such relationships may bring forth more adequate data. In the forest at Tremont, Beech and Sugar maple are among the predominating trees but the association contains a community of fungi not only of the climax type but additional species associated with other stages of the bog successional series. Such evidence points toward a development through the hydrarch series in spite of the fact that the forest is adjacent to a xerarch dune series.

The two successions described serve to illustrate the successional advance of mushroom communities. Similar description of other successions would also show parallel successional advance of mushroom communities.

HUMANIZING SCIENCE TEACHING.

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I.

There are two outstanding types of poor teaching done by two types of teachers:

1. The first is a "teacher" who has little or no interest in either subject or in the student. This is of course the lowest form of teaching which does probably more harm than good, much like disinterested hired help in business who can run your trade "in the ground" in very short time. In education as in business, salesmanship is the essential quality that puts the thing over, in other words *education as well as goods must be sold by creating a desire to possess it.*

What a teacher of this type can do to a school is well illustrated by the following incident which came under my own observation some years ago in Pike County, Indiana in a country school house of the little red variety "on the hillside in the woods". For three years an enthusiastic teacher taught the school and in that time the interest of the community increased so remarkably that every available bit of space in the room was occupied by seats and chairs and the school was a beehive of life and industry. After the third year this teacher was promoted to the principalship of the schools of one of the smaller towns in the county and a new teacher came to teach the little school on the hillside. Now a great change set in; by the middle of the year the enrollment was exactly half of the other teacher's number the year before and by the end of the year she had about one third as many. Of course this was before compulsory attendance was in force but suppose it had been since the day of truancy laws what would have happened then? Beyond a doubt it would have been little better for the Community, because the majority would have attended under protest and their taste for education would have turned to nausea; and antagonism to the teacher would have made out of that room a place of contention and discontent.

I was personally much interested in this case because some of my own friends and acquaintances attended there and so I visited there one day and here is what I saw: The teacher, a young lady, sitting behind a small table, appeared half asleep, almost sullen in all her questions and remarks to the children, entirely without enthusiasm, no circumstance could seemingly induce her to smile and all in all she cast such a gloom over those children it gave one the impression she was dealing with two great evils, namely, the children and the curriculum of studies, that life was not worth living and the brats under her instruction were the worst ever wished on to any teacher since the profession was invented.

2. The second kind of poor teaching is caused by an over-estimation of the importance of the subject and a lack of interest in the student. Such a teacher will invariably dehumanize his teaching by regarding the learner as a sort of necessary evil in order that an opportunity may be found to teach *all* the important facts of the subject exactly as they appear to his own mature mind. He disregards the ability of the student to understand and fails to awaken an interest by giving the student some points of contact with his life's experiences and interests. Such a teacher is always a driver and never a leader of the young minds under his training.

II.

Now for two types of good teaching:

1. The highest type is that accomplished by a teacher who is interested in both his subject and the students. Such a teacher naturally senses the nature of every student individually and tries to connect up the subject with some human interest so that even the slowest ones can find it interesting to know something about it. This is the teacher who knows that a spark of interest must be kindled before the mind can have a desire to learn for in learning as in eating there must be a desire to partake or it simply will not happen. This teacher is essentially a leader instead of a driver *and blessed is he who can lead and need not drive.*

3. Another kind of good teaching is often accomplished by a teacher who has the proper human sympathies al-

though he may not have a first class knowledge of the subject to be taught. Such a teacher will, for the sake of the students, feel the responsibility to prepare the work well enough to achieve real results.

III.

Now in conclusion. How can teaching be humanized? It is, of course, easier said than done otherwise we could all do it and the teaching of Science would be like a picnic on a fine day or life at the edge of Paradise. The main point I believe is that cold isolated facts can be vitalized as a rule by connecting them up with some well known human interests as for instance in Chemistry the study of carbon or nitrogen and their compounds in relation to foods, poisons, plant growth, explosives, etc. In Biology the study of a fish or frogs, even their anatomy, can be related to human life both economically and structurally; their value to man is evident enough to the student and their structure is very much like that of our own bodies in many particulars and then their actions are really wonderfully like our own in response to stimuli upon the different senses.

Finally, what is teaching after all? I think we must agree that while some facts of knowledge must be imparted it is of far greater importance to arouse life interests which will remain and cause the learner to gather up more knowledge along the entire way of life.

A NEW FORM OF ECTOTROPHIC MYCORHIZA.

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Mycorhizas have many different forms and characteristics but certain types are limited to certain genera of trees. Mycorhizas of coniferous trees have characteristic forms that differ from those of deciduous trees though there are many variations in both cases.

The ectotrophic mycorhizas commonly found on deciduous trees have four parts. They are: (a) the fungus mantle, (b) a layer of cells that are elongated on one side of the root and irregular in shape on the other side, (c) about three rows of ordinary cortical cells and (d) the central cylinder. It is the area containing the radially elongated and irregular cells that is characteristic of deciduous trees. The fungus filaments penetrate between the cells in this region and enter the area of ordinary cortical cells. Usually, however, they penetrate only a very short distance into this area and sometimes not at all.

Mycorhizas found on coniferous trees have only three parts. These are: (a) the fungus mantle, (b) several rows of ordinary cortical cells and (c) the central cylinder. The fungus mantle is often not very well developed. The fungus penetrates between the cortical cells sometimes clear to the central cylinder.

The new form described in this paper was found on Quercus bicolor (see Fig. 1). Four regions could be distinctly seen in this form, namely: (a) the fungus mantle, (b) about five or six rows of ordinary cortical cells filled with a substance of some kind, (c) several rows of ordinary cortical cells not filled with the substance and (d) the central cylinder. This form of mycorhiza has characteristics of mycorhizas of both coniferous and deciduous trees. The fungus mantle is very well developed, unlike the mycorhizas of coniferous trees but similar to those of deciduous trees. However, the fungus filaments are not able, under any conditions, to penetrate the cells of the cortex. A close examination with the oil emersion microscope proved that the fungus did not gain entrance in a single case. Apparently the deposit in the outside area of cortical cells served

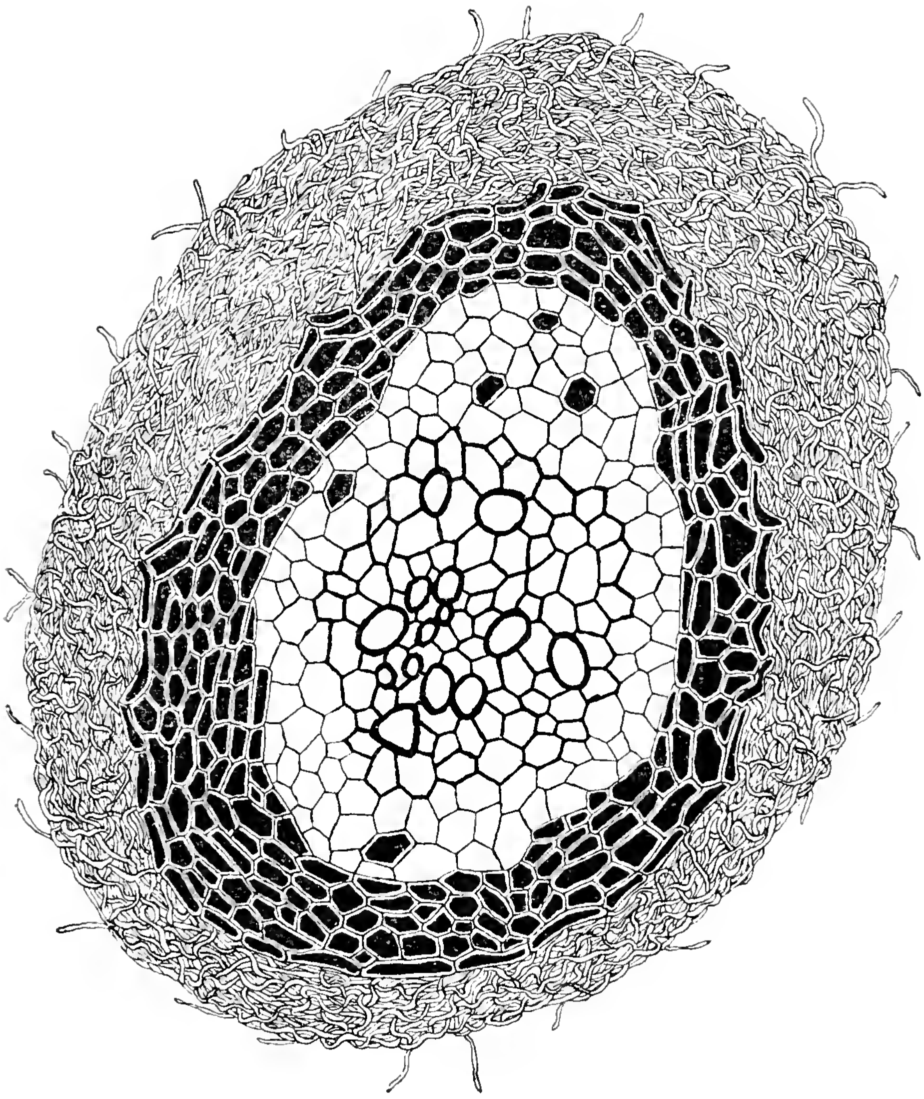

Fig. 1. Cross section of mycorhiza of Quercus bicolor

as a barrier that would not permit the fungus to enter. The central cylinder and the ordinary row of several cortical cells are the same as is usually found in other forms of mycorhizas.

It is necessary for the fungus to obtain nourishment from some source and the question confronts us as to where it has received enough nourishment to produce such a well developed mantle. It is rather doubtful that enough nourishment could be obtained from the outer row of cells of the root. There is a possibility that the fungus penetrated the younger portion of the root nearer the tip, and the mantle then grew back over the older portion of the root but was unable to enter the tissues. Whatever the case may be, it is quite evident that the fungus was unable to enter the root at that particular place from which the section was taken, and this seems to have been due to the unusually large amount of secreted substance in the cells. It is common to find this substance (probably resin or tannin) in a few cells of a mycorhizal root but not in such large amounts.

This phenomenon adds evidence in favor of the contention of McDougall[1] and some other workers that the symbiosis represented by ectrotrophic mycorhizas is antagonistic in nature. It is apparent that the fungus is parasitic on the tree but there is no evidence that the tree is parasitic on the fungus. On the other hand, such evidence as we have points to an attempt on the part of the seed plant to exclude the fungus. Mycorhizas have not previously been collected from Quercus bicolor and much more work needs to be done before definite conclusions can be drawn but the evidence from this one collection indicates that this species of oak is apparently able to "throw up a barrier" to prevent the penetration of a mycorhizal fungus and this may be a clue to the reason why some seeds plants form mycorhizas and others do not, that is, some may be more efficient than others in protecting themselves from the mycorhizal fungi.

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[1]McDougall, W. B., Mycorhizas of Coniferous Trees. Jour. Forestry 20:255-260. 1922.

THE VENUS-FLYTRAP (DIONAEA MUSCIPULA ELLIS.)

W. B. McDougall, University of Illinois.

In limited areas of the coastal regions of North Carolina and South Carolina grows a curious little plant which is found, in a state of nature, no where else in the world. This is the Venus-Flytrap (Fig. 1), so called because the blade of each leaf is modified into a trap by means of which insects of various kinds are caught. The generic name, Dionaea, is derived from that of Dione, the mother of Venus. The plant was first discovered by John Bartram about 1765 and specimens of it were sent by him to England where it was described and named by John Ellis.

The Venus-Flytrap is perennial by an underground stem and has fibrous roots. The leaves which are one to six inches long and partly succulent are all basal and so closely imbricated below as to form a bulb-like structure at the surface of the soil. The petioles are broadened by lateral wings and are the chief photosynthetic organs of the plant. At the upper end the petiole is abruptly contracted to a narrow, short stalk to which the blade is attached. In early summer a naked and usually unbranched scape from three to fifteen inches tall, which bears an umbel-like cluster of greenish white flowers, is produced.

The leaf blade consists of two semicircular lobes with a stout midrib between. The margin of each lobe is fringed with cilia-like teeth and on the upper surface of each lobe are three long hairs which are very sensitive to mechanical stimuli. When one or more of these hairs is touched by an insect, or anything else, the lobes come together quickly, the marginal teeth interlocking like the fingers when one's hands are folded, and the insect is held a prisoner. This closing of the trap, to be sure, is not so nearly instantaneous as is that of a man-made steel trap. The movement is a turgor movement, that is, it is due to a sudden change in the water content of certain cells along the midrib. This change in the turgidity of the cells causes the blades to move as though they were hinged to the midrib. It is the same sort of movement as that of the leaves and leaflets of the sensitive plant and the rapidity of movement is quite comparable to what is frequently observed when a sensitive plant is subjected to a mechanical stimulus. In spite of the moderate rate of closing the insect seldom escapes being caught since the marginal teeth, which are incurved to begin with, are quickly brought close enough together to prevent it. Figure 2 shows that the sensitive hair consists of a definite stalk and an elongated distal portion. Just what makes this hair so sensitive and how the stimulus is transmitted to the cells along the midrib are matters that cannot as yet be adequately explained.

Scattered over the upper surface of each lobe of the trap are a number of short-stalked glands. When an insect is caught in the trap these glands are stimulated to secrete protein digesting enzymes and the digestible portions of the insect are thus rendered soluble and are absorbed and used by the plant. After the insect has been digested and absorbed the trap slowly opens again in preparation for the next victim. The whole process, from the time the insect is captured until the trap has opened again, may require two or three days, but several of the traps may contain insects, in different stages of digestion, at the same time, while some others on the same plant will usually be found open. This sort of interrelation between the plant and insects is known as antagonistic nutritive disjunctive symbiosis.

The Venus-flytrap occurs in a savannah type of vegetation where it is a minor element from the ecological point of view but forms societies of greater or less extent. The habitat is somewhat comparable to that of northern bogs. The soil is sandy and mildly acid. Soil acidity tests made in a flytrap society at the edge of a long-leaf pine forest in August, 1926, gave a Ph. value of 6.0. The soil is underlain by a non-draining subsoil and, while the water table may be at or above the surface during portions of the year, the soil may become very dry at other times. All of the plants of the community show xeric tendencies. This is shown in the flytrap by its succulence and by the fact that it has persistent, thick-walled root-hairs. No mycorhizal fungi have been found in connection with the roots of this plant.

The habitats to which this plant has become adapted are of limited extent and the plant is not extending its geographic range, so that, if these habitats should be destroyed or materially changed, the Venus-flytrap would undoubtedly become extinct.

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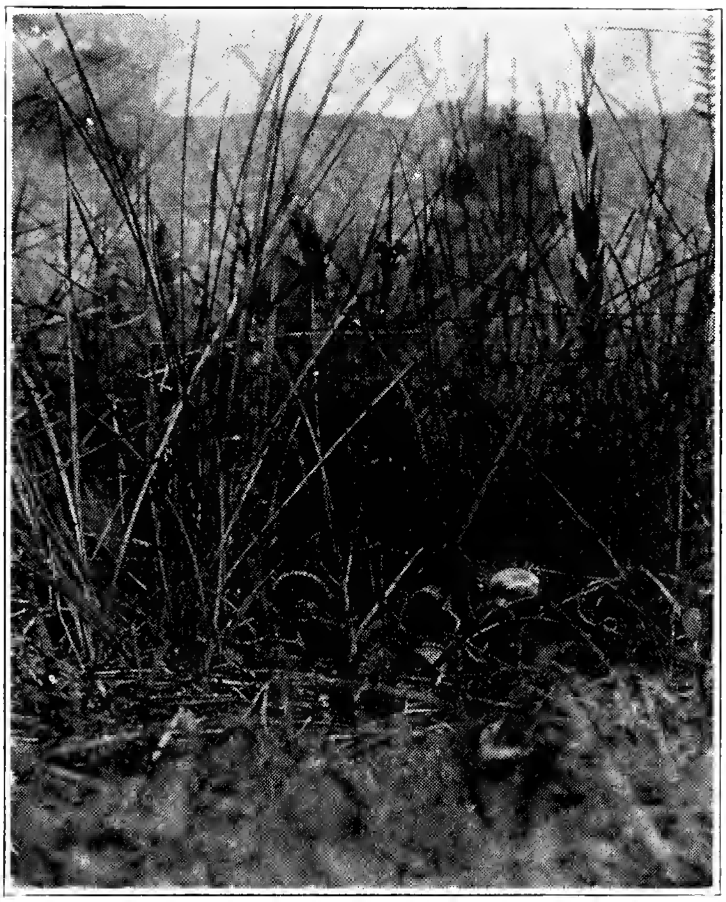

Fig. 1. The Venus-flytrap.

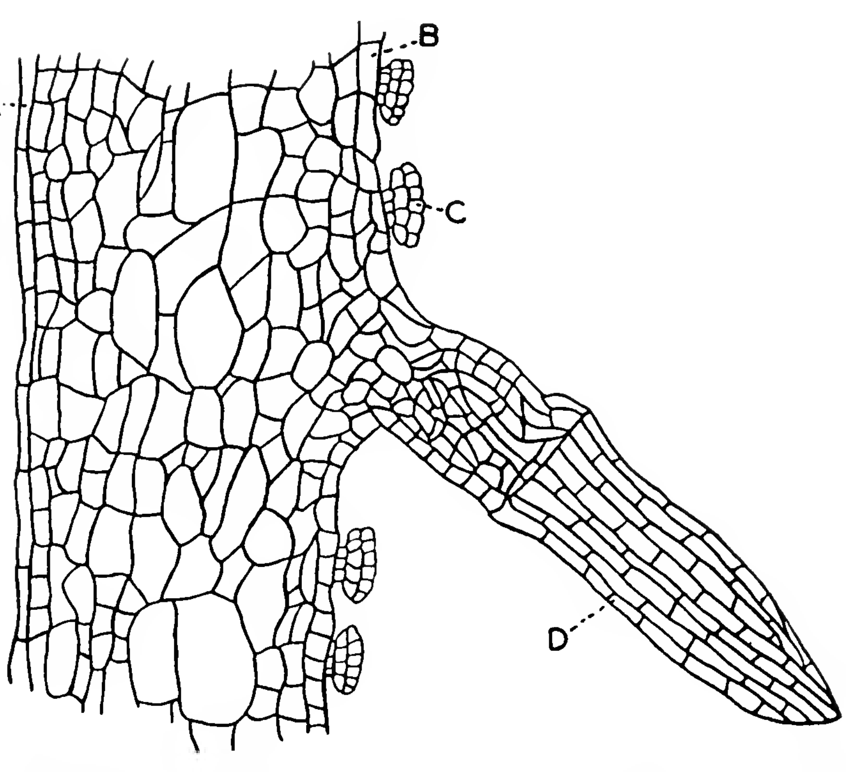

Fig. 2. Cross section of one of the lobes of the trap-like leaf showing one of the sensitive hairs and four glands. A. Lower epidermis. B. Upper epidermis. C. Enzyme-secreting gland. D. Sensitive hair.

A STUDY OF THE ALGAE OF A FRESHWATER STREAM

W. G. SOLHEIM AND W. T. PENFOUND.

The algae of the state of Illinois have received little attention from investigators. The most extensive investigations are undoubtedly those of Transeau on the algae of Charleston and vicinity. Eddy (1925) has studied to some extent the algal succession of a stream in various stages of development near Muncie. No other definite study of any given area has been made. Since algae form an integral part of any flora it seems strange that more attention has not been given them.

The investigation here recorded deals with a small freshwater stream which empties into the Salt Fork river just north of Urbana. The stream consists of a lower cutting portion with a fairly rapid current and an upper portion in which there was little or no movement, formed by log dams. The stream is fed by springs keeping the water fairly fresh at all seasons.

During the dry period of the summer of 1926 the lower part of the stream completely dried up for about a week. Later on during the periods of abundant precipitation the water rose so high as to practically wash out the majority of the algae. However the algae were soon present again in great abundance following periods of this nature. Such periods were always of short duration.

Collection and Identification of Algae.*

Collections of algae were made between April 13, 1926 and April 1, 1927. In all collections were made on twenty different dates, at least one being made every month with the exception of January. In order that the collecting should not be entirely indiscriminate the stream was divided into stations on the basis of varying conditions. Repeated collections were then made from each station on the dates recorded in the table.

*The authors wish to express their appreciation to Dr. Stella M. Hague for aid in determination of some of the forms.

	Running Water																				Stagnant Water																			
	1926																	1927			1926																	1927		
	Apr. 13	Apr. 20	Apr. 27	May 4	May 11	May 18	May 25	June 8	June 18	June 23	July 7	July 20	Aug. 17	Sept. 20	Oct. 12	Nov. 16	Dec. 16	Feb. 8	Mar. 11	Mar. 31	Apr. 13	Apr. 20	Apr. 27	May 4	May 11	May 18	May 25	June 8	June 18	June 23	July 7	July 20	Aug. 17	Sept. 20	Oct. 12		Dec. 16	Feb. 8	Mar. 11	Mar. 31
Myxophyceae																																								
Coccogonales																																								
Chroococcaceae																																								
Synechocystis																																								
S. aquatilis	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Merismopedium																																								
M. convolutum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	c	c	c	c	c	c	c	–	c	c	c	–	–	s	s
M. glaucum	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Hormogoniales																																								
Oscillatoriaceae																																								
Oscillatoria																																								
O. limosa	–	a	–	–	a	s	–	–	r	–	–	–	–	–	–	–	–	r	r	c	c	a	a	c	s	s	r	–	–	–	–	–	–	–	–	r	r	–	s	c
O. curviceps	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	s	s	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
O. ornata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	s	–	–	–	–	c	–	–	–	–	–	–	–	–	–	–	–	–
O. geminata	–	r	–	–	–	–	–	–	–	–	–	–	c	–	–	–	–	–	–	–	–	–	–	c	s	–	–	s	–	r	r	r	–	–	r	–	–	–	–	–
O. formosa	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	s	–	c	–	–	–	–	–	–	–	–	–	–	–	–	–	–
O. princeps	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	a	a	a	a	a	a	a	a	a	a	c	s	r	r	–	r
O. tenuis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	c	s	c	r	–	r	–	–	–	–	–	–	–	r	r	–
O. chlorina	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	s	–	–	s	–	s	–	–	–	–	–	–	–	–	–	–
O. acuminata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	a	c	–	–	c	–	–	–	–	–	–	–	–	–	–	–
O. chalybea	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	c	c	c	–	s	–	–	–	s	–	–	–	–	–	–
O. minnesotensis	–	–	–	–	a	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	c	–	–	–	–	–	–	r	–	–	–	–	–	–	–
O. amphibia	–	–	–	–	–	–	–	–	–	–	–	–	c	–	–	–	–	–	–	–	–	–	–	–	–	–	c	–	–	–	r	r	–	–	–	–	–	–	–	–
O. subtelissima	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	c	–	–	–	–	–	–	–	–	–	–	–
O. sancta	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	s	–	–	–	–	–	–	–	–	–	–
O. subsalsa	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	s	s	r	–	–	–	–	–
O. amoena	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–
O. agardii	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	c	–	–
O. animalis	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Spirulina																																								
S. major	–	–	–	–	–	–	–	–	–	–	–	s	–	–	–	–	–	–	–	–	–	–	s	s	r	a	s	s	r	s	–	–	–	–	–	–	–	–	–	–
S. nordstettii	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Microcoleus																																								
M. sp.	–	–	–	–	–	–	–	–	r	s	–	r	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Nostocaceae																																								
Anabaena																																								
A. inaequalis	a	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	a	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
A. variabilis	–	–	–	–	–	–	–	–	–	–	–	a	a	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Scytonemaceae																																								
Plectonema																																								
P. tomasinanum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	–	–	–	–	–	–
CHLOROPHYCEAE																																								
ISOKONTAE																																								
Protococcales																																								
Palmellaceae																																								
Tetraspora																																								
T. lubrica	–	–	c	c	c	–	–	–	–	–	–	–	–	–	–	–	–	r	c	c	–	c	c	s	–	–	–	–	–	–	–	–	–	–	–	–	–	–	c	c
Autosporaceae																																								
Scenedesmus																																								
S. obliqua	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	c	–	–	–	–	–	–	–	–	–	–
Siphonales																																								
Vaucheriaceae																																								
Vaucheria																																								
V. spp	–	–	–	a	a	c	s	–	c	r	–	a	–	–	–	–	–	a	c	c	c	–	–	c	–	c	–	–	r	s	–	–	–	–	–	s	–	r	s	c
Siphonocladiales																																								
Cladophoraceae																																								
Cladophora																																								
C. glomerata callicoma	–	–	s	s	c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	c	a	–	c	a	c	c	c	–	c	c	c	c	–	c	c
C. crispata	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	c	–	–	–	–	–	–	–	–	–	–	–	–
C. keutzingeana	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	s	–	–	–	–	–	–	–
Ulotrichales																																								
Ulotrichaceae																																								
Stichococcus																																								
S. subtillis	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	s	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
S. spp	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	r	–	s	–	–	–	–	–	r	–	–
Chaetophoraceae																																								
Chaetophora																																								
C. attenuata	–	–	–	–	s	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	r	–	–	–	–	–	–	–	–	–	–
C. elegans	–	–	–	–	–	c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	a	r	c	–	s	–	–	–	–	–	–	–	–
Draparnaldia																																								
D. plumosa	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	c	c	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Stigeoclonium																																								
S. stagnatile	–	a	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	a	a	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	c	a
S. subsecundum	–	–	–	–	a	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Microthamnion																																								
M. keutzingeanum	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	r	–	–	–	–	–	–	r	–	–
Aphanochaetaceae																																								
Aphanochaete																																								
A. repens	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	c	–	–	–	–	–	–	–	–	–	–	–	–
A. sp	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	s	–	–	–	–
AKONTAE																																								

	Running Water																			
	1926																	1927		
	Apr. 13	Apr. 20	Apr. 27	May 4	May 11	May 18	May 25	June 8	June 17	June 23	July 7	July 20	Aug. 17	Sept. 20	Oct. 12	Nov. 16	Dec. 16	Feb. 8	Mar. 11	Mar. 31
Conjugales																				
Zygonemaceae																				
Mougeotia																				
M. spp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	c	c	c
Spirogyra																				
S. porticalis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
S. weberi	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
S. hassallii	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
S. spp	—	c	—	c	a	c	—	—	—	—	—	s	—	—	—	—	—	a	a	c
Desmidaceae																				
Closterium																				
C. moniliferum	—	s	—	c	s	r	—	—	—	r	—	—	r	—	—	—	—	—	—	—
C. acerosum	—	—	—	—	s	—	—	—	—	c	—	—	—	—	—	—	—	—	—	—
C. spp	—	—	—	—	—	s	—	—	—	—	—	—	c	—	—	—	—	—	—	c
Mesotaenium																				
M. sp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	c	c	—
STEPHANOKONTAE																				
Oedogoniales																				
Oedogoniaceae																				
Oedogonium																				
O. spp	—	—	—	—	c	—	—	—	r	—	—	—	—	—	—	—	—	—	—	—
HETEROKONTAE																				
Heterococcales																				
Tribonemaceae																				
Tribonema																				
T. bombycina	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
T. spp	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

	Stagnant Water																			
	1926																	1927		
	Apr. 13	Apr. 20	Apr. 27	May 4	May 11	May 18	May 25	June 8	June 17	June 23	July 7	July 20	Aug. 17	Sept. 20	Oct. 12	Nov. 16	Dec. 16	Feb. 8	Mar. 11	Mar. 31
Conjugales																				
Zygonemaceae																				
Mougeotia																				
M. spp	—	—	c	s	s	a	a	c	r	r	—	—	—	—	—	a	s	c	c	a
Spirogyra																				
S. porticalis	—	c	—	—	—	a	—	—	—	—	—	—	—	—	—	—	—	—	—	a
S. weberi	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	c	—
S. hassallii	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	a	—
S. spp	a	a	c	a	a	c	c	c	s	c	c	c	s	—	s	c	s	a	a	a
Desmidaceae																				
Closterium																				
C. moniliferum	—	s	—	s	s	s	c	r	r	r	r	—	—	—	—	—	—	—	—	—
C. acerosum	—	—	—	s	—	—	r	r	r	—	—	—	—	—	—	—	—	—	—	—
C. spp	—	—	—	—	—	s	—	s	—	r	—	—	—	—	—	c	s	s	c	c
Mesotaenium																				
M. sp	—	—	—	r	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
STEPHANOKONTAE																				
Oedogoniales																				
Oedogoniaceae																				
Oedogonium																				
O. spp	r	c	s	s	s	c	c	a	a	a	a	c	a	a	c	c	s	—	r	r
HETEROKONTAE																				
Heterococcales																				
Tribonemaceae																				
Tribonema																				
T. bombycina	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	a	c
T. spp	c	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	a	a	c

For purposes of determination of species it was necessary to bring the collections to the laboratory since field identification of algae is practically impossible. Only in a very few cases can an algae be placed in the genus to which it belongs without microscopic examination.

All forms found have been placed in their respective genera and a good number of specific determinations have been made. However, the latter was not possible in all cases as all the algae were not at the stage necessary for specific diagnosis. Time did not permit the culture of these forms for identification purposes.

Results.

The results are imbodied in the following table. This table has been divided into two sections, the first listing the algae found in running water, the second, those found in stagnant water. Their frequency throughout the period is designated as follows: (a) abundant, (c) common, (s) scarce, (r) rare, and (—) none found. West's scheme of classification has been followed and the algae are listed according to it.

An examination of the table reveals several interesting things. In the first place the number of species and the total number of algae is greater at all seasons of the year in stagnant water than in running water. This is natural enough and is what one would expect. Also, it is quite probable that several of the species found in the running water are not normally found there but in this case have washed in from the stagnant portion of the stream and were caught in passage through the running portion.

Most of the species present in the running water were also present in the stagnant portion. Usually they were much more abundant in the latter place. A few forms, however, were more abundant in running water as *Tetraspora lubrica*, *Stigeoclonium* spp., and *Vaucheria* spp. *Drapernaldia plumosa* was found only in running water.

Secondly the table reveals a rather definite seasonal succession. Transeau[1] in treating of the periodicity of algae divides them into six groups: 1. Winter annuals, 2.

[1]E. N. Transeau. The periodicity of freshwater algae. Am. Jour. Bot. 3:121-133. 1915.

Spring annuals, 3. Summer annuals, 4. Autumn annuals, 5. Perennials and 6. Ephemerals. This same grouping is made use of here as far as possible. The significance of each group is made clear by consulting the table when species are referred to it.

In grouping the algae as indicated above a single species may be considered alone or all the species belonging to one genus may be considered collectively. In some cases as in *Spirogyra* and *Oedogonium* only the latter can be done as specific determinations were rarely possible.

Taking the species of *Oscillatoria* collectively the table shows that they are spring and early summer perennials. In other words the genus *Oscillatoria* is represented throughout the year but the greatest number of species and also total number occur between the middle of April and the first part of July. Considering individual species, *Oscillatoria limosa* is a winter annual, *O. tenuis* a spring annual, *O. princeps* a summer annual or perhaps a summer perennial. Several species are ephemerals while others appear to be spring annuals but cannot be definitely classified as such until more evidence is secured.

The fluctuations in abundance of a single species from date to date is largely due to flooding as previously mentioned. Flooding is a very important factor in determining the distribution and local abundance of algae.

A striking difference is shown between the seasonal abundance of *Spirogyra* spp. and *Oedogonium* spp. *Spirogyra* spp. collectively are winter perennials while *Oedogonium* spp. are summer perennials. In the early spring *Spyrogyra* is the predominant form and in the summer *Oedogonium* is largely the predominant form. Following the predominance of *Spirogyra* spp. and overlapping them and *Oedogonium* spp., *Oscillatoria* spp. especially *O. limosa* and *O. princeps* are largely the predominants. *Mougeotia* spp. and *Tribonema* spp. were associated with the *Spirogyra* spp. as sub-predominants in the seasonal succession.

Although all the species found cannot be definitely collected into perodicity groups the table suggests the following grouping:

1. Winter annuals; *Oscillatoria limosa, Tetraspora lubrica, Stigeoclonium stagnatile, Spirogyra porticalis,* S. spp. and *Tribonema* spp.

2. Spring annuals; *Oscillatoria geminata, O. tenuis, O. acuminata, O. chalybea* and *Spirulina major.*

3. Summer annuals; *Oscillatoria princeps* and *Oedogonium* spp.

4. Perennials; *Merismopedium convolutum* and *Cladophora glomerata callicoma.*

5. Ephemerals; The remaining species either fall into this group or else the evidence is such that it is at present impossible to place them in any particular group.

Summary.

1. The distribution and seasonal succession of algae in a freshwater stream consisting of a lower portion with running water and an upper portion with stagnant water near Urbana, Illinois has been studied.

3. The algal flora of the running water differed from that of the stagnant water in that the total number as well as the variety of species was much smaller in the former case. A few species of attached forms were more abundant in running water than in stagnant water.

4. The annual succession of algae was definite and often very striking, the flora being almost completely changed in relatively short periods.

5. Some algae are of long duration, whereas others are very abundant but only for short periods. On the basis of their periodicity, the algae have been grouped as winter annuals, spring annuals, summer annuals, perennials, and ephemerals.

6. Flooding was one of the greatest factors in the distribution of the algae, especially in the lower part of the stream.

THE FLORA OF THE RIGHT OF WAY OF THE ILLINOIS CENTRAL RAILWAY:

Waddams to East Dubuque.

H. S. PEPOON, M. D. LAKE VIEW HIGH SCHOOL, CHICAGO.

The author has traversed various portions of the territory covered by this paper, and during two summer vacations, walked the line from Waddams to East Dubuque, and from East Dubuque to Waddams.

It is to be taken for granted that this trip of about fifty miles was not made in one day, but, as it were, by the relay method. To illustrate the procedure, an early morning train was taken to Portage, some 16 miles from East Dubuque, and from 9 to 4 occupied in walking this portion. Another time, the Burlington train dropped three of us at Galena Junction (just across the Galena River from Portage), at 3:30 A. M., and our trip then extended until darkness overtook us in the outskirts of the western terminus; so by similar stages, back and forth, at various seasons, the ground has been thoroughly explored.

A somewhat extended statement is necessary to give a clear idea of why this stretch of railway was taken as a plant survey area. The Illinois Central was built from Freeport to East Dubuque in and near the year 1858, long before much of the land was under cultivation, and while 90 percent of the forest lands were as yet uncut. This one factor accounts for such features as small areas of "Original Prairie", something very hard to find in these days—undisturbed and unpastured *marsh lands*—bits of *original cliff* and steep *ravine sides*—*slough* remnants on the Mississippi bottoms—a portion of a western sandy plain epitomized in N. W. Illinois by a northward extension of the noted Sand Prairie of Jo Daviess—Carroll county.

Along the Galena and Mississippi Rivers are numerous places where deep and rugged ravines, and great jumbled rock masses or cliffs afford for all time, havens of refuge for many rare plants, simply because the section men, however laudable their desire may be to keep neat and clean the right of way, cannot mow or burn such spots. This burning business is a dire catastrophe for many plants. The writer tried to induce the Illinois Central in the days of Mr. Wallace, to permit certain *placarded* areas to go unmowed and unburnt. The Railroad's answer was "No", because of fire hazard to surrounding farm crops. Certain of the marshes and ponds, and slough margins are too wet either to mow or burn. Here then, are the last stands of many notable plants. Long may it be before the ponds dry up.

Waddams at our eastern limit, is on the highest peak of the right of way, something like 1014 feet in elevation, and this "1000 feet" continues for some seven miles to Warren. The surrounding region is Glacial Drift, with many undrained prairie marshes, small ponds and with a gently rolling surface. Some five miles to the west, between Nora and Warren, the driftless area is entered. This first section is entirely prairie, and contains some ten restricted areas that may justly be termed "original."

From the margin of the Drift to the vicinity of Apple River, the marginal region of the Driftless Area is passed over. The land is high and rolling, with numerous hollows and from the earliest days, was almost entirely without trees, except along the creeks, with an elevation well above 900 feet. There are some high dry knolls west of the head waters of Clear Creek, with the bed rock but a few feet below the surface. The railway cuts miniature canyons through this limestone.

From Apple River west for some distance, wooded areas occur, succeeded by more open country which culminates in the famous Law's Cut, a mighty gouge in the Maquoketa Shales. Before reaching the cut, the small west branch of Apple River is crossed. This occupies its preglacial channel in a broad flat valley. We are now fairly in the hill land of Mill creek, Hell's Branch and East Fork of the Galena River and down the last named stream, in tortuous course, midst ever heightening hills, the road wends out upon the alluvium of Galena River, past the ancient lead mine city of Galena on its bluffs and slopes and with one last swinging curve out to the bottom lands of the Mississippi.

From Portage to East Dubuque, the towering bluffs and cliffs are on the right, broken by three river valleys; and to the left, the sloughs, bayous, swamps, bottoms and waters of the great river. So narrow is this strip of land in places that the two other railway lines run their trains over the Illinois Central tracks, there being no room for more. Beyond Portage are many steep wooded slopes abutting on the right of way, numerous ravines, and for some distance, a wonderful palisade of towering lime stone cliffs. After crossing the Little Menominee River, the double tracks separate, the south or east bound passing through the sandy barren before mentioned, joining some two miles east of the western goal. From start to finish, the rails have pursued every direction of the compass except north and east, thus giving every manner of exposure. With the exception of about three miles, the whole distance has been in Jo Daviess Co., and for four miles, just south of the Illinois-Wisconsin Line.

With the above as a working stage, let us investigate the plants of the right of way. The author has a list of 1211 plants found in the county, every part having been repeatedly covered. On the area under consideration, 605 species have been recorded, or exactly one-half lacking one. Truly a remarkable showing.

It may be of interest to tabulate a few groups before considering some of the rarer and more choice forms that here are finding their last hope of existence in the whole county.

There are 110 examples of good and genuine weeds. This is no slander upon the zeal of our section men, for be it known, there is no place like a railway for such an exhibit. Many of these are tramps, pure and simple, and lead a precarious life, season by season, each year with a somewhat different combination. Such are the three wild four o'clocks, (Oxybaphus); numerous spurges (Euphorbia); the lance-leaved sage (Salvia lancifolia); two Chenopodiums, the Jerusalem oak and Mexican tea, the Cotton plant, Silver orach (Atriplex argentea); Flax, rape, turnip, wheat, oats, rye, barley, and alfalfa represent our cultivated plant group. Cow-herb (Vaccaria) is a showy example of a tramp weed.

Among these tramps are a few that cannot be considered weeds, at least with us. The western gum weed or tar weed (Grindelia squarrosa) is found here and there; the showy evening primrose (Oenothera speciosa) rarely occurs; the hoary night-shade (Solanum elaeagnifolium); Froelichia; Scarlet gaura (Gaura coccinea); the wild potato vine (Ipomoea pandurata); Petunia; tomato; hop clover (Trifolium procumbens) are tramp plants of this character.

To summarize further, we find:

17	ferns
100	grasses
70	sedges
110	weeds
35	water plants
100	composites or members of the Aster family
40	shrubs
133	other plants
605	

Fifty-five species of trees adjacent to or leaning over the line fences may be referred to. These cannot perhaps be included in actual right of way plants but would be there but for the hand of man.

The ferns are found almost exclusively on the rocky portions of the right of way from Warren west. The rock brake (Pellaea) is more and more finding such rock cuts congenial dwelling places. Here also, the Woodsia thrives, and the dainty and interesting bulblet fern (Cystopteris). On the great rock-fragments the walking fern is occasional, and the ostrich fern forms small colonies on the low alluvium of creek borders. The flowering fern is at home on shaded banks and the very rare Feei cliff fern (Cheilanthes Feei) is overlooked on sun exposed cliffs.

The grasses and sedges are very abundant on all the marshy and prairie portions, as well as in the shade of the Mississippi bluff woods. There are 53 species of the genus Carex, 10 of Cyperus, 15 of Panicum. The only species that need special mention are wild rice (Zizania); purple love grass (Eragrostis pectinacea); blue joint (Andropogon furcatus); sand-binder grass (Calamovilfa); sand grass (Panicum virgatum); the curious drop seed grass (Sporobolus heterolepis); the great cord grass (Spartina); two mesquite grasses (Bouteloua hirsuta and oligostachya); and the great Lyme grass (Elymus robustus).

A few water plants or wet marsh forms are worthy of comment. The western water lily; two yellow pond lilies (Nymphaea advena and rubrodisca); the yellow and white water crowfoots; an arrow head (Sagittaria latifolia) with a leaf and stalk 6 feet in length; the rare Lophotocarpus calycinus in an isolated flood pond near East Dubuque; five species of yellow and purple bladderworts (Utricularia); water willow (Decodon); the great swamp rose mallow (Hibiscus militaris); the water plantain (Alisma).

Some 12 trees that may with propriety be listed are: the canoe birch on the Mississippi bluffs; the yellow birch on the bottoms; the red cedar on the bald cliffs; at their base, the Kentucky coffee tree; the ashes, green, black, red and white in appropriate soils; the red mulberry on the lower part of the rich wooded slope; the king nut or bottom shagbark hickory on the dry bottoms; the black sugar maple and the rock elm, associates on rocky lowlands.

The shrubs are soon disposed of, for of the many, only a few need attention; the juniper is at home on the cliff-brows; the yellow bush honeysuckle (Diervilla) on the rocky banks; the genuine arrow wood (Viburnum dentatum) and now and then a wild snowball (Viburnum americanum) on a damp cliff; yellow and red honeysuckles are here and there; the shrubby cinquefoil (Potentilla fruticosa) delights in cool damp cliffs, where also the prickly gooseberry, the nine-bark (Physocarpus) and the American yew (Taxus) are to be found. Five species of Cornus or dogwood are often met with, the common one being the small white (Cornus paniculata). In the undrained swamps, buttonbush and many willows grow.

Of the herbaceous plants not included in the above, and numbering some 233 species, there are many very striking forms, a number of which have not been found in Jo Daviess Co. except along the Illinois Central Railway. Let us dispose of these first, without order but as they occur from Waddams to East Dubuque. As will be noted, these plants are largely original prairie species.

Between Waddams and Nora are colonies of the palmate, larkspur and birdfoot violets; the early crowfoot (Ranunculus rhomboideus) and the white blue-eyed grass (Sisyrinchium albidum). Between Nora and Warren are many fine examples of the cream colored wild indigo (Baptisia bracteata), the Quamash (Camassia), the wonderful white fringed orchis (Habenaria leucophoea) in a blanket of white on the moist low prairie; the deep blue prairie gentian (Gentiana puberula), the most enduring and bluest of our species; the flesh colored milkwort (Polygala incarnata); and the prairie parsley (Polytaenia). Near Apple River is a fine collection of purple coneflowers (Brauneria pallida); the prairie dandelion (Agoseris); the yellow hop clover, and the spicate blazing star (Liatris spicata). West of Apple River are numbers of cream wild indigo and Valerianella (V. chenopodifolia); also great collections of the edible valerian.

Near Galena, by the side of the river, is a great patch of the glade mallow (Napaea), this having been found by the author in but one other locality in Illinois; the showy hedge nettle (Stachys tenuifolia); a red form of oxalis (O. rufa of Britton) always in wet rock cuts; the two colored skullcap (Scutellaria versicolor; Sullivantia and Zygadenus chloranthus or Camass. While found elsewhere, the lilies (L. superbum and philadelphicum) are far finer on the undisturbed soil of the railroad strip. The yellow lady's slipper occurs in many places, the small white form on Apple River only.

Along the stretch of road from Portage to East Dubuque are a number of fine plants. Here only do we find the beautiful Ipomoea before named and the rose mallow; twinflower (Jeffersonia); golden Corydalis; the long flowered Puccoon; the striking poppy mallow (Callirhoe involucrata); the white plains thistle (Cirsium undulatum); C. pumilum, the fragrant one, beloved by country children who plunder it for nectar, extends the whole length; at one place only is the great Rudbeckia (R. subtomentosa) found; the small white milkweed thrives at the western limits, while the showy prairie species (Asclepias sullivantia) abounds at the eastern portion.

Much more might be said but enough has been presented to emphasize strongly the part our great railways, built nearly three-quarters of a century ago, have in conserving and preserving our fast diminishing company of choicer plants. Here many I have named are making their last stand before extinction. It is indeed a pity that some way cannot be found to enable the railroads to set apart here and there choice remnants of this vanishing flora, to be placarded and cared for by state or local societies, as some evidence of "the glory that once was."

In conclusion, I wish to thank the Illinois Central Railway for many courtesies extended in the past days, and for the use of their large scale maps which have been used in making the sectional maps of this paper. The railroad possesses the last rear-guard of the innumerable host of beauties that once made glad the Illinois lands. This is an asset not adding an iota to the dividend of dollars, but which, preserved to the flower-loving public who ride on its trains, will engender in the hearts of an increasing constituency, a kindlier opinion toward a so-called soulless corporation, that is thus able to blend with its great undertakings, a generous and fostering concern for the flower suppliants to be cherished or blasted by its decree.

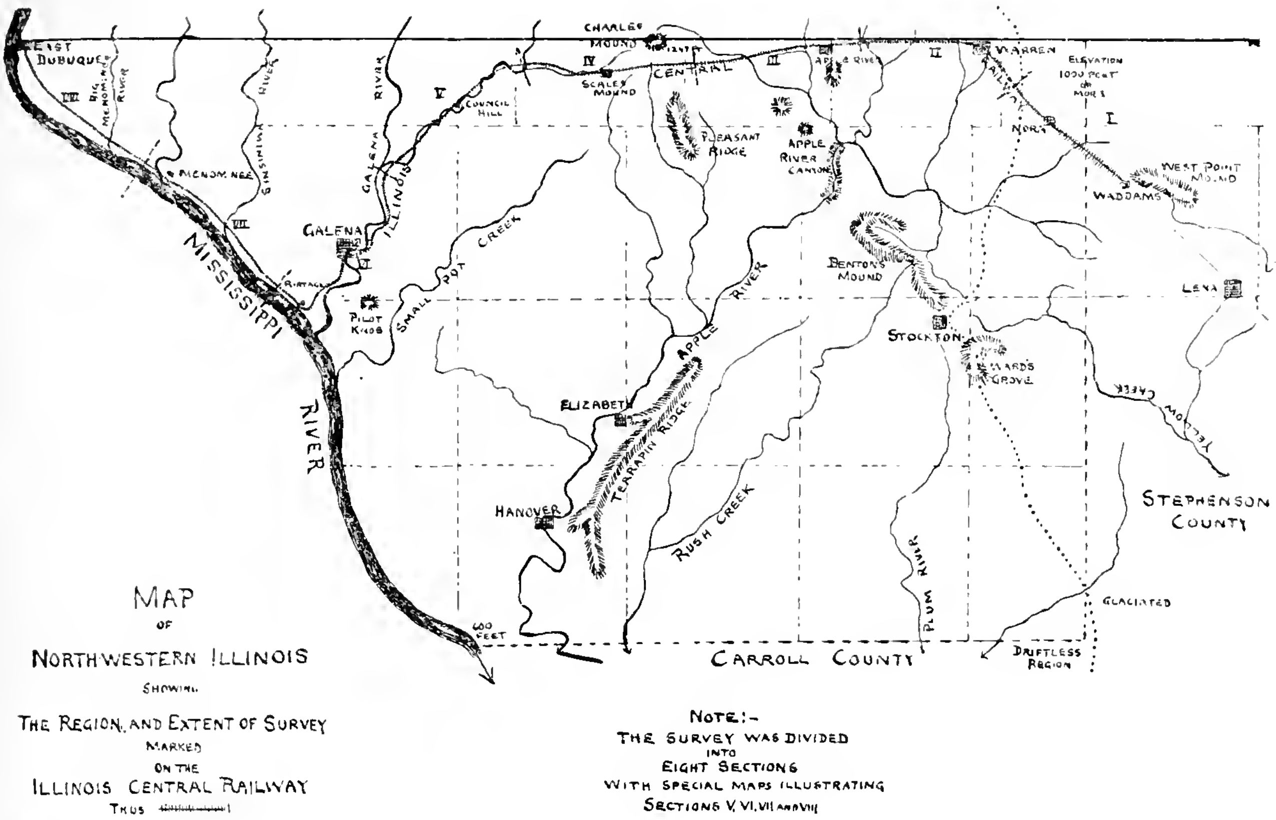

FIG. 1

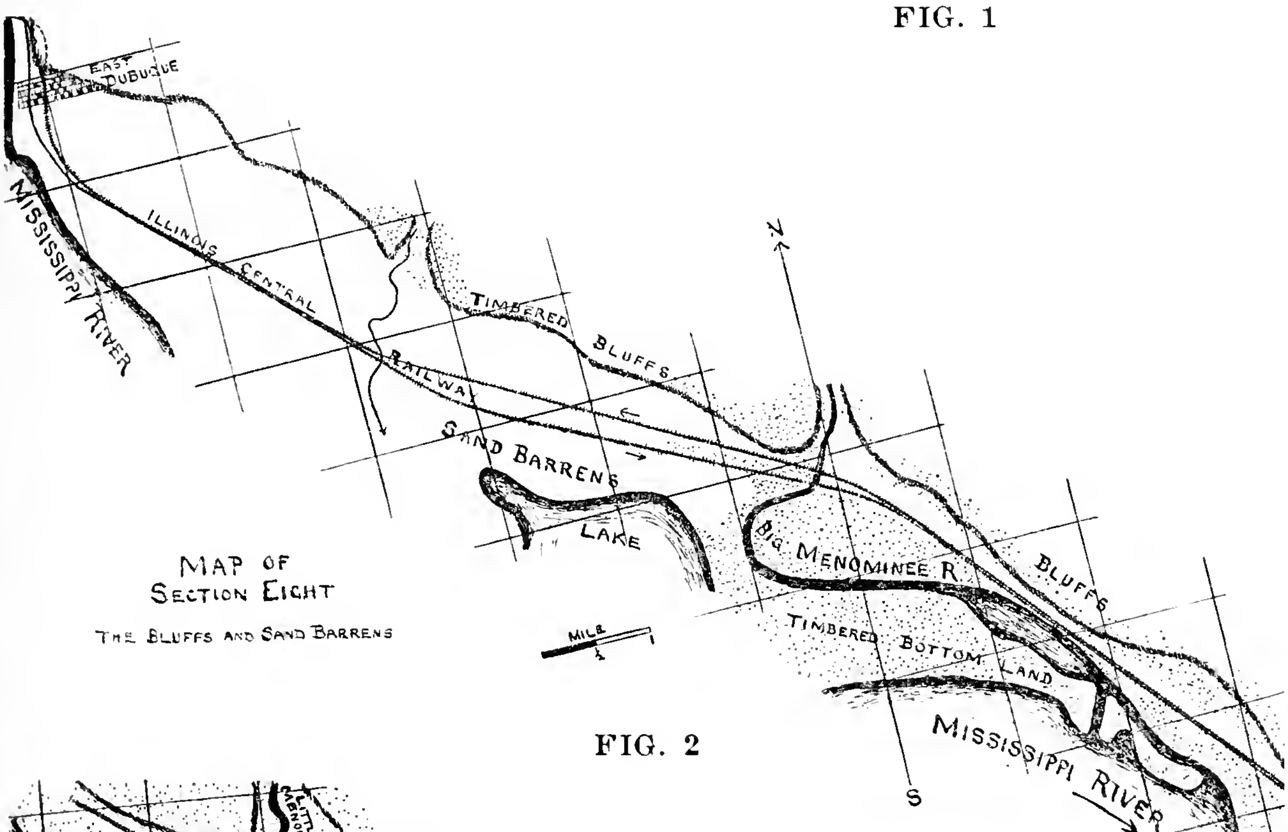

FIG. 2

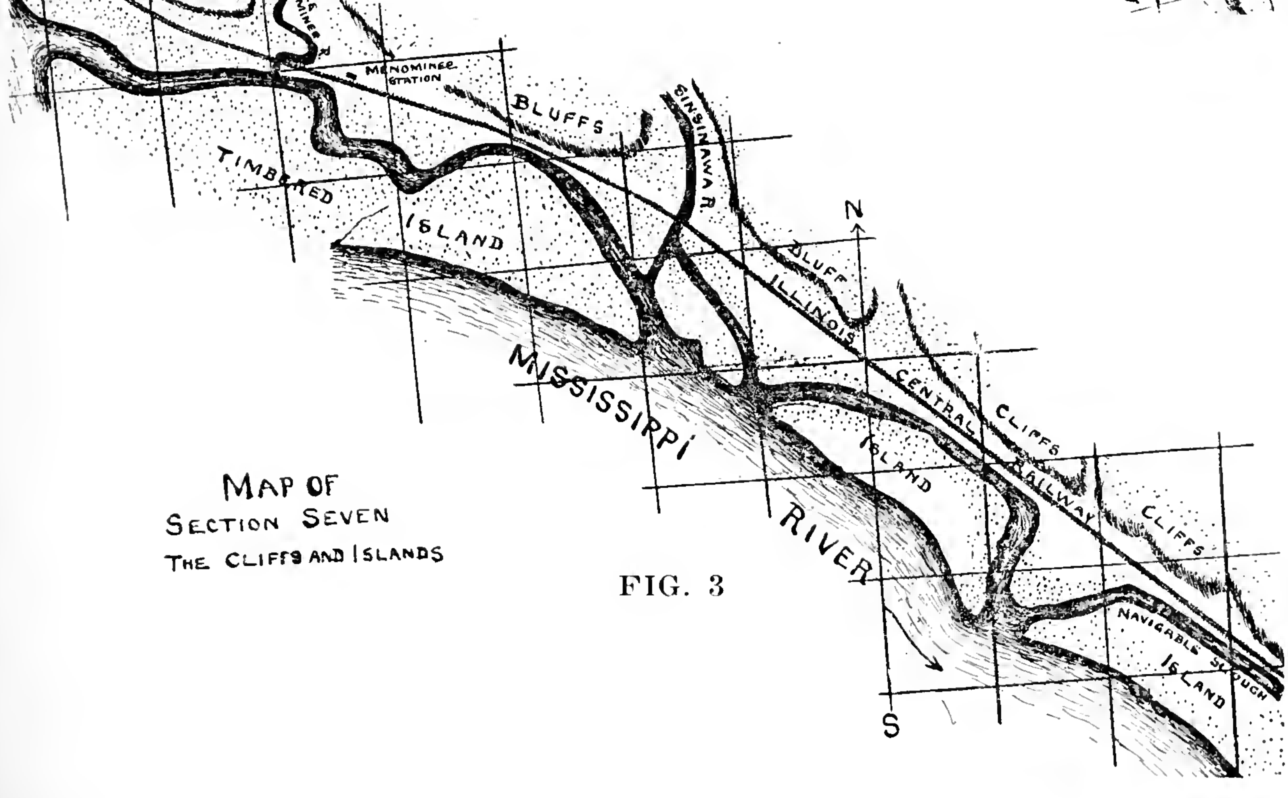

FIG. 3

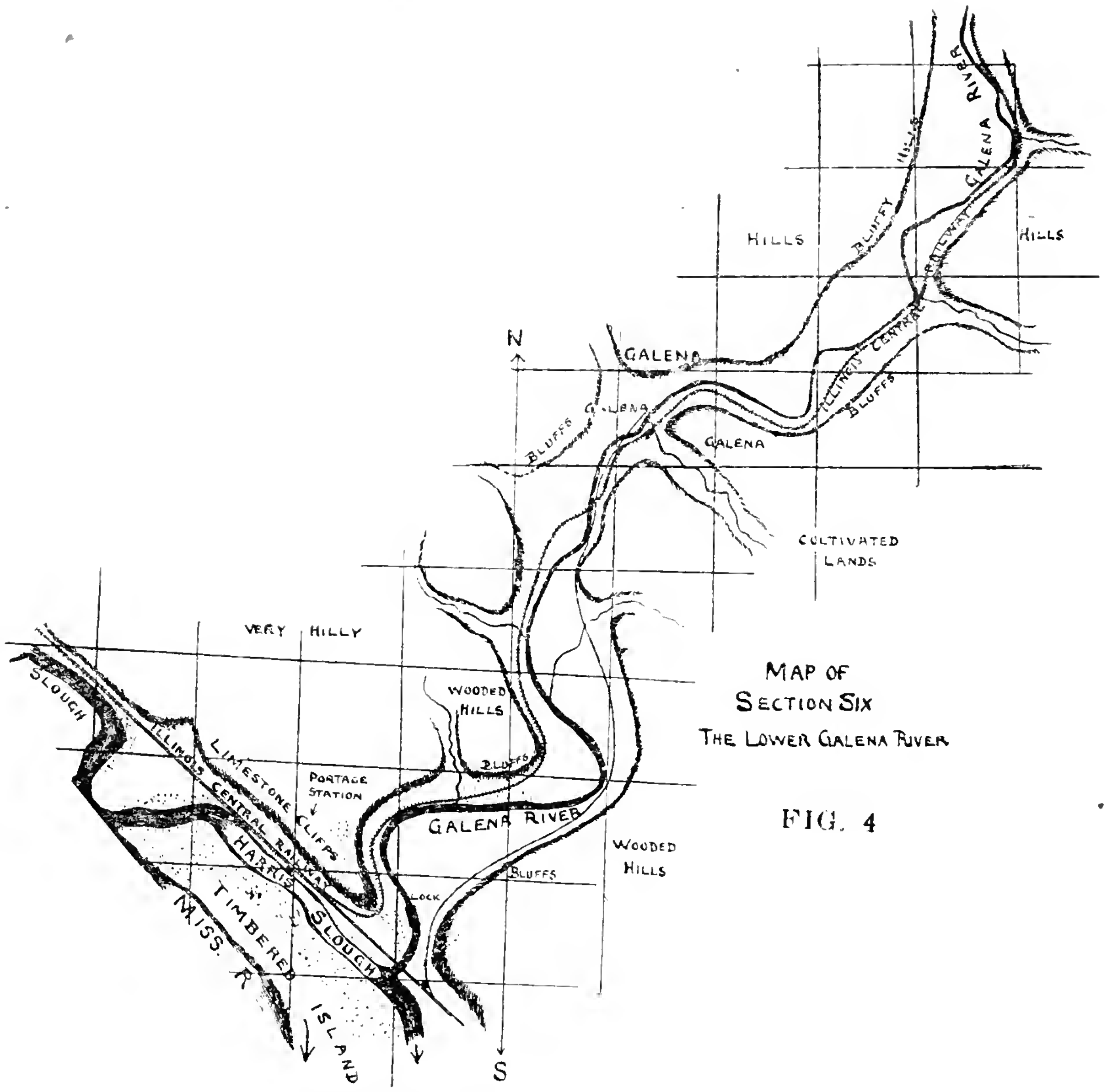
MAP OF
SECTION SIX
THE LOWER GALENA RIVER
N
S
GALENA RIVER
HILLS
BLUFFY HILLS
ILLINOIS CENTRAL RAILWAY
GALENA
BLUFFS
CULTIVATED LANDS
VERY HILLY
WOODED HILLS
LIMESTONE CLIFFS
PORTAGE STATION
SLOUCH
HARRIS SLOUCH
TIMBERED ISLAND
MISS. R.
LOCK

FIG. 4

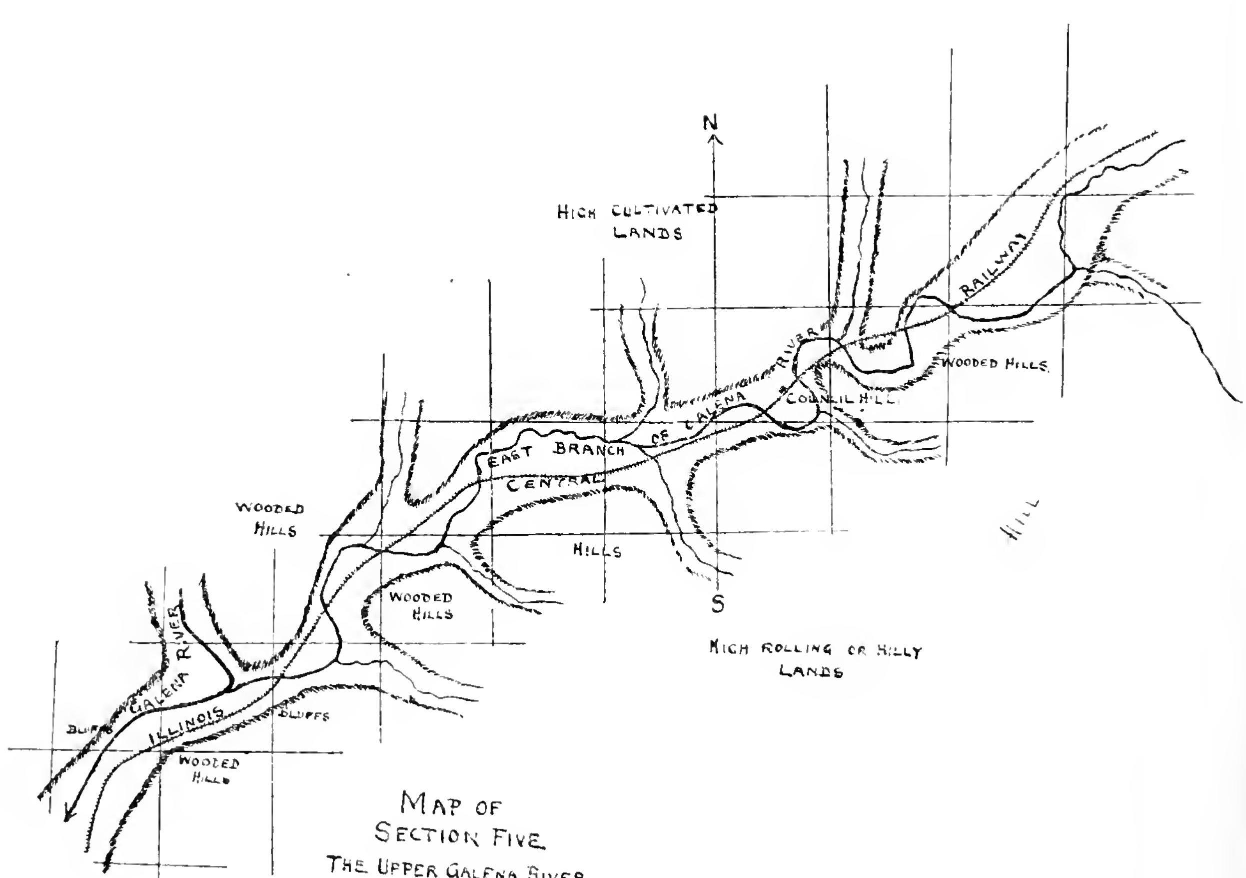
MAP OF
SECTION FIVE
THE UPPER GALENA RIVER
N
S
HIGH CULTIVATED LANDS
RAILWAY
WOODED HILLS
COUNCIL HILL
EAST BRANCH OF GALENA RIVER
CENTRAL
HILLS
HIGH ROLLING OR HILLY LANDS
GALENA RIVER
ILLINOIS
BLUFFS

FIG 5

THE EFFECT OF VITAMIN (B) AND (C) DEFICIENCY ON THE MECHANICS OF THE INTESTINAL TRACT.

BEULAH A. PLUMMER, SPRINGFIELD HIGH SCHOOL,
SPRINGFIELD, ILLINOIS.

An experiment was conducted in order to determine whether deficiency diets materially affect the motility of the intestinal tract in beriberi rats and in scurvey guinea pigs.

There is according to Alvarez (1922) a definite rhythmic gradient in the intestine from pylorus to colon, the rate of rhythmic contraction varying from seventeen to twenty per minute in the duodenum to ten per minute in the lower ileum while the larger bowel is more sluggish than the small intestine.

The method of isolated strips as described by Alvarez (1922) was used in this experiment and comparisons of the normal with the experimental segments were made in rate of and amplitude of rhythmic contractions, tonus and duration, or the length of time during which the excised strips exhibit spontaneous contractions in oxygenated Locke's solution.

After decapitation the abdomen of the animal was quickly opened. A loop of intestine two and one half centimeters long was removed from the duodenum immediately below the stomach, the same length of terminal ileum and a similar portion of the colon about thirty millimeters above the anus. The remainder of the tract (with the exception of the caecum) was put into Petri dishes and placed on ice where the temperature registered from one degree to five degrees Centigrade.

The three isolated strips were suspended in a dish containing exactly one liter of oxygenated Locke's solution kept at a constant temperature of 38°C by means of a pencil thermostat. The oxygen was liberated through a glass cannula which was fastened to the bottom of the dish and the bubbles passed through the solution at the rate of ten per minute. Levers were arranged which recorded the rhythmic contractions and tonus on a kymographic paper. The leverage, length of arm, and load were not changed throughout the course of the experiment so that the work and magnification were comparable. Preparations of both the normal and experimental animals were made in this manner and tracings were run from the refrigerated strips on the second, third and fourth days after removal from the animal. The normal animals were starved for forty-eight hours previous to the experiment to insure an empty alimentary canal.

Twenty-four rats were given B free diet. The ration consisted of casein (18) grams, starch (54) grams, lard (15) grams, butter fat (9) grams, and salts (4) grams. (Osborne & Mendel). The average time on this diet was seven weeks during which there was a gradual loss in weight and in general a marasmic condition. The number of feces decreased which seemed indicative of constipation. Five of the experimental animals developed a spastic gate at which stage they were killed for the experiment. Seven normal animals were used for controls.

As shown in Chart I the normal duodenums lived 148 minutes longer than the beriberi duodenums, the normal ileum 173 longer than the beriberi ileum while the normal colon exceeded the beriberi colon by 467 minutes. In every case tracings from strips of the intestine on ice were run on the second day; but not one of the beriberi segments showed motility on the second day while six of the normal duodenums were active, one of the normal ileums and seven of the normal colons.

The contraction rate was calculated for the first and third hours—Chart II. Both the normal and experimental duodenums contracted the first hour at the same rate, but the (B) deficient duodenums lost rapidly so that at the end of the third hour the normal was giving almost double the number of contractions. Even the first hour the beriberi ileum showed a decidedly lower rate than the normal and at the end of the third hour the beriberi ileum dropped to the zero point while the normal ileum was able to give 268 contractions. The two colons kept pace with only a difference of eight contractions in favor of the normal at the end of the third hour.

Chart III—The tonus factor showed a great variation in the number of waves, especially in the normal ileum and colon. In the duodenum the first hour, there were on the average only two more waves, in the ileum 19, in the colon 16.

In the case of the ileum, the amplitude of the rhythmic tonus contractions averaged higher in the normal than in the beriberi strips. This was also true for the duodenum and the colon but here the difference in favor of the normals was less marked.

Excised intestinal segments of the beriberi rat showed no spontaneous contractions or tone after twenty-four hours on ice. Therefore, the endurance of the intestinal motor mechanism is doubtlessly impaired in Vitamin (B) deficiency since in every experiment the normal strips were active on the second day. Absence of Vitamin (B) from the diet of a rat diminished the length of time during which an excised strip exhibits spontaneous contractions in oxygenated Locke's solution. The amplitude and rate of the rhythmic contraction is markedly decreased in the spastic stage of the beriberi rat especially in the duodenal and ilial segments.

The same method was employed for testing the mechanics of the intestinal tracts in acute scurvy. Ten normal guinea pigs and nine scorbutic animals were used in the experiment.

The experimental guinea pigs were fed C free diet composed of oats and a mixture of alfalfa meal with wheat flour (equal parts by weight). When they had reached the stage of advanced scurvy they were killed. Due to a loss of appetite prior to death, the tract was usually empty except the caecum and sometimes the colon.

As shown in Chart IV—the first day there was no difference in the duration factor for the normal and scurvy duodenum but the normal ileum lived 18 minutes longer than the scorbutic. In the colon there was a difference of 50 minutes in favor of the normal strips. On the second day the normal duodenum outlived the scurvy duodenum by 185 minutes, the normal ileum exceeded by 134 minutes while the normal colon lived 81 minutes longer than the scurvy colon. The story for the third day is practically the same, since the normal duodenum lived 169 minutes, the normal ileum 167 minutes and the normal colon 165 minutes longer than the scorbutic strip. The fourth day the normal duodenum showed an average life of 65 minutes while none of the scurvy segments showed activity. The normal ileum outlived the scurvy ileum by 16 minutes while the normal colon exceeded the scurvy colon by 105 minutes.

The scorbutic colons usually showed activity or survival for 96 hours, and in every experiment the length of time which the normal strips survived and contracted exceeded that of the scorbutic, not only on the first day but on the second, third, and fourth days after death.

Chart V—In determining the rate of rhythmic contractions for the first day, 1st and 4th hours, the normal duodenum contracted more rapidly than the scorbutic. The scurvy ileum showed a hypermotility. At the beginning of the first hour, the rate of the scurvy colon surpassed the normal but at the end of the fourth hour the record was reversed. On the second, third and fourth day the curves showed that the normal strips uniformily surpassed the scorbutic segments.

In computing the work based on the amplitude and number of rhythmic contractions for the first and fourth hours, the record showed that more work had been done by the normal segments than by the scurvy segments with the exception of the scurvy ileum for the first day, first hour. The records for the three succeeding days demonstrates the greater efficiency of the normal strips.

Chart VI and VII—A count of the number of tonus waves was made for the 1st and 4th hours; also the amplitude of these waves was measured in both the scorbutic and normal tracings for the four successive days. Tonus of the intestinal wall of the moribund scorbutic guinea pig showed a slight increase in the duodenum with a marked increase in the colon. However, there was a decrease in the tone of the scorbutic ileum.

In estimating the number of duodenum, ileum and colon segments which were capable of spontaneous activity and tone during the four successive days, the percentage was much higher for the normal than for the scorbutic strips.

In the scurvy guinea pig, we found in general that the colon showed initial hypermotility. The colon of the animal with most advanced scurvy gave the highest amplitude of rhythmic contractions, three of them reaching 97, 95 and 90 millimeters while the highest amplitude recorded for the normal colon was 87. Extreme amplitudes were also noted in a guinea pig showing practically the same degree of scurvy.

If the autonomic activity of the intestinal strip as recorded by the method herein employed is a true index of the physiological condition of the local intestinal motor and muscular mechanism, we may conclude that deficiency of Vitamin (B) on the whole diminishes the motility both in amplitude and rate of contractions and shortens the time during which excised strips exhibit spontaneous contractions. Deficiency of Vitamin C likewise shortened the duration of the excised strip and diminished the rate of rhythmic contraction with the exception of the ileum the first hour of the first day, but tonus and amplitude of rhythmic contraction were increased.

According to the results of this experiment, deficiency of Vitamin (B) affects the mechanics of digestion since stasis and hypomotility seem to characterize the beriberi intestinal tract. Lack of Vitamin (C) decreased the duration of the strips also diminished the rate of rhythmic contractions; but the increased amplitude of the rhythmic contractions indicated hypermotility in the colon and also some hyperactivity in the duodenal strip. The tonus of the intestinal wall was considerably increased in the scorbutic strip.

In comparing the effect of deficiency of Vitamin (B) with the effect of deficiency of Vitamin (C) on the activity of the digestive tract, it would appear that the effects are opposite. Lack of (B) causes a decrease of activity with retention of the intestinal contents while lack of (C) does not interfere with peristaltic digestion to as great a degree. However, the results seem to indicate a speeding up of motility in the acute moribund stage.

In as much as the beriberi strips of the rat and the scorbutic strips of the guinea pig were unable to show motility as long under the same experimental conditions as the normal, the experiment indicates that the mechanics of digestion are involved in both the deficiency of Vitamin (B) and (C). However, the effects on motility in (B) deficiency may be quite different pathologically from the effects of (C).

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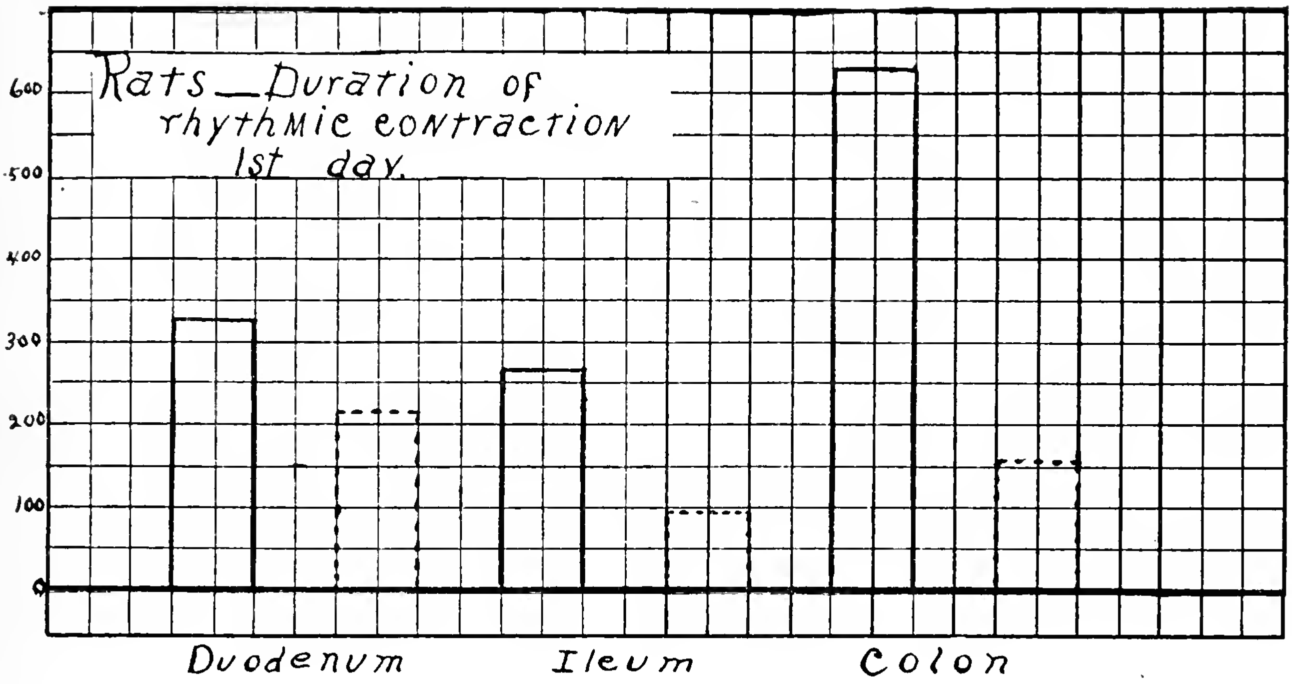


Chart I.—The length of time which excised strips can exhibit spontaneous contractions and tone in oxygenated Locke's solution is longer in the normal duodenum, ileum, and colon than in the polyneuritic segment. Normal——; Polyneuritic................

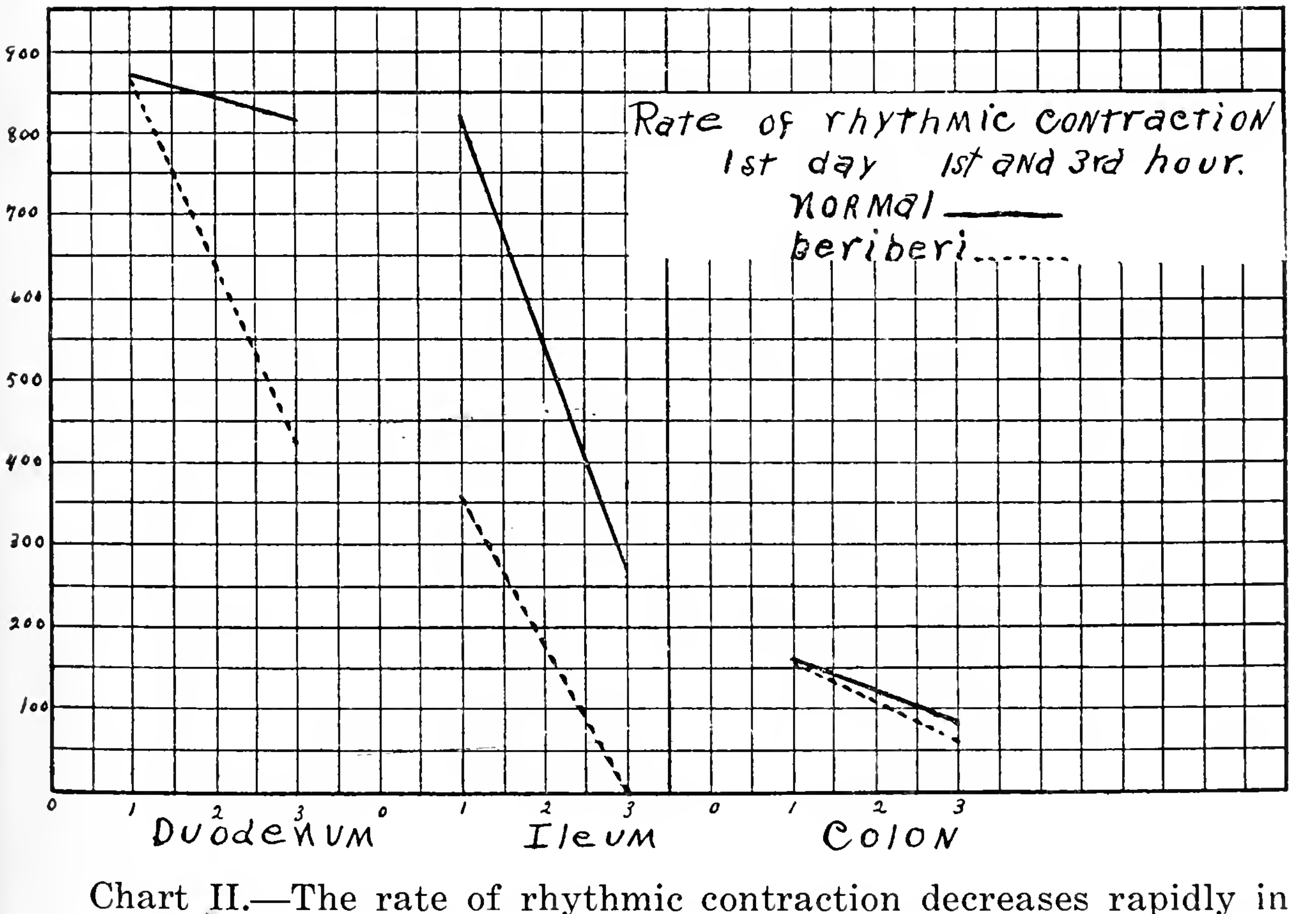


Chart II.—The rate of rhythmic contraction decreases rapidly in the duodenum and ileum segments of the polyneuritic rat. The rate of spontaneous contraction is lower in the polyneuritic colon and the decline gradual.

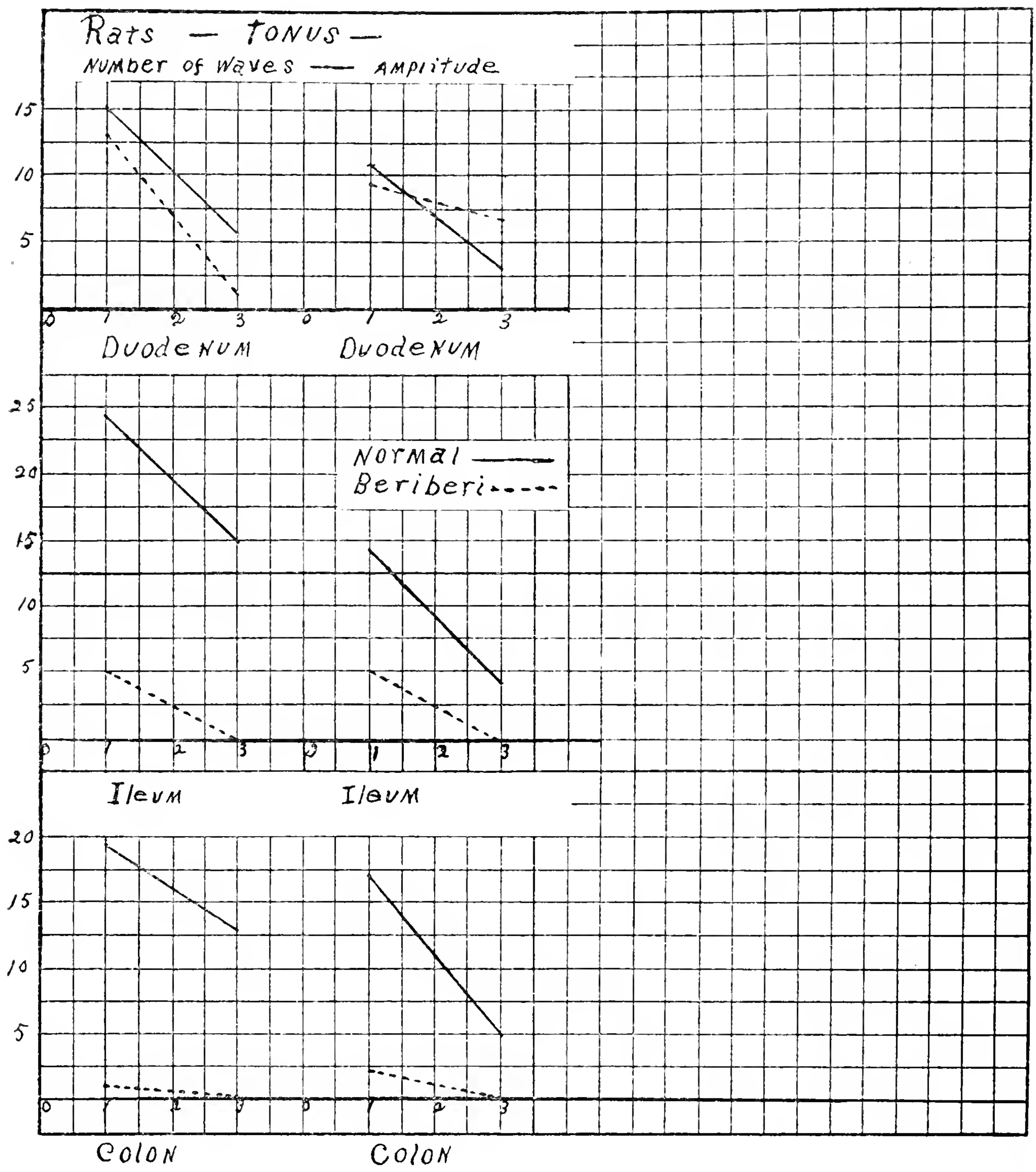


Chart III.—In the beriberi rat, the excised strips of the duodenum and colon show a decrease in tonus both in the number and in the amplitude of waves.

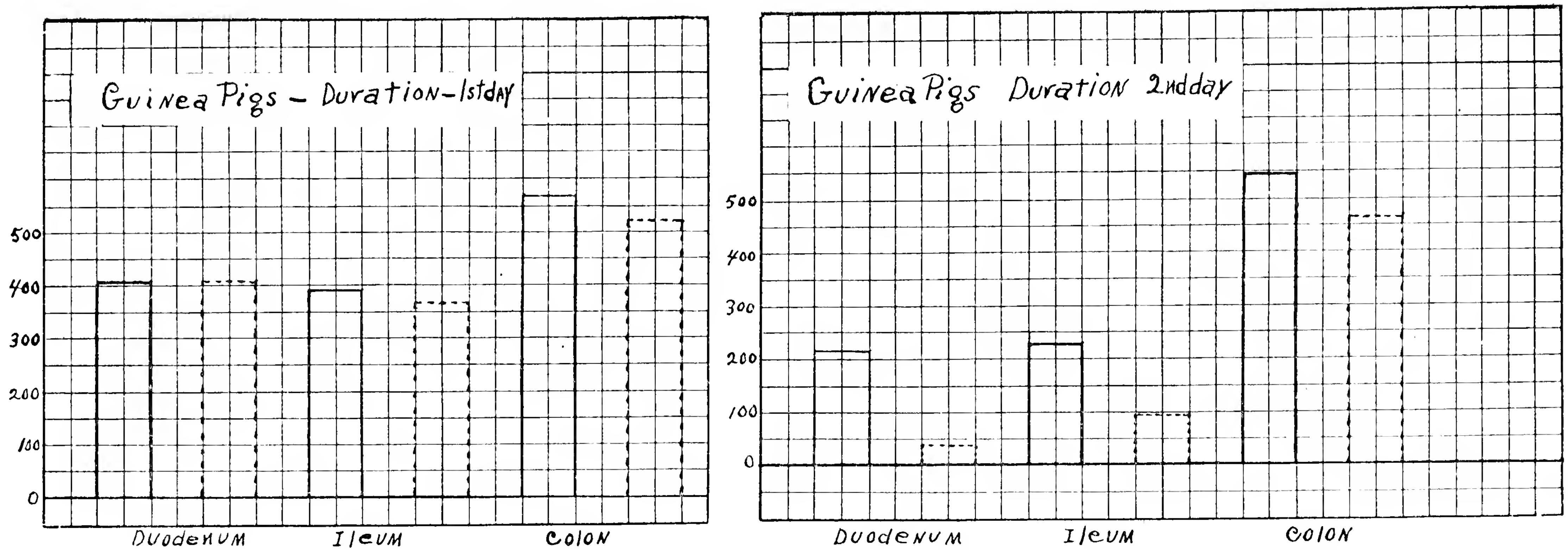
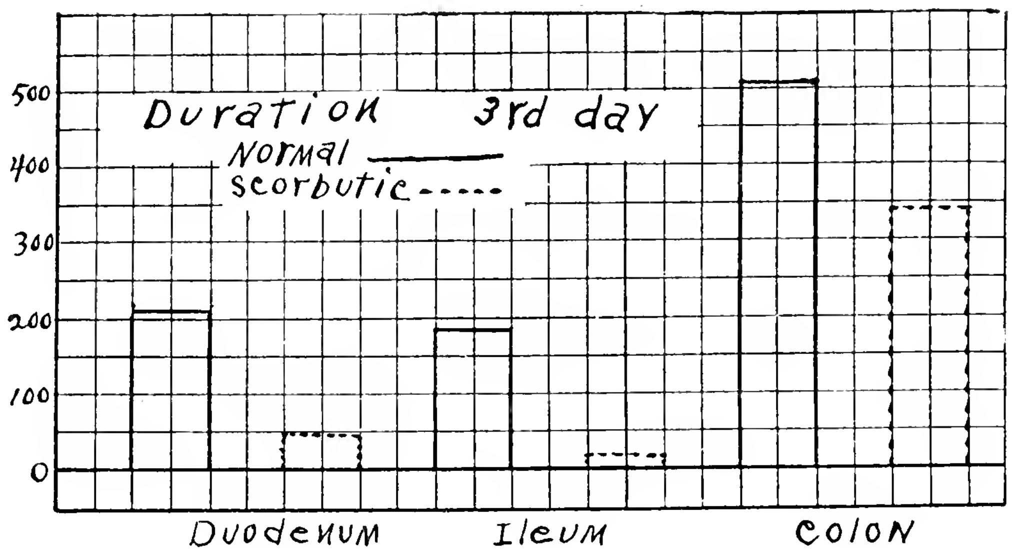


Chart IV.—The first day, the length of time during which excised strips can exhibit spontaneous contractions and tone in oxygenated Locke's solution is longer in the normal ileum and colon than in the scorbutic strip. There is practically no difference in the duration of the normal and scorbutic duodenal segments.

The second day, the duration is longer in the normal duodenum, ileum, and colon than in the scorbutic strip.



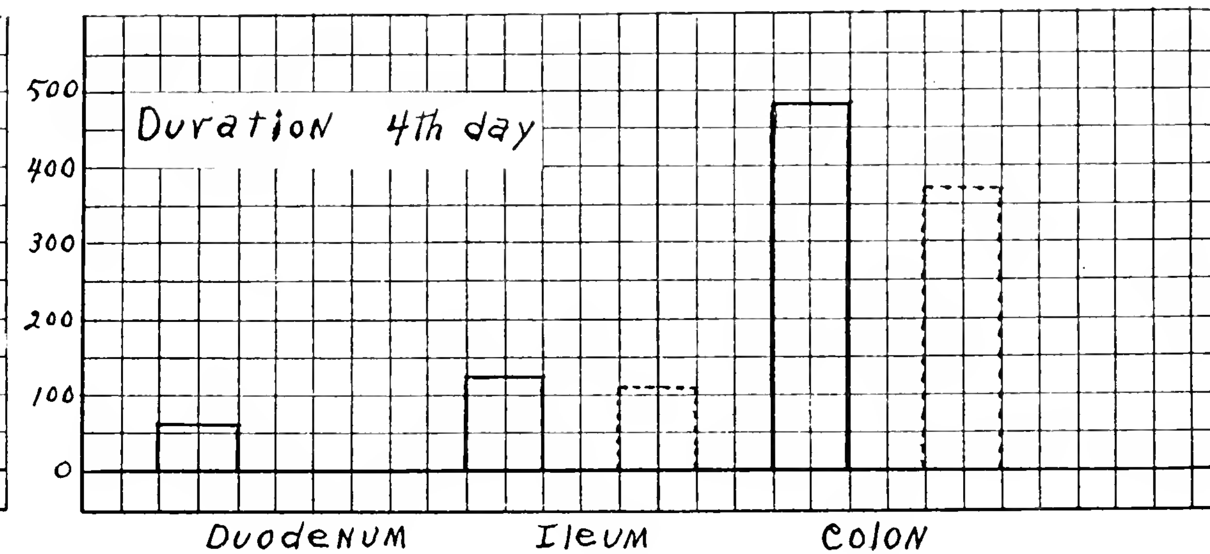


Chart IV (Continued).—The third day, the length of time during which excised strips exhibit spontaneous contractions and tone in oxygenated Locke's solution is longer in the normal duodenum, ileum, and colon than in the scorbutic segment.

The fourth day, the duration is longer in the normal duodenum, ileum, and colon than in the scorbutic segments. The scorbutic duodenal strips did not exhibit activity.

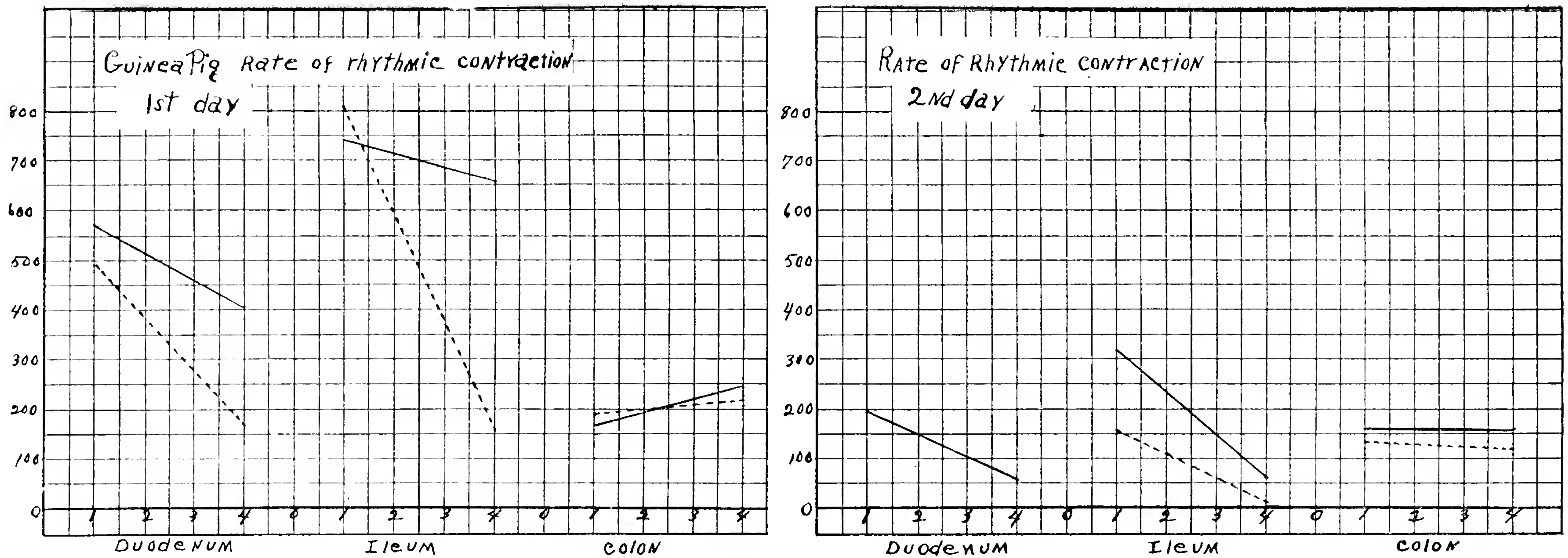


Chart V.—The rate of rhythmic contraction in the scorbutic duodenum the first day is lower than the normal. The scorbutic ileum exhibits hyperactivity with a marked decrease in rate. The scorbutic colon exceeds the normal in rate for the first hour. Normal———, scurvy............

The second day the rate of rhythmic contraction is higher in all of the normal segments than in the scorbutic strips.

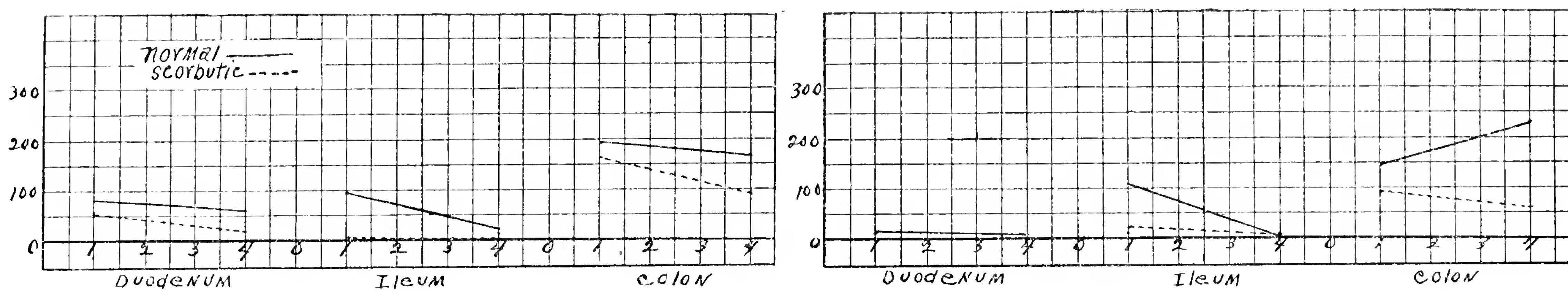


Chart V. (Continued).—Guinea Pig—Rate of Rhythmic contraction. The rate of rhythmic contraction is higher in the normal duodenum, ileum, and colon than in the scorbutic segments the 3rd and 4th day.

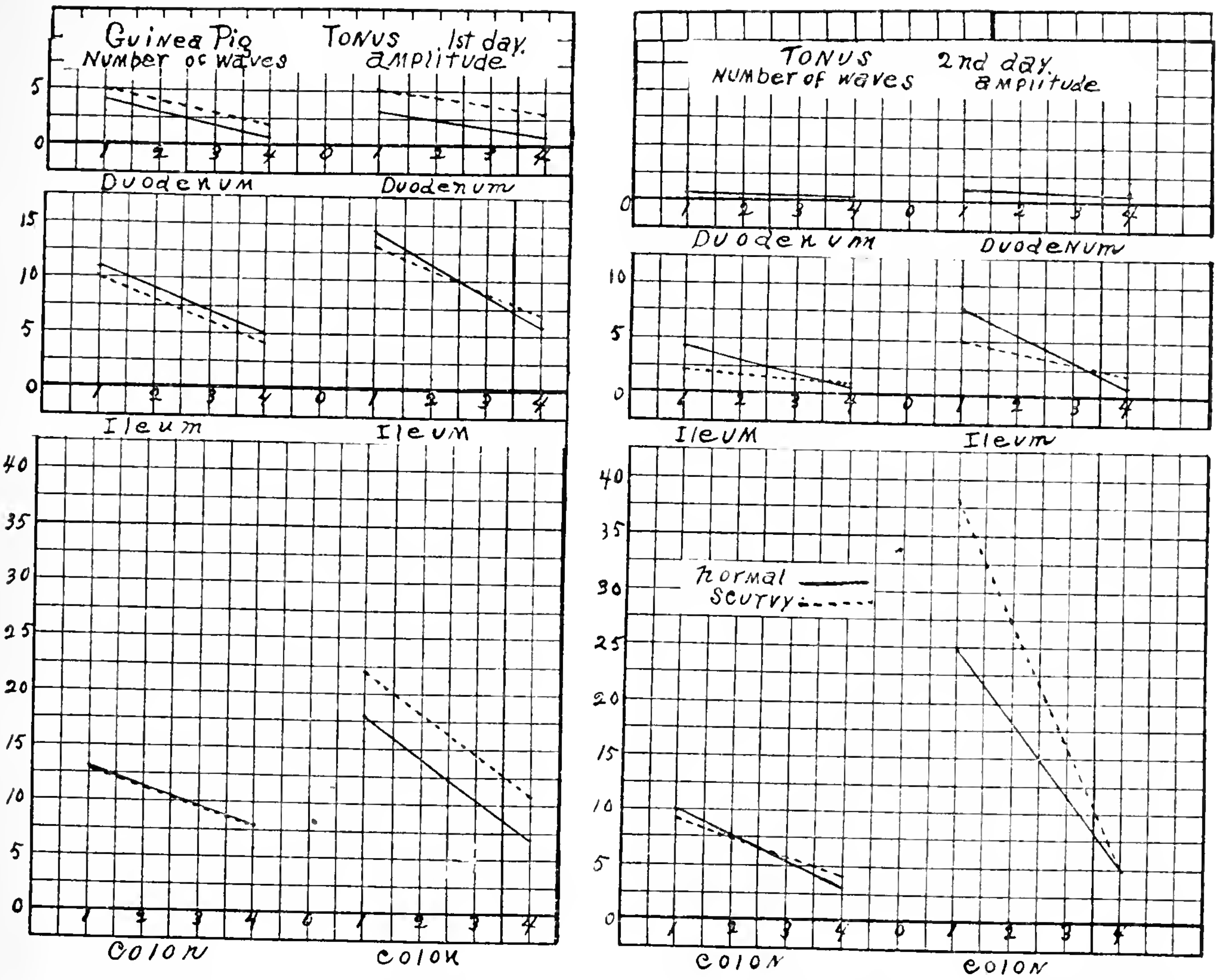


Chart VI.—The excised strips of the scorbutic duodenum and colon the first day show an increase in both number and amplitude of tonus waves for the first and fourth hours. The reverse is true in the scorbutic ileum.

The second day, the scorbutic colon showed marked hypermotility.

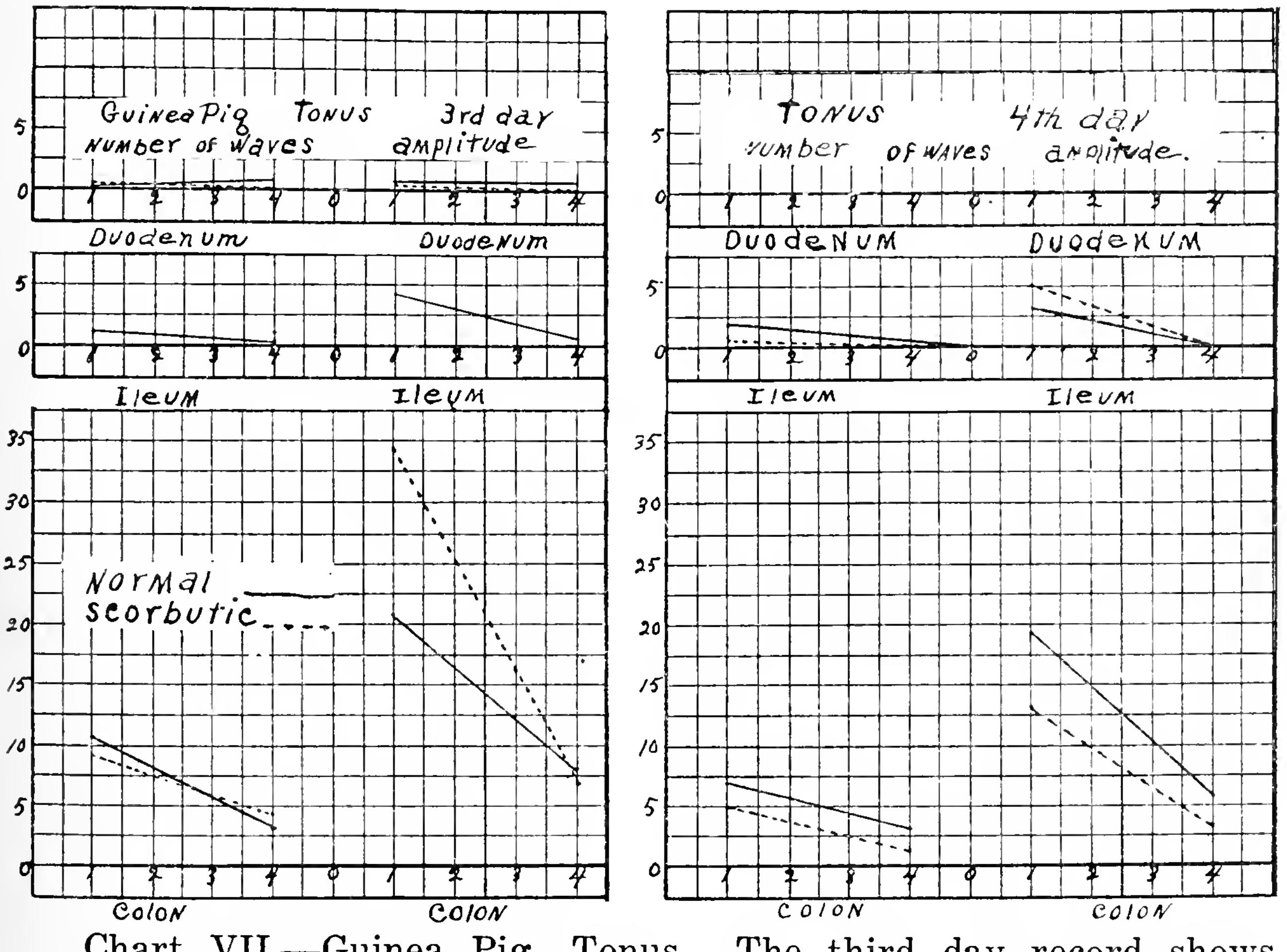


Chart VII.—Guinea Pig—Tonus. The third day record shows marked hypermotility in the scorbutic colon. There was no duodenal activity the fourth day. The normal colon strips showed more tone than the scorbutic.

THE LIGNEOUS FLORA OF RICHLAND COUNTY, ILLINOIS.

By Robert Ridgway, Olney, Illinois.

[The following is an abstract of a paper based on material collected during the years of 1914 to 1927, inclusive, and identified by the leading botanical authorities.]

Why investigation of the flora in certain parts of the United States has been so long neglected by botanists is little short of a psychological puzzle. The geographic distribution of plants is certainly an important part of botanical science; yet it is a common experience of local botanists to find that knowledge of this subject is very far from being exact. Two instances among the many that have been encountered by the writer will be sufficient to prove this assertion: Gray's "Manual" (seventh edition), Britton and Brown's "Illustrated Flora," and all other authoritative text-books on the botany of the Eastern United States that have been consulted, ascribe to *Viburnum dentatum* an extreme northeastern range, Michigan being given as its southwestern limit; yet that species has an extensive range over the central Mississippi Valley, occurring as far southward as the extreme southern portions of Illinois and Missouri; while *Malus platycarpa hoopesi,* which was known only from cultivated trees as recently as the date of publication of the second edition of Sargent's "Manual of the Trees of North America" (1922) occurs, rather plentifully, as an indigenous tree in Richland County, Illinois, as does also *M. angustifolia,* a southern species, not previously recorded (authentically) from farther northward than Pope and Johnson counties.

Few botanists seem to realize that natural conditions are changing so rapidly, not only in the more densely populated agricultural sections but also in parts less thickly settled, that it will soon be too late to ascertain the composition of the indigenous flora, indeed is already too late in many parts, where a greater or less number of the native plants are gone forever; others are so completely established by naturalization that it is now sometimes impossible to know whether a species is really indigenous or not. The transformation of the country through deforestation, drainage, cultivation, pasturage, burning, and other agencies, the greater part of which has occurred within the memory of persons now living, is in some instances so profound that an individual born seventy-five years ago who left his home in childhood or early manhood would now scarcely recognize the country of his nativity.

The following remarks by Mr. Chas. C. Deam, State Forester of Indiana, will apply equally well to this portion, at least, of Illinois:

"The acquisition of additional data is rendered difficult or impossible, because 90 per cent of our area has been cleared. The original distribution of any species in Indiana can now be approximated only. The composition of our flora a few centuries hence can only be conjectured. No doubt several of our native species have already disappeared, and many more are doomed to extinction, because destructive agencies such as the cow and hog, axe and plow, and the steam dredge are ever busy. . . . Already the opportunity for obtaining data on the plant life of our prairie has gone. The opportunity for making a record of the original plant life of the barrens of Indiana has forever passed. The opportunity for acquiring a complete knowledge of the dune and lake flora is rapidly disappearing. When we motor over our improved highways among the fields of our alluvial bottoms, if we pause long enough to think, we will realize that the once virgin forest with its numerous native plants has disappeared forever." (Proc. Indiana Acad. Sci., Vol. 34, 1924 P. 39.) And this extract from a letter, dated April 22, 1918, from the late Dr. C. F. Millspaugh, Botanist of the Field Museum of Natural History, will show the need of botanical exploration in this portion of Illinois.

"I hope that you will be able to continue your very interesting and effective collecting and that this Museum may further benefit thereby. The more we work on the Illinois Flora the more we appreciate not only that there is deep need of the result that we hope to attain, but that the state has been all too meagerly worked in its most promising regions."

When Richland County was first settled the forests covered certainly much more than half, possibly as much as two-thirds, of the total area; but they are now reduced to about one-tenth, and of this remnant only 160 acres remain in a condition approaching that of the virgin forest. Such extensive deforestation within so short a time necessarily means the total extirpation of some of the more local trees, shrubs, and other plants; while drainage of swamps or marshy areas, grazing, and forest fires, have also contributed to this loss. The original prairie flora is practically gone, only small remnants remaining here and there, mostly along roadsides and fence-rows, where annual mowing and burning is steadily reducing not only the area and number of such remnants but the number of species composing them. Such places are, in fact, the last refuge of many native plants, both ligneous and herbaceous, chiefly species of the open country and margins or outskirts of the woodlands. One of these, the Chicasaw plum *(Prunus angustifolia)*, plentiful up to ten years ago, is now difficult to find; two of the wild crab-apples *(Malus lancifolia* and *M. platycarpa hoopesi)* have become relatively scarce, and the hawthorns *(Crataegus)*, while still fairly numerous, are widely scattered and far less abundant than they were a decade ago. Even from the woods themselves several species have practically disappeared. The writer has been able to locate, after ten years' search and inquiry, only three linden trees *(Tilia)* one beech tree, and two Kentucky coffee-trees *(Gymnocladus)* in the county.

Fifty years ago the cane *(Arundinaria macrosperma)* formed extensive and in places nearly impenetrable thickets in the bottoms of the Little Wabash and Fox rivers, and before the settlement of the country probably occupied the bottomlands of most of the streams. At the present time, however, every vestige of the cane has disappeared except in two areas of very limited extent. The mistletoe *(Phoradendron flavescens)*, once abundant, is now exceedingly rare, its scarcity being partly due to the disappearance of most of the mature trees of its principal host the common elm *(Ulmus americana)*. The white pond-lily *(Castalia odorata)* was once plentiful in Mutrie Slough and other similar places, but these have been drained and the aquatic plants have, of course, disappeared.

Recognizing the urgency of prompt action, the writer has, during the past twelve years, devoted as much time as could be spared from other duties to the collecting of specimens of the now existing flora. Unfortunately his opportunities have been relatively few and available at irregular intervals, so that nothing like a systematic exploration has been possible; and consequently it is practically certain, when it is considered that so many species are more or less local, and that not more than 50 of the 670 (approximately) separate areas of woodland in the county have even been set foot in, that a considerable number could be added to this list.

The author's chief interest being in the woody plants, these have naturally received the most attention. Of herbaceous plants, only the grasses and sedges have received anything like special attention; as to the others, the genera *Aster* and *Solidago* are fairly well represented in the author's collection; the aquatic flora has been completely neglected, and it may be said that as to non-ligneous plants in general he has barely "skimmed the surface."

So far as the writer is aware, the only catalogue of the plants of southeastern Illinois north of the Ozark Uplift is Dr. Jacob Schneck's "Catalogue of the Flora of the Wabash Valley below the Mouth of White River", published in 1876 (Cox's Geological Survey of Indiana, volume for 1875, pp. 504-579), in which are listed 867 species of plants. Unfortunately, Dr. Schneck did not, in most cases, specify whether a given species was collected on the Illinois or the Indiana side of the Wabash River; neither did he distinguish between indigenous and naturalized species. From the writer's intimate acquaintance with Dr. Schneck, whom he often accompanied on his collecting trips, he is prepared to state that by far the greater part of the material on which the catalogue was based was collected in Wabash County, Illinois.[1] While very incomplete, from lack of time for thorough investigation of the local flora, Dr. Schneck's catalogue is nevertheless a most interesting and valuable

[1]Dr. Schneck was a physician with a large country practice, and most of his botanizing was done during visits to his patients in the country districts about Mt. Carmel.

contribution, especially from the standpoint of geographic distribution. His list includes twenty-two plants that were, at that time, far out of their known range, most of them being of southern distribution. A posthumous addition to Dr. Schneck's catalogue was published in 1911 (Proceedings of the Indiana Academy Science, 1911, pp. 365-369) by Mr. Chas. C. Deam, State Forester of Indiana, compiled from annotations in Dr. Schneck's handwriting in a copy of the original catalogue. In this paper 150 species are added to the list, making a total of 1017 species; but in this case also there is no indication, except in a few instances, of whether a particular species was found in Illinois or in Indiana.

In 1882 the present writer's "Notes on the Native Trees of the Lower Wabash and White River Valleys, in Illinois and Indiana" was published (Proc. U. S. National Museum, V. pp. 49-88). In this were enumerated, with annotations, 92 species of trees. The following year "Additions and Corrections to the List of Native Trees of the Lower Wabash" appeared (Botanical Gazette, VIII, Dec., 1883, pp. 345-352), and eleven years later, "Additional Notes on the Native Trees of the Lower Wabash Valley" (Proc. U. S. National Museum, XVII, 1894, pp. 409-421, pls. 10-14), both by the same author. All these were based, like Dr. Schneck's catalogue, on observations made on both sides of the Wabash, but chiefly in Wabash County, Illinois, and, like Dr. Schneck's catalogue, these papers were not sufficiently explicit concerning localities where the species mentioned were observed.

No mention seems to have been made of any plants of Richland County until 1921, when a most interesting and instructive paper by Mr. Ernest J. Palmer, entitled "Botanical Reconnaissance of Southern Illinois" appeared (Journ. Arnold Arboretum, 11, Jan., 1921, pp. 129-153). Although Mr. Palmer's paper was based essentially on investigations in the extreme southern counties (Union and Alexander to Gallatin), reference is made, among the 204 species of ligneous plants included in the paper, to 10 species observed in Richland County.[1] The following year

[1]The species mentioned by Mr. Palmer as having been seen by him in Richland County are: *Arundinaria macrosperma*, *Salix humilis rigidiuscula*, *Quercus lyrata*. X*Q. tridentata*, *Rosa palustris*, *Acer rubrum drummondi*, *Cornus stricta*, *Fraxinus profunda*, *Catalpa speciosa*, and *Viburnum dentatum*.

11 additional trees were accredited to Richland County in the second edition of Professor Sargent's "Manual of the Trees of North America", these being *Quercus borealis maxima, Q. runcinata, x. Q. exacta, x. Q. saulei,*[2] *Ulmus alta, U. serotina, Malus lancifolia, Crataegus phaenopyrum, Prunus lanata, P. munsoniana,* and *Fraxinus biltmoreana,* these records being based on material sent to Professor Sargent by the writer.

The collections and observations made by the author in various parts of Richland County, mostly since 1914, have, as previously stated, been made at irregular intervals, opportunities for the work being relatively few and brief. Nevertheless the best possible use has been made of the little time that was available, and nearly 2900 numbers, mostly of ligneous plants, have been collected. While extreme points in the county, except the northwest corner, have been visited, it has not been possible to make anything approaching an exploration of the entire area; indeed only about 5½ per cent of the separate wooded areas in the county have been explored. It is, therefore, evident that very much remains to be done before our knowledge of even the ligneous plants of Richland County can be anywhere near complete.

Except in the case of plants that are common and well known, or so distinct as not to require the dictum of experts, all the identifications are by leading botanical authorities. Most of the ligneous plants were determined by Professor C. S. Sargent or, during his illness, by Mr. E. J. Palmer (at the Arnold Arboretum), both of whom have been most kind and obliging. A series of the *Crataegi* (124 numbers) has been examined and, in part named, by Mr. W. W. Eggleston, assistant botanist in the Forest Service and Bureau of Plant Industry, U. S. Department of Agriculture. The grasses were identified by Professor A. S. Hitchcock and Mrs. Agnes Chase; other herbaceous plants mostly by Dr. B. L. Robinson, Dr. Wm. Trelease, Dr. J. N. Greenman, and the late Dr. C. F. Millspaugh; while a considerable collection, made several years prior to 1914 and deposited in the National Herbarium, was

[2]This, however, is an error, since *Q. montana*, one of the parent species, *XQ. saulei* being a hybrid of that species and *Q. alba*, does not occur in Richland County, the nearest point where it is known to grow indigenously being in Martin County, Indiana, about 60 miles farther east.

named by Mr. Paul C. Standley and Mr. E. S. Steele. Mr. B. F. Bush, of Courtney, Missouri, has rendered valuable help in determining certain forms of *Celtis, Fraxinus, Hypericum, Rosa, Tilia, Ulmus* and *Viburnum.*

A considerable part of the material sent, several years ago, to specialists for identification has not yet been reported on; consequently many species of herbaceous plants that might have been included in a catalogue of the Richland County flora must be omitted. This difficulty in obtaining authoritative identification of specimens has been a serious obstacle, wholly unforeseen and unexpected, and is much to be regretted.

The greater part of the material collected by the author in Richland County is deposited in the National Herbarium, the Gray Herbarium, and the herbaria of the Arnold Arboretum, the University of Illinois, the Field Museum of Natural History, and the Missouri Botanical Garden. The author has retained a set of the ligneous plants (except of the earlier collections) for reference.

As a result of the author's studies of the trees and shrubs of Richland County one fact stands out with great clearness; namely, that certain genera are, so far as their component forms are concerned, so little understood as to be in a condition little short of chaos, attempts to identify the species by any of the standard text-books being useless, because their satisfactory determination thereby is in many cases simply impossible. Such genera as *Cornus, Crataegus, Malus, Rosa, Rubus, Salix, Smilax,* and *Vitis* have certainly not been satisfactorily worked out; and the same, although perhaps to a less degree, may be said of *Carya, Amelanchier, Acer, Fraxinus, Tilia, Ulmus,* and *Viburnum.* Of these genera certain species, of course, are so well characterized that no difficulty is found in their identification; but others do not (at least so far as this region is concerned) conform to any of the species as described by standard authorities, or else agree equally well with more than one. The difficulty encountered by the writer in such cases he might himself attribute to his own inexperience or incompetence were it not for the fact that in forms of nearly all the genera named above he has received from leading botanists (sometimes from the same one), on different occasions, two or even three, determinations for the same thing, based sometimes on specimens from the same individual tree or shrub.[1]

Only a brief statement can be given here as to the composition of the Richland County flora, as far as it is known. Of the total of 907 species and varieties that have been thus far identified, 216 are woody plants, the families most numerously represented being as follows:

Malaceae	42
Fagaceae	18
Salicaceae	16
Juglandaceae	15
Rosaceae	14
Aceraceae	12
Caprifoliaceae	10

The genera with the greatest number of species and varieties are:

Crataegus	31[2]
Quercus	17
Salix	14
Carya	13
Acer	11
Malus	8

In order to determine the life-zone relationships, or position, of Richland County, and especially to ascertain the extent to which its vegetation may be affected by the "climatic handicap" (as compared with an area of cor-

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[1]Since the above was written the author has read an excellent paper by a well-known botanist from which the following is quoted. "Every complex genus in our Flora needs further elaboration. Among such may be mentioned Aster, Carex, Cyperus, Meibomia, Panicum, Quercus, Rosa, Rubus, and Viola. In fact there is scarcely a genus but which on critical examination presents surprises. Species have been misunderstood; strange species from the outside are found in our midst; even distinct undescribed species are not rarely brought to view." (Taxonomic Botany and the Washington Botanist. By A. S. Hitchcock, Bureau of Plant Industry; Journal of the National Academy of Sciences, Vol. VII, No. 9, pp. 251-263.)

[2]Many of the Crataegi are species previously known only from Southern Missouri. Two are new species, thus far known only from Richland County, having been described in 1925 (Journ. Arnold Aborstrun, Vol. VI, pp. 2, 3) by Professor Sargent. Some of the species included in the above enumeration have, however, been identified doubtfully or tentatively; but there are a considerable number of others, not included in the count, which have not yet been determined.

The forms of *Malus* include only one of doubtful identification. Among the others there are two of special interest, namely, *M. augustifolia*, a southern species heretofore recognized only in two of the extreme southern counties of Illinois (Pope and Johnson), and *M. platycarpa hoopesi*, a very distinct species, previously known only from cultivated trees. Both are not uncommon in Richland County.

The wild crab-apples and hawthorns are not only exceedingly difficult trees to understand, botanically, but, as "weed trees," are becoming scarcer each year. Therefore, in order to preserve as many of the forms of these two genera as practicable of the species indigenous to the county, and segregate them where they can be conveniently studied and compared, the author has been collecting them from "the wild" and transplanting them to Bird Haven, where there are now growing 119 specimens of *Crataegus* and 66 of *Malus*, besides 21 of the former and 8 of the latter that were already growing there when the land was purchased.

responding latitude near the Atlantic Coast), which is said to characterize the Middle West in general, it has, of course, been necessary to compare meteorological records for the two sections. This has been done by selecting nine Weather Bureau Stations in the Lower Wabash Basin and an equal number in the Middle Potomac Basin. The records for the former cover periods averaging 21.8 (19 to 38) years for temperature, and 28.1 (19 to 38) years for precipitation, those for the latter averaging 24.9 (13 to 46) years for temperature and 27.7 (13 to 48) years for precipitation,[1] the average elevation above sea-level of the former being 460.1 (384 to 500) feet, of the latter 237 (50 to 500) feet; all but three stations (one Wabash and two Potomac) being between the parallels of 38° and 39°, and these exceptions barely outside those limits.

Careful comparison of these records shows that the climatic difference between these two regions is in reality not greater than that between almost any two stations in either region, and that, so far as the Lower Wabash Valley is concerned, the alleged "climatic handicap" is rather insignificant and practically negligible as a factor affecting plant life.

The comparison shows that the Lower Wabash Basin has an excess of heat for the six warmer months amounting to 12° (by monthly averages) and for the six colder months a deficiency of 4.8°; that the mean maximum temperature averages higher for every month but three (December, January, and February), the deficiency for these amounting to 3.5°; that the mean minimum temperature also averages higher for every month but two (January and February), the deficiency for which is only 1.5°; and that while the highest recorded temperature is 4° higher (113° against 109°) the lowest recorded temperature is actually 1° *less* (—25° against —26°). As to seasonal averages, the Lower Wabash Basin shows an excess of heat amounting to 1.8° for Spring, 1.7° for Summer, and 1.4° for Autumn; and a deficiency of only 0.8° for Winter. The average date of the first Killing frost (or temperature of 32°) is exactly the same for the two regions (October 20); while that of

[1]For precipitation the average of 12 stations in the Lower Wabash Basin has been computed but only 9 for the Middle Potomac Basin, the records for one of the latter covering too short a period (6 years only).

the last Killing frost in Spring is three days earlier in the Lower Wabash Basin (April 15 against April 18).

As to precipitation, the Lower Wabash region shows an excess for each month except July and August, the total excess (by monthly averages being 3.34 inches, the deficiency for July being 0.30 and that for August 0.21 of an inch; the total amount for the year averaging 41.89 inches against 38.85 inches for the Middle Potomac region.

While collections of the local flora are far from being complete they have covered the ground sufficiently to indicate pretty clearly the position of Richland County in relation to life-zone areas. The following enumeration does not include several forms which at present are of doubtful status on account of insufficient material; should these prove to have been correctly identified (for example *Ulmus serotina*) they would increase considerably the number of species of southern range.

By species of northern, southern, or eastern range is meant those whose mass distribution is distinctly in the direction of those points of the compass. Those considered of central range are mainly if not strictly limited, as indigenous plants, to the Mississippi Valley, as a whole or in part, though a considerable number of these extend so far southward as to reach the Gulf States or, in some instances, even Florida, and therefore might almost as well be included with those of southern range; indeed, in some instances it is hard to decide as to the category in which a species should be placed.

Ligneous Plants of Richland County.

Species of northern range	13
Species of southern range	38
Species of central range	56
Species of eastern range	1
Species of general range	108
Total number	216

The herbaceous flora of Richland County is, as already stated, very imperfectly known, nevertheless, so far as the species have been determined they show approximately the same relative proportions as the ligneous plants.

Herbaceous Plants of Richland County.

Species of northern range	59
Species of southern range	73
Species of central range	66
Species of eastern range	7
Species of general range	(486)[1]
Total number	691

[1]This number, however, includes many naturalized species, the elimination of which is prevented by lack of time.

A statement of the number of identified herbaceous species and varieties in each family that have been collected to date in Richland County may be of interest. They are here given in numerical order:

Compositae	100	Cichoriaceae	16
Poaceae	83	Violaceae	13
Cyperaceae	60	Asclepiadaceae	13
Fabaceae	30	Ammiaceae	12
Labiatae	22	Polypodiaceae	11
Scrophulariaceae	22	Cruciferae	11
Polygonaceae	21	Solanaccae	11
Ranunculaceae	17		

(All the other families are represented by less than 10 each. This enumeration also includes naturalized as well as indigenous species.)

The genera represented by 10 or more species are the following:

Carex	46	Viola	13
Aster	18	Panicum	12
Solidago	14	Asclepias	10

MODIFICATIONS AND ASSOCIATED STRUCTURES OF THE FIRST THREE VERTEBRAE IN THE BUFFALO FISH ICTIOBUS URUS.*

L. A. ADAMS.

There is a very striking modification of the first three vertebrae in the Cyprinodont fishes, correlated with the swim-bladder and also with the Weberian ossicles, a small chain of bones connected with a hydrostatic function. The modification consists of a great enlargement of the parts of the vertebrae to form a large neural spine region, the Weberian ossicles, a very large and specialized haemal rib structure which supplies a support for the ossicles, cavities for the blood vessels and an anterior base for the swim-bladder. These parts of the vertebrae have been so modified that it has been necessary to study their embryological development to determine their exact homologies, and in some cases, there is still doubt as to their exact origin. This modification of the vertebrae and the development of the ossicles is characteristic of the Cyprinodont fishes, occuring in no other group. Hydrostatic organs exist in other fishes, but they function in a different way and without the aid of special skeletal changes.

The first vertebra is not greatly modified except in the antero-posterior compression of the centrum, which makes this part thin and disc like. A long, thin process extends out from the centrum, paralleling and closely appressed to a similar structure from the second vertebra. The dorsal fact of the centrum is marked by two deep pits that serve as articulations for the ventrally projecting processes of scaphium, the second Weberian ossicle. (Figs. 1, 3 and 4.)

The first vertebra has neural arches but no development of a neural spine. The claustrum, the first Weberian ossicle, is articulated with the antero-ventral face of the neural arch, while the antero-dorsal face articulates with the skull.

The second vertebra is much more modified than the first, with a large neural spine, a strong lateral process and

*Contributions from the Zoological Laboratory of the University of Illinois, No. 313.

highly specialized haemal process and spine. The neural arch projects anteriorly and supports the neural arch of the first, while the neural spine is much enlarged, heavy and broad at the base with a greatly expanded neural spine that is as long as the centra of the three vertebrae. The principal function of this spine is in supplying surface for the muscles. The haemal process is broad and long with a strong attachment to the centrum. This process joins a similar process from the third vertebra to form the expanded haemal structure. A transverse process extends out laterally, paralleling a similar process from the first vertebra. The neural arch supplies the principal articulation for the neural arch of the first vertebra and at its anterior region, supplies an articulation for the third Weberian ossicle, the intercalarium. (See Figs. 3 and 4.) The lateral surface of the centra of both the second and the third vertebra, serve as an articulation for tripus, the fourth ossicle which works on these centra, using them as a fulcrum.

The third vertebra is marked by a long spine from the neural arch, which is pushed posteriorly by the spine of the second. The neural arch is wide but the spine is thin, narrow and closely joined to the posterior face of the second. The haemal process joins with the same structure of the second vertebra as before mentioned, thus forming a large ventral bone with expanded sides. (Figs. 4 and 5.) A pair of small processes are directed posteriorly to aid in the association of the Weberian ossicles with the swim bladder and to form a passage for the blood vessels. This process extends to the posterior end of the fifth vertebra. Laterally the haemal processes of the second and third vertebrae fuse and form a ventrally projecting, triangular structure with a V shaped trough which extends to the ventral end of the bone. The dorsal end is forked in its origin from the two centra. The anterior face is large, irregular and deeply concave. The pharyngeal structures extend into this concavity, while the lateral wing is attached to the posterior face of the cleithrum by muscle. Just ventral to the centra there is a large haemal passage.

The posterior face is much more irregular than the anterior and more varied in its architecture. (Fig. 5). The haemal process extends laterally from the third vertebra, joining a corresponding process of the second. From the latero-ventral region of the third, a part of the haemal process extends ventrally, to form a process that extends along the ventral side of the centra, while a small wing extends ventrally to join the extension of the haemal structure. Two large, lateral fenestra supply openings, through which the most posterior of the Weberian ossicles extend, to come in contact with the swim bladder, while on the median line there is a bony covered passage way for the return of the veins from the head region. (See Fig. 5). Posterior to the three modified vertebrae, the rest assume normal shape and conditions.

Weberian Ossicles.

The Weberian ossicles consist of a small chain of three or four bones that in all Cyprinodonts, lie along the centra of the first three vertebrae. They were first seen by Rosenthal, but they were first described by E. H. Weber in 1820, in a now famous paper entitled "De aure et auditu hominis et animalium." Weber considered the bones homologous with those of the mammalian ear and used the same names in their description, but later study showed that they were different structures and not homologous, so different names were supplied for them. It was shown that the chain is connected with the semicircular canals of the ear and it is now assumed that they have a part in a hydrostatic function, by which the fish is informed of changes in pressure in the swim-bladder. Thilo calls the apparatus a manometer and thinks that the pressure is applied through the bones to the fluids of the brain and spinal cord, where the sensation is registered. It is difficult to see just how this would work and also to determine what special receiving organs would get the sensation through this channel. The Weberian ossicles usually consist of a chain of three or four small bones, the claustrum the most anterior, then follow the scaphium, intercalarium and the tripus. (See Fig. 3.)

The most anterior of the chain, the claustrum, is attached to the neural arch of the first vertebra, facing ventrally and slightly to the posterior. It is firmly sutured to the neural arch so that there is no possible movement, although the suture lines are retained even in very old specimens. The bone is cupped, with expanded lips that meet a similar face on the scaphium. The lips of the two bones meet in a close articulation except for a small opening on the inner side which may be correlated with the hydrostatic function. The origin is not settled, but it is generally considered as having its origin from the skull vertebra according to Goodrich and Nusbaum. Wright considers it as a modification of the spine of the first vertebra. (Fig 2.)*

Scaphium, the second bone of the series, articulates with the claustrum. It also is cup shaped with expanded lips so that it can be closely appressed to the claustrum, or drawn away as the pressure on the swim bladder increases. It has a peg like process on the ventral side which fits, into a corresponding depression on the dorsal side of the centrum of the first vertebra. (Fig. 2.)

When there is a movement of the ossicles, it is on this bearing that the scaphium moves. A ligament attaches it to the intercalarium and finally to tripus.

The third bone of the series, the intercalarium, is a small splint of bone that extends from the ligament that joins the scaphium and tripus, to the anterior part of the centrum of the second vertebra. It serves as a brace for the chain of bones in the ossicle series and holds the bones out from the neural processes. Its origin is the first neural arch according to Goodrich, but others derive it from the neural arch of the second vertebra. It is the incus of Weber. (See Figs. 3 and 4.)

The fourth and the most conspicuous of the ossicles is tripus, which connects the ossicles directly with the swim-bladder. It is a flat, blade like bone, narrowed at the ends, with the anterior end in contact with the other members of the series, through a connective tissue band, while the posterior end is connected with the swim bladder. On the inner or mesial face there is a large bearing at right angles to the main bone, that serves as the bearing for the articulation with the centra of the second and third vertebrae. Extending posteriorly, it passes under the haemal arches of the third vertebra, and comes in contact with the anterior end of the swim bladder. (Figs. 3 and 4.) The bone is nicely balanced on its bearing so that a very free movement is possible, and a slight change in the density of the gas in the swim-bladder will cause a movement of tripus and through it, a movement of the whole series. The origin is given by Goodrich as a modification of the first rib, while Sagemehl gives it as a modification of the third rib.

Mechanically, the Weberian ossicles are beautifully adapted for the purpose that seems to be theirs, of giving the animal notice of changes in depth and consequently of changes in pressure. Correlated with these structures, in the adaptation are the first three vertebrae, which aid in the mechanism by first supplying the material from which the ossicles are made and secondly by developing speciliazations of their parts that will assist the ossicles in performing their function. In no other group is the modification of the vertebrae so striking as in the genus Ictiobus.

While these structures have been studied for years it is quite evident that much remains to be done on them, before they are thoroughly understood. Both developmental and experimental studies should be used to add to our knowledge of the origin of the parts and to clear our ideas of the function of the whole apparatus.

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Legend.

Fig. 1 Lateral view of the first three vertebrae showing the ossicles. A part of the haemal arch is removed. X⅔.

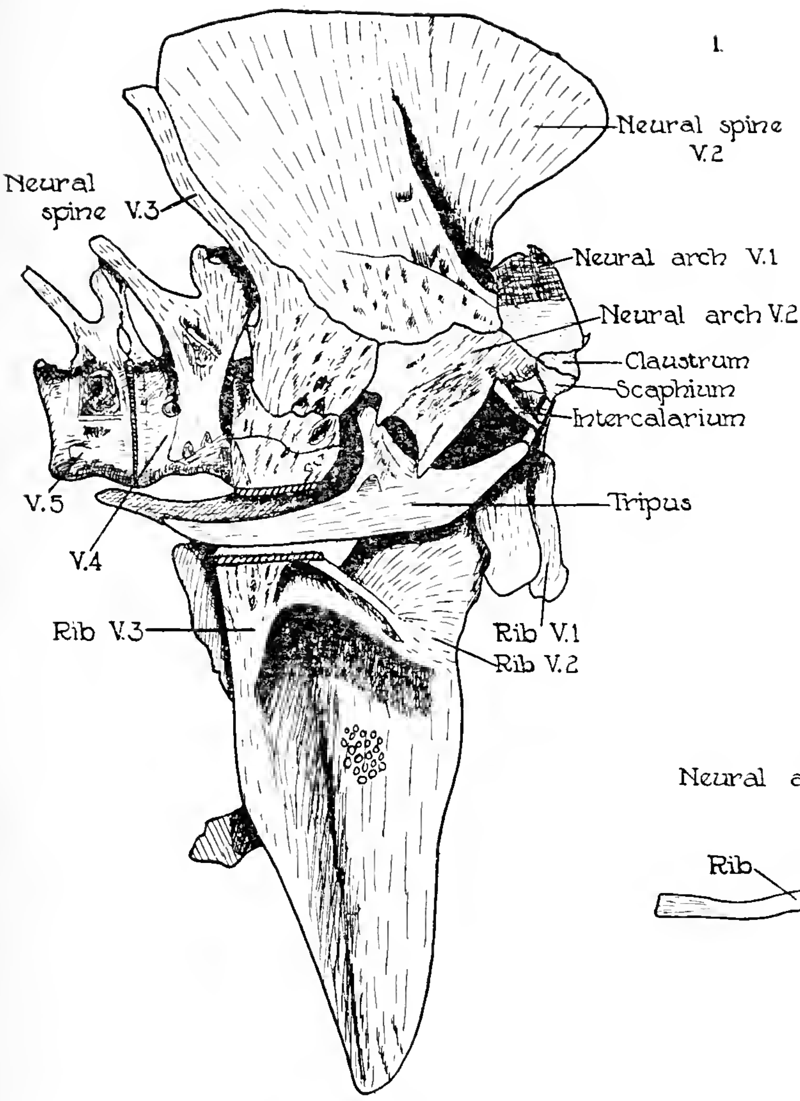
Fig. 2 Dorsal view of the right scaphium. X5.

Fig. 3 Anterior view of the first vertebra showing the position of the claustrum and scaphium. X⅔.

Fig. 4 Posterior view of the third vertebra, showing the relation of the structures in this aspect. X⅔.

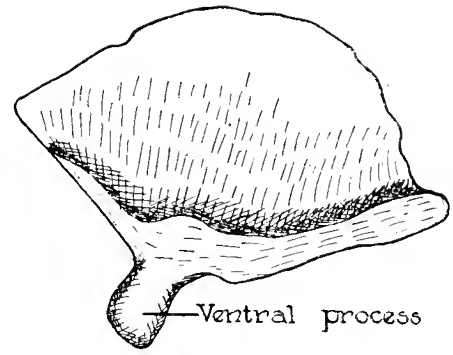
Fig. 5 Lateral view of the Weberian ossicles, showing the bones in position. Left side. X5.

1.



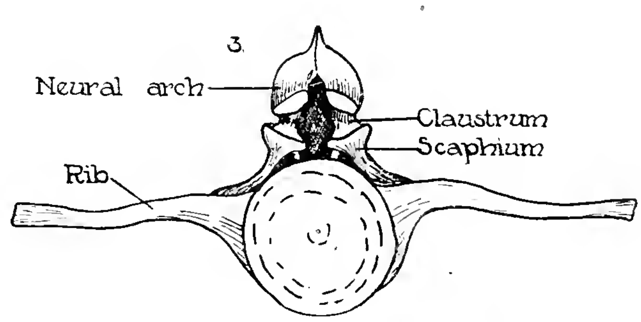
Neural spine V.2
Neural spine V.3
Neural arch V.1
Neural arch V.2
Claustrum
Scaphium
Intercalarium
Tripus
V.5
V.4
Rib V.3
Rib V.1
Rib V.2

2.



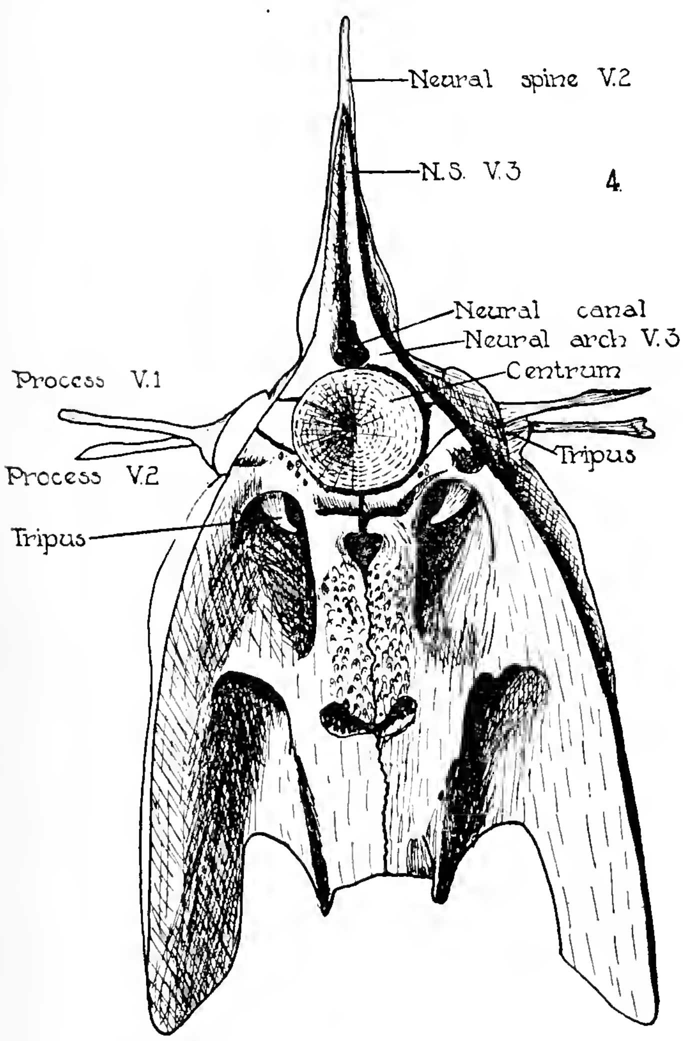
Ventral process

3.



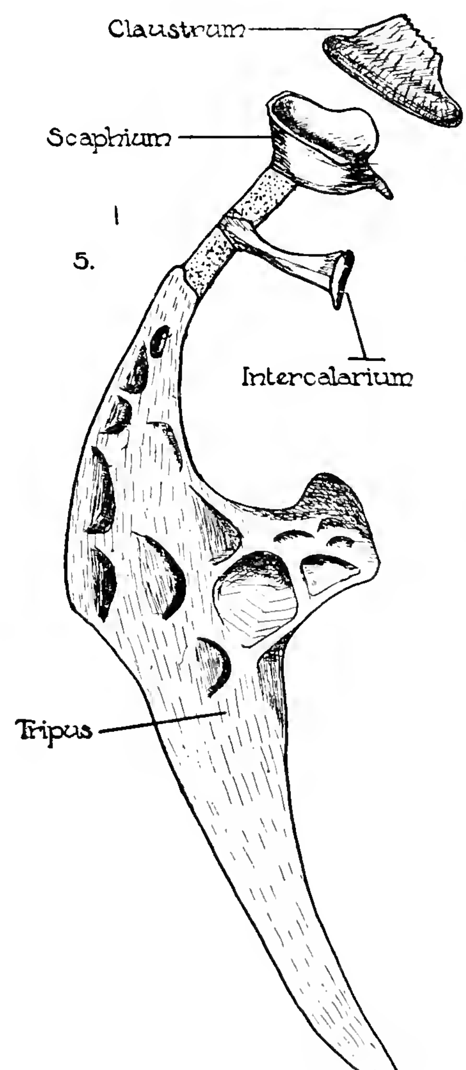
Neural arch
Claustrum
Scaphium
Rib

4.



Neural spine V.2
N.S. V.3
Neural canal
Neural arch V.3
Centrum
Process V.1
Process V.2
Tripus
Tripus

5.



Claustrum
Scaphium
Intercalarium
Tripus

WHAT HIGH SCHOOL STUDENTS EAT.

Clarence Bonnell, Township High School,
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Why are we "too fat" or "too skinny"? This is a vital question for many high school girls, and some boys, to say nothing of older maidens, middle aged matrons and some gentlemen, of either the rotund or the bean pole type. What does the quantity of food eaten have to do with this momentous question?

Not in the hope of adding much, if any, new information to what has already been scientifically demonstrated, but more with a view to learning whether the girl, already underweight and anemic, who is starving herself even now against the day when she *may* be too stout, is or is not striving against fate, we undertook to gather the following data.

A class of one hundred-twenty second year biology students averaging nearly sixteen years in age were asked on a certain Wednesday to record as they came to the laboratory the various portions of food consumed during the preceding twenty-four hours. Kinds and amounts eaten at breakfast, the noon lunch, supper, and between meals were listed separately. There were sixty-five girls and fifty-five boys. They came from the homes of merchants, miners, railroad workers, farmers and professional people. They represented the average family of a prosperous community. Wednesday was chosen to avoid irregularities in diet due to week end social activities.

A high class cafeteria is maintained in the school. The majority get their noon meal there. Some go home for lunch and others bring all or part from home. Of course the food was not weighed but each item was carefully estimated as to amount, and its food value in calories was estimated by use of standard tables, the calories from fat, carbohydrate and protein being listed separately. The data do not represent precisely any one child's actual food consumption, but we believe the errors above and below normal in both the amount consumed daily and in estimation of calories are such that we get an average that has value. In most cases the students said that the record represented fairly well their average daily consumption.

It is apparent, from questions put to this class, from studies made with other classes, from observations made in the cafeteria where three or four hundred students eat daily and from the observations of restaurant and hotel people, that most individuals and most families fall into a routine as regards the kind and quantity of food used. When you know the person or the family you can guess with reasonable accuracy what will be ordered and eaten at the next meal. So intent are students on getting the thing to which they are accustomed that they pass by without notice some foods which are served frequently such as loganberries or figs in sirup. Some students were unaware that such foods had been before their eyes at meal time. So we think and many of the students said that this snap shot at their daily food habits is a fairly good likeness.

In this connection other facts appeared. A surprising number of students had never tasted foods which are more or less commonly used in other families, such as mackerel, codfish, asparagus, rhubarb, okra, turnips, dried beef, veal, currant jelly, gooseberry pie and even the meat of turkey. Strange to say, many expressed a positive (imaginary of course) dislike for foods which they admitted they had never tasted. These and other illustrations too numerous to state here point to the fact that the average American when he is at his regular eating place uses food that varies little more than the rations of an army or the menus of charitable or penal institutions. The good wife may plan and stew both literally and figuratively to get up something new but the fact remains that she and her family after all stick to much the same substantial fare.

Our record of the sixty-five girls and fifty-five boys shows that eight girls and none of the boys omitted breakfast. Seven girls and one boy did without lunch at noon. Two boys and three girls went without supper. Forty-two boys and sixty-two girls ate between meals. Some of the reasons for omitting meals were trivial. Some likes and dislikes for certain foods grew from chance impulses. Insistence on the part of parents that certain foods should be eaten grew into positive dislikes on the part of the child. One boy always drinks much water with his meals at home but takes no water with his lunch at school. His mother keeps his glass full at home, but he must stop at the cafeteria fountain to fill his glass at school so he goes without. Those in charge of the young in the development of their food habits might profit by more scientific inquiry into why we eat what we do eat. What a multitude of parents would rise up to call him blessed who could point the way to prevent children from being "finicky" about their eating!

Our grand totals for the one hundred twenty young people show 67,649 calories supplied by the breakfasts, 70,796 at noon and 91,291 at the evening meal. To this we add 38,449 calories from the candy, cake, fruit, bread, meat, etc. eaten between meals, making a total of 268,352 calories for the day. Thus more than 14% of the food was taken between meals.

The averages per child are more interesting. They are, estimated in calories; for breakfast 564; for lunch 590; for supper 761; between meals 320; total 2,235 calories per day for each child. The average for boys is 2,612 and for girls 1,918.

Nine boys and eleven girls were more than five pounds overweight, and twenty-one boys and thirty-one girls were more than five pounds underweight. Getting down to the school girl's problem of what makes one "too fat" or "too skinny", we find that, of the nine boys who were overweight, five ate more than the average boy and four ate less. Of the eleven girls who were overweight, three ate more than the average and eight less. The evidence is slightly in favor of eating *more* if you would be slender.

Now, considering the fifty-two who were underweight, nine boys ate more than the average and twelve ate less. Fifteen girls who were underweight ate more than the average and sixteen ate less. Here the evidence is slightly in favor of eating *less* if you would be slender.

Considering extreme cases, four girls who were credited with more calories between meals than at any regular meal were little, if any, either overweight or underweight. This interferes with our theories concerning the importance of eating only at regular meal times, but the sting is less penetrating when we remember that these girls rather regularly eat much at certain times between meals. The girl charged up with more calories per day than any other girl, a total of 3,383, is very active, weighs ninety pounds and is nineteen pounds underweight. Another girl whose record is but 958 calories per day is twenty-eight pounds overweight. Still another who eats two meals a day and nothing between meals used but 1,042 calories and is 52 pounds overweight. A boy charged with 4,155 calories, more than any other boy, is but seven pounds overweight.

So far as our limited data indicate, the amount eaten has very little to do with whether one is stout or slender. Other influences such as heredity, sleep, exercise, regularity of habits and the variety and kinds of food used seem to have far more to do with the problem. However, careful note of the nutritive ratio was made with each individual, and there was little to indicate that even the kind of food had much to do with the weight. Just as often as otherwise, the child whose protein ratio was high was of good weight, and the eaters of starch and sugar were about as often as not thin. So most of us have decided to forget whether we are to be fat or skinny and to eat as much as we crave of those things which do not interfere with our comfort or health while we go about attending to those habits which we believe have more to do with our well being and comfort.

MARINE AQUARIA FOR HIGH SCHOOLS AND COLLEGES.

LYELL J. THOMAS, Zoological Laboratory, University of Illinois.

Living marine animals and plants for class use in biological laboratories far removed from the ocean are generally not even considered possible. Students in such laboratories see only preserved specimens or pictures. The University of Illinois zoological laboratory has had living marine animals shipped in from Woods Hole, Mass., for a number of years during the mid winter season. The animals generally lasted but a few days and were soon forgotten. The past four years an attempt has been made to keep these animals alive throughout the year and longer with marked success.

Sea water was shipped in barrels at a cost of about $8.00 per barrel but this was found to be too expensive and results obtained were not as good as synthetic water made according to Ditmar's formula which cost about $1.00 per barrel. Sea water made according to this formula can be made from either tap water or rain water. C. P. dry chemicals were used. The formula is as follows:

Sodium chloride	27.213 gm. per L.
Magnesium chloride	3.807 gm. per L.
Magnesium sulphate	1.658 gm. per L.
Calcium sulphate	1.260 gm. per L.
Potassium sulphate	0.863 gm. per L.
Magnesium bromide	0.076 gm. per L.
Calcium carbonate	0.123 gm. per L.

In making up sea water from tap water the amount of $CaCo_3$ contained should be known. In most cases this may be omitted from the formula. The tap water at the University of Illinois contained 10.22 gms. per gallon. This amount together with other impurities may be reduced by bringing the water to the boiling point and then allowing it to stand and cool. Excess carbonates settle to the bottom of the container and the supernatant fluid is siphoned off. The C. P. dry chemicals are added according to the proportions given in the formula and are allowed to dissolve. This water may be made up a year or more in advance if stored in tightly corked carboys, however it is best to start the aquaria some time in advance of the arrival of the animals.

Since the publication of a paper by Thomas (1925), considerable advance has been made in the handling of the animals upon their arrival. Shipments have been made from the Pacific as well as from the Atlantic. Animals sent from the Marine Biological Laboratories at Woods Hole, Mass., come in paraffin lined wooden buckets and may be shipped by express without danger of spoiling from November to March to any point in the Central States, although shipments have come through as late as June in good condition. If the aquaria are started with a shipment of Ulva or sea lettuce, Fucus, and eel grass several months before the animals are ordered they will be in better condition to receive animals.

Small aquaria 9″ x 9″ x 14″ with aluminum frames and slate bottoms have proved very satisfactory, although larger aquaria 29″ x 20″ x 18″ with alberine stone ends and bottoms have been better. The small aquaria have loose fitting covers to aid in cutting down evaporation. The use of covers on the large aquaria proved very unsatisfactory as the rise in temperature due to the covers was more detrimental than the cutting down of the evaporation. Loss from evaporation is made by the addition of rain water, sprinkling it on slowly to avoid a sudden change in concentration. When the synthetic sea water is first placed in the aquarium, about three-fourths full, a line is drawn to mark the water level. If rain water is added every few days so as to keep the water level fairly constant better results are obtained.

A layer of coarse wood charcoal covered with gravel and fine white filter sand helps to keep down gases formed from decomposition of organic materials and also gives a place of lodgment for burrowing forms. Bits of brick and shells scattered about on top serve as a place for attachment of plants and sessile animals.

The addition of one or two clams to each aquarium helps to purify the water. Red, brown, and green algae do well, especially Ulva. Practically all tide-pool life has been kept for a year or more, some forms for over two years. The heat of the summer months in the green house at the Vivarium where some aquaria are kept takes a considerable toll of life, but aquaria in the laboratory in windows on the north at a cooler temperature go through without much loss. A ten dollar order should be sufficient to supply a dozen aquaria. A twenty-five dollar order might give a greater variety but would necessitate a considerable waste unless spread out over two dozen or more aquaria.

The greatest temptation is to crowd too many animals into one aquarium. A typical grouping of animals might be cited taking examples from among fourteen in the vivarium. Aquarium No. 1, size 29″ x 20″ x 18″, has one star fish, two small sea-urchins, one sea cucumber, a sponge, a few serpulids or tube worms, a clam, a few Bryozoa, and corals, four mud snails and numerous small micro crustacea. The sea urchins have developed from larval forms brought in on the introduced Ulva. The sea cucumber has lived for over a year and has regenerated its entire internal organization. The beginner may want to throw out sea cucumbers that have cast their digestive apparatus due to excessive handling, however, if the viscera spewed into the aquaria are removed and the animal is not disturbed regeneration generally takes place. The star fish placed in the aquarium last fall has regenerated two new arms. No. 4 aquarium contains a sea urchin which has developed from the larval state, a sea anemone which has produced numerous small anemones by budding, corals which have spread and developed new colonies, tube worms which have laid their eggs and numerous young have developed and have become attached to the vegetation and to the sides of the aquarium, and Clava leptostyla another colonial coelenterate. No. 10 contains four fiddler crabs which have been living for over a year and six Limulus or horse shoe crabs. This aquarium is divided so that half of it is a miniature beach of fine white filter sand where the fiddler crabs tunnel and the horseshoe crabs bury themselves. Crabs should not be placed with other animals. Different species of crabs with large pincher feet should not be placed together. A shore crab was removed because of its canabalistic habits to another aquarium where on April 10 it was found laying eggs. Aquarium No. 2 contains barnacles, sea anemones, two clams, snails, serpulids and Nereis which have reproduced, and Syncoryne mirabilis, a colonial coelenterate which has spread over the glass of the aquarium. Two years ago Obelia commissuralis McCr. produced medusa or jelly fish which were observed by an entire class of over two hundred students. Recently Tunicates have developed and their colonies have spread about the aquarium. They make splendid demonstration specimens to show the reversal of the blood flow and represent the primitive tho degenerate Chordate.

In the balanced aquarium the feeding of the animals is not a problem. The production of micro crustacea is great enough to furnish the coelenterates with food. Crabs and star fish may be fed crushed snails sparingly once a month or the crabs and sea anemones may be given bits of raw beef or codfish on a stick. The codfish is prepared from a good commercial brand of the dried product by soaking it in running tap water for a half day. The sea water in which the animals are shipped should not be used for some time and then only after thorough aeration. However, the plankton which it contains should be strained off through a silk handkerchief or bolting cloth for sometimes it contains larval forms which may develop later to create new surprises.

The success of marine aquaria depends upon the prompt removal of dead animals, excess food, decayed vegetation, and white molds that may appear. Some aeration in addition to oxygen from growing plants is advisable. The appearance of turbid water or a foamy froth indicates animals are dying and should be removed. And last the interest and attention of the one in charge is necessary. For those who are interested in making biology a live subject marine aquaria are practical aids to this end.

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THE COATI.

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During September, 1925, a lone specimen of Coati mundis (Nasua narica) was killed near Lockport, Illinois. This mammal was discovered in a tree by a farmer named George Bump.

This Coati is a native of South America and Mexico, sometimes traveling across the border into southern United States. In South America they range as far south as Paraguay. They hunt in bands, several families running together. They live in trees and on the ground. They live on small animals, fruit and roots. The latter they obtain by digging with their badger-like feet or with their hog-like snout.

The Mexicans call them Tejons or raccoons. Since they are active and playful, they are often used as pets. Maybe that will explain the appearance of this lone specimen so far from its native habitat.

THE FAIRY SHRIMPS OF ILLINOIS [1]

H. J. VAN CLEAVE.

The fairy shrimps of Illinois have been but little studied. Prof. S. A. Forbes, in the early days, directed considerable attention to this group and brought together a very representative collection of specimens. In more recent years they have been neglected. Recently, I have had the opportunity of examining collections from various parts of the country and as a result have accumulated some records of the occurrence of two species formerly not recorded from Illinois. One of these includes the record of a genus not previously listed for the State.

In 1876, Prof. Forbes described *Eubranchipus serratus* from specimens collected at Normal, Illinois, in April, 1876. The type material of this species remained in the collections of the Illinois State Laboratory of Natural History. I have had the privilege of examining these collections of Eubranchipus. The original alcoholic material upon which the description of *E. serratus* is based had been dried up. Some years ago Prof. Frank Smith in reexamining these specimens succeeded in restoring them to the extent that many of the diagnostic characters were observable. In addition to this type material, the Natural History Survey collections contain series of *Eubranchipus serratus* collected by Forbes from the type locality at Normal, Illinois, covering the period from 1876 to 1882. The restored type specimens and others in the collection identified by Forbes agree in all details with specimens occurring commonly in the vicinity of Urbana, Illinois.

A. S. Pearse, in 1912, described what he deemed to be a new species of Eubranchipus under the name of *Eubranchipus dadayi*. His description and his figures differ in no manner from specimens of *E. serratus* from the type locality identified by Forbes. I therefore maintain that *Eubranchipus dadayi* Pearse, 1912 is a direct synonym of *Eubranchipus serratus* Forbes, 1876.

[1]Contributions from the Zoological Laboratory of the University of Illinois, No. 311.

In preparing the key to the Phyllopoda for Ward and Whipple's Fresh-Water Biology, Pearse (1918) made use of characters noted by Forbes in the original description of *E. serratus* to run this species to an entirely different section of the key from that including his species *E. dadayi*. The identity of the two species was thereby obscured.

Forbes (1876:13) characterized the abdominal segments as "narrow in front, with rounded anterior angles, while the posterior angles are produced backward, giving a decidedly serrate appearance to the abdominal margin." Later (Page 22) he laid less stress upon the angular projections of the abdomen and described the abdomen as "somewhat serrate." In fact such is the condition shown in his drawing of the abdomen (Fig. 21 Plate 5).

Pearse (1918: 669) construed this serrate appearance of the abdominal segments as due to lateral projections similar to those described for Hay's species *E. gelidus*. By so doing, Pearse grouped *E. serratus* with *E. gelidus* and failed to recognize the identity between *E. serratus* and *E. dadayi*.

Only after collecting Eubranchipus locally over a period of years and after a careful examination of the Forbes collections did the writer become convinced of the invalidity of *E. dadayi* which must fall as a synonym to *E. serratus*.

Thru the courtesy of Prof. L. M. Turner of Blackburn College at Carlinville, Illinois, I recently received specimens of Eubranchipus collected from temporary pools in February, 1927. These individuals very clearly belong to the species *Eubranchipus vernalis*, one of the species characteristic of the eastern states, but previously not recorded from Illinois. Smaller individuals of this same species are in my collection from another locality in southern Illinois. These last mentioned specimens were collected by Mr. W. F. Shay near Mulberry Grove in the very early part of January, 1926.

Unidentified fairy shrimps from East St. Louis, Illinois, July 18, 1906, in the collection of the Illinois Natural History Survey have been identified as *Streptocephalus coloradensis* Dodds. This species, described by Dodds, from mountain lakes of 5,000 to 8,500 feet elevation in Colorado, has not been reported from Illinois previously. In fact the present record is the first published account of the occurrence of this genus within the State.

In connection with the study of material incident to the preparation of this paper microscopic mounts were prepared to show the heads of four species of Eubranchipus in similar orientation. These mounts were photographed to the same scale of magnification and are here reproduced as figures 1-4.

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EXPLANATION OF FIGURES.

Figures 1 to 4. Microphotographs showing the heads of four species of Eubranchipus at same magnification. In each instance the stained head was mounted in damar with its caudal or posterior surface uppermost. The large jaw-like appendages are the second antennae, modified for clasping during copulation. These modifications are lacking in the females.

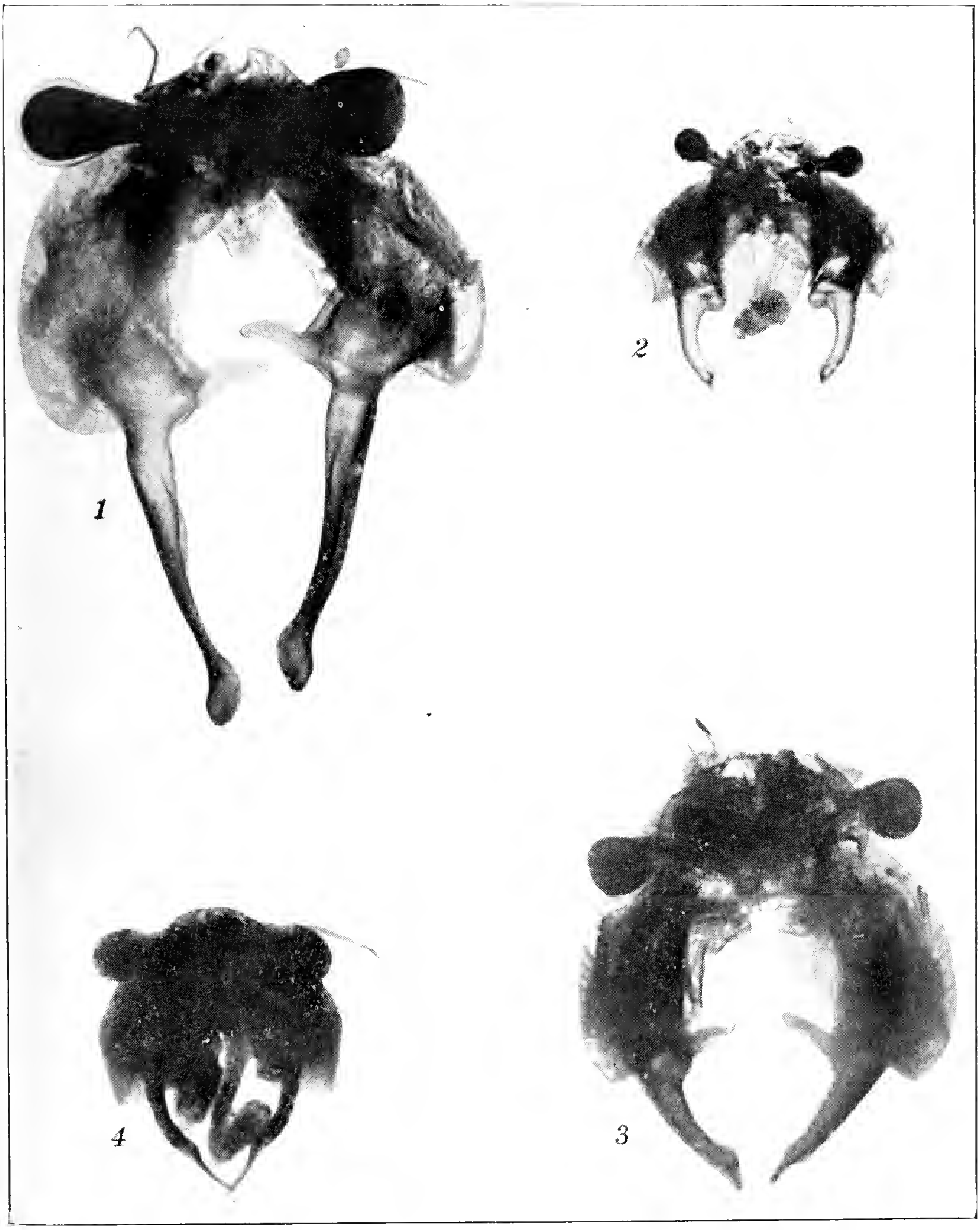

Fig. 1. *Eubranchipus vernalis*, collected at Carlinville, Illinois.

Fig. 2. *Eubranchipus gelidus*, collected at Syracuse, New York.

Fig. 3. *Eubranchipus serratus*, collected at Urbana, Illinois.

Fig. 4. *Eubranchipus ornatus*, collected at Bloomington, Minnesota. (Ill. State Natural History Collection, No. 31272).

A STUDY OF THE CHARACTERS FOR THE IDENTIFICATION OF THE SNAKES OF ILLINOIS[1].

H. J. VAN CLEAVE

Ignorance and progress are two of the conditions responsible for the sure and rapid extermination of our native snakes. Ignorance of their economic importance and an exaggerated sense of danger have combined to place the harmless snake on the defensive whenever he and man meet. Add to this the fact that modern intensive agriculture and marked increase in population are speedily destroying the native habitats of snakes and you begin to appreciate why snakes are becoming less common throughout our State. It is only thirty-five years since H. Garman (1892) prepared his valuable contribution entitled "A Synopsis of the Reptiles and Amphibians of Illinois," yet in this relatively short interim many of the snakes which he recorded as common throughout the State are but rarely seen today even by those who go into the field for the sole purpose of finding them.

It is rather poor sporting sentiment to kill a snake on sight from fear that it might be one of the relatively rare, dangerous varieties, especially when it is well known that most of the snakes in our vicinity are distinctly beneficial to man. The fact that a few snakes are dangerous seems slight provocation for condemning every creature that crawls. Few people are willing to look closely enough at the snake which they meet to be able to recognize one kind from another. "Garter snake," "rattle snake," and "water moccasin" are about the only names that the average person calls to mind when he attempts to name a snake which he has encountered. As a matter of fact there are forty-one different species and varieties of snakes found within the State of Illinois.

In the belief that ignorance as to the kinds of snakes is largely responsible for the "kill on sight" policy, the following tables have been prepared as an aid to the recognition of the species occurring within this State. Many of the forms here listed are very limited in their distribution.

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[1]Contributions from the Zoological Laboratory of the University of Illinois, No. 312.

TABLE I.

Arrangement of the Snakes of Illinois According to the Dorsal Color or Color Pattern.

Solid color only	Longitudinal stripes only	Spots or cross bands only	Spots and longitudinal stripes	Solid color with neck ring only
1.* *Carphophis amoena helenae*	22. *Natrix grahamii*	6. *Heterodon contortrix*	28. *Storeria dekayi*	3. *Diadophis punctatus arnyi*
2. *Farancia abacura*	25. *Natrix septemvittata*	7. *Heterodon simus*	29. *Storeria occipitomaculata*	4. *Diadophis punctatus edwardsii*
8. *Liopeltis vernalis*	28. *Storeria dekayi*	10. *Coluber constrictor constrictor*	32. *Tropidoclonium lineatum*	5. *Diadophis punctatus strictogenys*
9. *Opheodrys aestivus*	32. *Tropodiclonium lineatum*	11. *Coluber constrictor flaviventris*	33. *Thamnophis radix radix*	
10. *Coluber constrictor constrictor*	34. *Thamnophis sauritus proximus*	12. *Elaphe guttata*	36. *Thamnophis sirtalis sirtalis*	
11. *Coluber constrictor flaviventris*	35. *Thamnophis sauritus sauritus*	13. *Elaphe obsoleta obsoleta*	37. *Thamnophis sirtalis parietalis*	
13. *Elaphe obsoleta obsoleta*		14. *Elaphe vulpina*		
27. *Natrix sipedon erythrogaster*		15. *Pituophis sayi*		
30. *Virginia valeriae elegans*		16. *Lampropeltis calligaster*		
31. *Potamophis striatulus*		17. *Lampropeltis getulus holbrooki*		
		18. *Lampropeltis getulus nigra*		
		19. *Lampropeltis triangulum triangulum*		
		20. *Lampropeltis triangulum syspila*		
		21. *Natrix cyclopion*		
		23. *Natrix kirtlandii*		
		24. *Natrix rhombifera*		
		26. *Natrix sipedon sipedon*		
		31. *Virginia valeriae elegans*		
		38. *Agkistrodon mokasen*		
		39. *Agkistrodon piscivorus*		
		40. *Sistrurus catenatus catenatus*		
		41. *Crotalus horridus*		

*The numbers preceding species names refer to the numerical arrangement of the species in Table II. By consulting Table II., common names and further characters for classification are available.

TABLE II.

A Tabulation of the Characters Available for the Recognition of the Snakes of Illinois*

Scientific and Common Names	Number of rows of dorsal scales	Dorsal scales keeled	Shape of the rostral plate	Number of nasals	Pit between eye and nostril	Loreal present	Number of upper labial plates	Number of lower labial plates	Number of preocular scales	Number of postocular scales	Number of subocular scales	Is the anal plate divided	Number of ventral scutes	Number of subcaudal scutes	Are rattles present?	Distinctive Color Markings: Dorsal Surface	Distinctive Color Markings: Ventral Surface
1. *Carphophis amoena helenae* worm-snake	13	0	normal	1	0	+	5	6	0	1	2–3	+	120–125	30–36	0	uniformly olive brown	flesh color
2. *Farancia abacura* horn-snake	19–21	+	normal	1	0	+	7–8	8–10	0	2	0	+	172–196	35–49	0	uniformly bluish black	brick red with black cross bands
3. *Diadophis punctatus arnyi* ring-neck snake	15–17	0	normal	2	0	+	7	7	2	2	0	+	145–193+	36–59	0	black or dark brown; yellow neck band	yellowish with brown or black spots
4. *Diadophis punctatus edwardsii* ring-neck snake	15	0	normal	2	0	+	8	7	2	2	0	+	149–152	51±	0	dark gray with bright yellow neck ring	immaculate or spots in a single median row
5. *Diadophis punctatus strictogenys* ring-neck snake	15	0	normal	2	0	+	7	7	2	2	0	+	150–	?	0	light brownish olive; yellow neck band	spots in single median row or irregular
6. *Heterodon contortrix* spreading adder, puffing adder	23–25	+	plow-shape	2	0	+	8	9	3–4	3–4	3	+	124–148	46–58	0	20–31 light median spots on brown; lateral spots smaller	light in old, dark in young
7. *Heterodon simus* spreading adder	25–27	+	plow-shape	2	0	+	8	9	3	3	3	+	146+	40±	0	about 35 dorsal blotches and 2 or 3 lateral rows	yellowish more or less blotched with black
8. *Liopeltis vernalis* smooth green-snake	15	0	normal	1	0	+	7	8	1–2	2	0	+	131–139	69–94	0	uniform pale green	greenish white
9. *Opheodrys aestivus* rough green-snake	17	+	normal	1	0	+	7	8–7	1–2	2	0	+	150–170	111–134	0	uniformly pale green	greenish white
10. *Coluber constrictor constrictor* black-snake	15–17	0	normal	2	0	+	7	8	2	2	0	+	173–179±	83–92±	0	solid blue-black, young with spots	white to slate
11. *Coluber constrictor flaviventris* blue racer	15–17	0	normal	2	0	+	7	9	2	2	0	+	172–190	89–110	0	uniformly greenish blue	greenish to pale yellow
12. *Elaphe guttata* corn-snake	25–27	0–5	normal	2	0	+	8	11	1	2	0	+	200–235	65–79	0	27-40 reddish dorsal blotches	yellowish checked with black
13. *Elaphe obsoleta obsoleta* pilot black-snake	25–29	17	normal	2	0	+	8	13	1	2–3	0	+	231–239	76–85	0	uniform black or gray with black blotches	straw with square or elongate black blotches
14. *Elaphe vulpina* fox-snake	25–33	9	normal	2	0	+	8	10	1	2	0	+	194–211	....	0	31–38 dorsal blotches on light brown	yellow with dark spots
15. *Pituophis sayi* bull-snake	31–35	+	normal	2	0	+	8	11–13	1–2	2–5		0	209–228	51–60	0	40–60 square dark dorsal blotches on yellow	whitish with large black blotches
16. *Lampropeltis calligaster* yellow bellied king-snake	25–27	0	wedged	2	0	+	7	9–10	1	2	0	0	199–207	43–47	0	46–78 dorsal blotches with ant. and post. margins concave	checkered or with only ends of ventrals mottled
17. *Lampropeltis getulus holbrooki* speckled king-snake	21	0	normal	2	0	+	7	7–10	1	2	0	0	200–224	41–52	0	yellow spot on each dorsal scale	yellowish with large dark blotches
18. *Lampropeltis getulus nigra* black king-snake	21	0	normal	2	0	+	7	9(8–10)	1	2	0	0	199–216	41–53	0	chiefly black; 50-90 very narrow yellow cross lines	gray with white spots
19. *Lampropeltis triangulum triangulum* milk-snake	17–21	0	normal	2	0	+	7	9	1	2	0	0	180–213	29–51	0	35–60 dorsal saddles	checkered black and white or suffused with red
20. *Lampropeltis triangulum syspila* red milk-snake	17–21	0	normal	2	0	+	7	9	1	2	0	0	180–215	43–54	0	23–35 dorsal saddles	checkered with square blotches
21. *Natrix cyclopion*	27–33	+	normal	1	0	+	8	10–12	1	2	2–3	+	±141	+65	0	brown obscurely marked with black	yellow to brown with black dot on each scute
22. *Natrix grahamii* Graham's water-snake	19–20	+	normal	1	0	+	7–8	10	2	2	0	+	156–173	54–65	0	brown with median and lateral pale stripes	yellowish with median stripe
23. *Natrix kirklandii* Kirkland's water snake	19	+	normal	1	0	+	6	7	1	2	0	+	131–133	52–65	0	brown with black spots, no stripes	brick red
24. *Natrix rhombifera* water-snake	27 (25–31)	+	normal	1	0	+	8	10–11	1	2–3	0	+	130–150	40–80	0	26–33 dorsal spots on brown	blotched with black
25. *Natrix septemvittata* striped water-snake	19	+	normal	1	0	+	7–8	9–10	2	2	0	+	140–149	64–81	0	brown; median scales and 5th row with dark stripe; light lateral stripe	yellow with two longitudinal stripes of brown
26. *Natrix sipedon sipedon* water-snake	23	+	normal	1	0	+	7	10	1	3	0	+	135–155	40–80	0	lateral spots not alt. with dorsal as far forward as head	numerous black edged half circles
27. *Natrix sipedon erythrogaster* copper belly	23–25	+	normal	1	0	+	7	10	1	3	0	+	145–155	64–85	0	uniform dark or reddish brown	uniform light or reddish, some with dark markings
28. *Storeria dekayi* deKay's snake	17	+	normal	2	0	0	7	7	1	1–2	0	+	120–128	48–60	0	grayish and chestnut with light median stripe and lateral spots	pinkish white
29. *Storeria occipitomaculata* red-bellied snake	15	+	normal	2	0	0	6–7	7	2	2	0	+	117–128	43–52	0	olive to chestnut; 3 pale occipital spots	reddish, without spots
30. *Virginia valeriae elegans*	17	+	normal	2	0	+	6	6	0	2±	0	+	120–125	25	0	uniform bluish black	yellowish white
31. *Potamophis striatulus* ground snake	17	+	normal	2	0	+	5	6	0	1	0	+	119–130	25–46	0	grayish or reddish brown, chestnut parietal band	yellowish or reddish brown
32. *Tropidoclonium lineatum* striped swamp snake	17–19	+	normal	1	0	+	6–7	5–7	1	2	0	0	138–150	26	0	grayish brown; light mid-dorsal stripe	transverse black spot on each plate
33. *Thamnophis radix radix* garter snake	17–21	+	normal	2	0	+	7–8	8	1	3	0	0	150–160	65–75	0	median and lateral stripes (on rows 3+4); black spots between stripes	greenish, black spots near edges
34. *Thamnophis sauritus proximus* ribbon snake	19	+	normal	2	0	+	8	8	1	3	0	0	170–180	100–108	0	dark brown or black with median and lateral stripes (on rows 3+4)	without spots
35. *Thamnophis sauritus sauritus* ribbon snake	19	+	normal	2	0	+	7	8	1	3	0	0	±157	115–118	0	light brown with yellow stripes median and on rows 3+4	greenish white
36. *Thamnophis sirtalis sirtalis* garter snake	17–19	+	normal	2	0	+	7	8	1	3	0	0	140–170	60–80	0	olive brown to dark: yellow or green median and lateral stripes (on rows 2+3)	greenish with black spots
37. *Thamnophis sirtalis parietalis* red-sided garter snake	17–19	+	normal	2	0	+	7	10	1	3	0	0	146–170	66–95	0	stripes on rows 2+3; skin between dark spots, orange to red.	grayish, greenish or bluish
38. *Agkistrodon mokasen* copperhead	23	+	large	2	+	+	8	10	3	4–6	2–3	0	±150	±45	0	light brown; inverted Y-shaped brown marks on each side	yellowish with black blotches on each scale
39. *Agkistrodon piscivorus* cotton-mouth moccasin	25	+	large	2	+	+	7–8	10	3	3	0	0	+136	+45	0	brown or blackish with about 11 transverse black bands	numerous black blotches; black posteriorly
40. *Sistrurus catenatus catenatus* massasauga or prairie rattler	25	+	normal	2	+	+	12–13	12–13	2	4	4	0	137–143	28	+	gray to blackish brown; 3 series rounded brown spots, about 40 dorsal	thickly blotched with black, paler anteriorly
41. *Crotalus horridus* timber rattler	23–25	+	small	2	+	+	14	15	2	5	5	0	+165	23	+	brownish yellow and black, posteriorly with zig-zag bands of brown	yellow; blotched and speckled with black at sides

*See foot-note on page 135.

Some are included on the basis of a few reports from the southern extremity of the State. Consequently the entire list would not be encountered at any one locality.

The positive identification of many of the snakes rests on characters such as the number of rows of body scales and number and arrangement of the minute scales covering the head (see Table II). However, color pattern is highly distinctive of many forms. As the first step in recognition the color or color pattern furnishes one of the most obvious clues. The Illinois species of snakes show five distinctive types of color marking as indicated in Table I. In this table attention is directed to the color of the dorsal part of the body only.

A key at best gives only part of the information which a student may desire when attempting to identify an unknown specimen. There is always the question of how one species agrees with or differs from another in respect to characters about which the key is silent. Thus an alternative key may separate two species on the presence of some character in one which is lacking in the other but leaves the reader in complete ignorance of how generally the feature in question may be represented in still other species. This condition has come to my attention frequently in connection with the teaching of classes in systematic Zoology. The aid of a number of graduate students was secured in the preparation of a table to present a full comparison of some of the taxonomic characters more commonly utilized in the identification of snakes. While most of the information presented in Table II. is available through the literature, it seemed worth while to put it into tabular form for ease of immediate comparison.

Within recent years the scientific names of snakes have undergone radical changes. As a consequence, many of the prominent early lists and keys have impaired value to the general student. In the accompanying tables the nomenclature is taken from the revised edition of Stejneger and Barbour's Check List, except in a few instances where the nomenclature of Blanchard has been followed.

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*The technical terms employed in Table II. may be defined briefly as follows:

Dorsal scales: the lines of small scales covering the back and sides of the body, arranged in longitudinal rows.

Keeled dorsal scales: those having a small median ridge lengthwise of the scale.

Rostral plate: the single, unpaired plate at the tip of the upper jaw.

Nasal plate: the plate in which the nostril is located. This may be a single plate completely surrounding the nostril or a pair of plates with the nostril between them.

Loreal: a small scale lying between the nasal and the preoculars.

Upper labials: the row of scales bordering the upper lip; those of the two sides of the upper jaw separated by the rostral.

Lower labials: the row of scales bordering the lower lip; those of the two sides of the lower jaw separated by the mental plate.

Preocular scales: one or more small scales directly in front of the eye. In a few instances these are wanting, then the scale touching the eye is longer than it is high and is called the loreal.

Postocular scales: one or more small scales just back of the eye.

Subocular scales: one or more small scales just beneath the eye between it and the upper labials.

Anal plate: the ventral scale located just in front of the anus. Designated as "divided" or "entire" depending on presence or lack of an oblique line dividing it.

Ventral scutes: the large transverse scales on the ventral side of the body extending from the head to the anus.

Subcaudals: the large scales on the under side of the tail, extending from the anus to the tip of the tail.

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A PRELIMINARY REPORT ON AN ECOLOGICAL PROBLEM IN THE ILLINOIS RIVER VALLEY.

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The problem is concerned principally with an observation of the effects of alternate draining and flooding on the botanical content of the Illinois River valley. The river in question has suffered a variegated history in the past seventy-five years, in fact, there is probably no other river in this section of the country that has been as much altered and as much removed from its original, or we might say, its primitive condition.

The most outstanding alteration has been due of course to the construction of a series of deep-water-way dams. Between 1877 and 1892 four such dams have been completed; one at Kampsville, 45 miles from the river's mouth, one at La Grange, one at Copperas Creek, and one at Henry. In 1871 the Illinois Michigan Canal, and in 1900 the Chicago-Drainage Canal were completed and the diversion of Lake Michigan water was initiated. The presence of these dams and the addition of the lake waters materially increased the average height of the river and in the early nineties thousands of acres of the lower river bottom land were flooded. This motivated and occasioned the construction of a series of reclamation projects and rapid construction of levees began in 1892-1900. This is especially true of the area extending from Kampsville northward to Pekin and later to some extent in the neighborhood of Hennepin. Some areas were pumped out and drained a few years after flooding, some not until they had been submerged for periods of time varying from six to twenty years and in fact some are now in the process of reclamation. In many cases it is not practical to reclaim the drowned land and these tracts still lie under water just as they were twenty-five years ago.

It is obvious that the field presents a wealth of material for plant ecological research. Within a few square miles there are areas in which comparative studies can be made of a wide range of ecological conditions; from the primitive, unmolested condition, flooded and unflooded, through all ages of reclaimed and cultivated land from twenty-five years to that very recently reclaimed. Fortunately for the investigator, but less happily for the valley land owners further field for research was made possible by the high waters of last Fall which broke the levees and submerged the enclosed area. In many cases there will be no attempt made to repair the damage, due to lack of money, and the once cultivated land will return to its condition before reclamation.

To facilitate study the investigator decided that a motor boat large enough to live in would be expedient. Such a boat was constructed in Carlinville, Illinois, and was trekked overland on a large hayrack, not with oxen, but with a farm tractor. Since the cruiser weighs almost three tons and is twenty-three feet in length, some rather interesting problems were encountered in its transportation and launching, but this was accomplished on June 25, 1927. The boat is fully equipt for cooking, eating, and sleeping, and there is sufficient room for research materials, and facilities are present for microscopic work, photographic developing and printing. A small auxiliary boat is carried for use in shallow water.

During the last summer several minor objectives were attained. First, a preliminary superficial survey was made of the entire field to gain an idea of the general set-up of existing conditions. This included a trip from a point 30 miles from the mouth of the river to a point four miles above Starved Rock which consumed approximately a month. Secondly, a detailed survey was made of the Kampsville area to secure specific information pertinent to the problem. This area was worked thoroughly as far as time permitted because it presents a representative and inclusive picture of the entire field. Third, a preliminary survey was made to determine the extent of water pollution as was evidenced by the presence or absence of aquatic plants. It was the hope of the investigator to find places in the river where plant life was distinctly and obviously impossible due to pollution from cities. Journeying northward from Kampsville there was no observed diminution in the shallow water aquatics until a point eight miles below Peoria was reached where the amount of plant life in the water fell off rapidly to practically nothing immediately below Peoria. Above Peoria the unpolluted-water-condition existed and persisted up to Hall's Landing Light which is between Lacon and Hennepin and about 124 miles below Chicago: the principal source of pollution. This was practically the northern limit of aquatic plants other than algae; (no attempt was made to make a thorough examination of the Thallophytic content of the river). Although no particular effort was directed in this direction, algae were certainly not conspicuous except for one species of Spirogyra which was found sparingly as far north as Starved Rock.

The point of total absence of aquatic plants was farther north than the investigator anticipated. This might be partially explained by the higher level of the river and of the greater dilution of the sewage due to the rains of August. The plants used as indicators of the condition of the water were as follows: *Potomogetans,* Polygonum, Sedges, Sagittaria, *Lemna,* Spirodela, *Ceratophyllum,* Hibiscus, *Vallisneria, Elodea.*

It is the intention of the investigator to spend at least two more summers in pursuit of the problem.

THE STARLING.

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On December 16, 1926, Mr. Lester Corrie of Joliet, Illinois, killed, what he thought to be a flicker, at the eastern outskirts of the city. Upon closer examination he realized that it was not a flicker and, as he had never seen a bird like it before, he took it to the Joliet Township High School for identification. He showed it to Mr. C. E. Spicer, Assistant Superintendent of the high school and he, being an ardent bird student, at once recognized it as a starling (Sturnus vulgaris Linn.) Mr. Corrie presented the bird to Mr. Spicer who had it mounted, and it is now a valued specimen in the High School Museum.

At that time we believed this bird to be the only starling to have been found in Illinois. Recently, however, Mr. O. M. Schantz, President of the Illinois Audubon Society, informed me that Mr. Wm. Lyon, President of the Inland Bird Banding Association, had trapped two starlings. Mr. Lyon confirmed this, saying that the two birds were caught in his traps at Waukegan, Illinois, in December, 1925. He banded both birds and released them, but to date neither of them has been heard from. Neither Mr. Schantz nor Mr. Lyon knew of any other starlings having been found in this state. Mr. Lyon tells me that at least one has been killed in Wisconsin, the specimen now being in the Milwaukee Museum. Mr. Spicer told me that he had heard that the bird had been reported in Iowa but I have not been able to verify this report. In December, 1926, Mr. Amos W. Butler, President of the Indiana Audubon Society reported to the Indiana Academy of Science that three starlings had been killed in that state during that and the preceding year.

These few birds found recently in our neighborhood are probably the forerunners of what bids fair to be the greatest bird invasion of our time.

The Starling is a European bird. At least three attempts have been made to introduce the species into the United States. The first attempt at Cincinnati, Ohio, and the second at Portland, Oregon, were failures; but the third attempt at New York City was highly successful. Approximately one hundred starlings were released there in 1890 and 1891. From these the species has multiplied and spread until it has become as common in the eastern states as its fellow countryman, the English Sparrow. It has been spreading in all directions from New York but especially to the west in states of the same latitude. At present its western breeding limit is probably in western Ohio. In the field reports for Bird Lore for December, 1926, we find the following: Observers in New York reported 7079 starlings; observers in New Jersey reported 3999; Mass., 1590; Pa., 1122; R. I., 488; Va., 375; Ohio, 341; Vt., 78; Me., 46; N. H., 26; Md., 25; Mich., 4. In no other states were any reported. These are the numbers of birds seen by a few observers during trips of a few hours each. One observer in New York estimated one flock at 3500. Another noted that there were more starlings than there were English Sparrows. These figures give an idea of the numbers of starlings in the east.

Up to the present time the economic status of the starling has not been determined, but the weight of eastern opinion seems to be against him.

Two conclusions are warranted. The first is that the starling has become firmly established as a member of our bird fauna. The second is that the species is spreading westward at rather a rapid rate. We may reasonably expect to hear of other starlings being found in Illinois during the present year. And we should study them carefully from their earliest appearance in order to determine what their coming will mean to us biologically and economically.

CYNIPID GALLS OF THE CHICAGO AREA.

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The cynipid fauna of the Chicago area is probably better known than that of any other American locality. For this reason it seems desirable to collect the descriptions of the galls of this area from the scattered technical literature that they may be available for the use of biology teachers not only in this area but in all northern Illinois, Indiana and Ohio as well as southern Wisconsin and Michigan. In this field lies much readily accessible illustrative material for biology teaching and any number of original problems in the working out of life histories and the interrelationships of the many various species sometimes associated in a gall. These descriptions have been considerably condensed and grouped first by host plants and then by part of plant affected and it is hoped that this may serve as a means for the determination of the galls of this area. How successful it may be in accomplishing this purpose only time and its continued use in the field can tell. To make it as complete as possible several galls are included which have not as yet been determined or reared and which are probably undescribed. Field observation will no doubt find still other kinds and add other hosts to those already known.

For the beginner in the study of insect galls it may be well to state that this treats only of the galls made by the true gallflies, or the family Cynipidae of the order Hymenoptera, whose galls are principally on oak but some occur on roses and a few other plants in the rose family and a few on various composites as will be seen in detail later, the record of the one reported on *Smilax* being questionable. These hosts often bear at the same time galls made by other agents e. g. by mites, aphids, psyllas, gall midges, trypetid flies or moths and some field experience will be necessary before one can assign the maker of the gall to its proper group. In general however the Cynipid galls may be recognized by being closed in every case and containing white, non-hairy larvae of characteristic shape soon learned by experience.

From a collection of galls from the field and placed in rearing, insects belonging to one or more of four classes are liable to be secured.

(1) The Cynipid maker which stimulated the plant to form the gall and which, having passed through the earlier stages of its life within, chews out as an adult to lay its eggs and die.

(2) Commensals which feed on the tissue of the gall. If the commensal is a beetle larva or a caterpillar no change is produced in the gall. But there are five genera of Cynipids which, unable themselves to stimulate a plant to form a gall, lay their eggs in the peripheral parts of a gall already started and cause it to become more or less deformed. This deformation may or may not kill the larva of the maker of the gall. The larvae of some species of one of these—*Synergus*, after feeding on the plant tissue, are known to break their way into the central cell and parasitize the maker. These five genera are often called guest flies or inquilines and were often mistaken by the early entomologists for the maker of the gall. These guest flies always leave the gall later than the maker.

(3) Parasites and hyperparasites such as chalcids, braconids, ichneumons etc., which feed upon the body of the maker or of a guest fly or on another parasite.

(4) Successors or lodgers which utilize an empty gall as a nest or simply as a shelter or place of hibernation.

The beginner in the study of the gall-making Cynipidae is handicapped and often discouraged by the lack of published information as to the date of emergence of the maker of the gall. Not knowing at what time of year to collect the galls to get the maker, he rears nothing or gets only guests or parasites. Some general suggestions on rearing methods, applying only to Cynipid galls however, may be of value. Galls on herbaceous plants like *Fragaria, Potentilla, Nepeta, Silphium, Ambrosia, Lactuca* and *Prenanthes* may be collected in the fall if they can be put where they will not dry out too much but are better left in the open all winter and brought into the laboratory in the spring. A pasteboard box with a vial or test tube in one side makes a convenient breeding cage. Many galls on shrubby plants like *Rosa,* and *Rubus,* may be treated in the same way. The succulent vernal galls on the leaves, buds or the flowers of oak must, however, usually be left on the tree until the larvae within use up all the nutritive layer of plant tissue and transform into pupae but such species develop rapidly and it is a matter of leaving them some days or at most but a few weeks longer. When the larvae are about mature or the pupa stage is reached, twigs bearing such galls can be put in a bottle of water and cotton plugged tightly around the stems at the mouth of the bottle so that the emerging flies can not crawl into the water and become drowned. This bottle should then be set in a battery jar with muslin tied over the top—if set under a bell jar the condensation water on the glass will wet the wings of the emerging flies. From galls of this type come fully-winged, active adults of both sexes whose adult life is short, a few days at most.

The more solid autumnal galls on oak, maturing and dropping just before or with the leaves, contain at that time, which is when they are usually gathered, a scarcely visible larval cavity in a thick translucent nutritive layer which is used up slowly during the winter. Such galls should be kept under more or less natural conditions out-of-doors on the ground in some sort of a wire cage. Select a shady spot in the woods if possible where there is a deep layer of leaf mold, safe from molestation and from fire in summer and well buried under snowdrifts in winter. Mice and squirrels are liable to destroy collections unless wire cages are used. Labels inside should give locality, date and host and may be written with waterproof ink on paper and then dipped in melted paraffin or better enclosed in a well-corked 7 by 25 mm. vial. The year of collection should not be omitted in the date. Two winters often pass before any flies appear and then some may emerge each spring for several years. The larvae transform in the fall before they emerge and remain in the galls as adults during the winter to come out when conditions are suitable in the spring. Adults may often be secured by cutting open galls in the late fall or winter but in this case it is better to let them crawl about in a vial until the chitin hardens and takes on its normal color rather than to kill them at once in a cyanide bottle. Adults from galls of this type are all agamic females and are comparatively long-lived, often surviving for a month or more in captivity. Many species normally emerge in late fall, for example all those of the genus *Disholcaspis,* (whose galls on twigs are in general bullet-shaped, detachable but not deciduous) and many wingless agamic forms such as species of *Acraspis, Xanthoteras, Zopheroteras,* etc. Some woody stem swellings on oak become so hard after being gathered that the insects even if they have already transformed can not chew their way out and it is necessary to cut them out. These are but general suggestions for the beginner and their value is indicated by the fact that the writer knows many kinds of galls which he has never yet been able to rear. A single gall casually collected is seldom worth the trouble of rearing. It may be the normal reaction of the plant to the stimulation of the Cynipid maker or it may be quite abnormal if that structure is modified by the attacks of guest flies or parasites and some field observation may be necessary to determine whether this is the case. Collecting to be of value usually requires definite search for quantities of material with the object of rearing in view. When gathering galls from the ground in the fall especial care must be taken to see that no galls of other kinds are included in the breeding cages.

For a number of years the writer lived at Evanston, Illinois and collected galls either within the city limits or along the north branch of the Chicago river four miles west or along the "north shore" as far north as Waukegan with occasional trips to the sand dune area at the southern end of Lake Michigan in Indiana and less frequent trips to the general region of the "sag" south-west of Chicago. In this Chicago area the writer found a total of 124 species of gall-making Cynipidae and in addition has field notes on some 30 other galls from this area either not determined or not reared, some of the more conspicuous of which are included in this paper. Further collecting will no doubt yield still other species for during the last year of residence there it was no unusual experience to find galls that years of previous collecting had never discovered. Moreover collecting on three of the nine oaks in the region was very fragmentary, these being seen hardly more than once or twice a year. Strangely enough the only species previously described from this area the writer has never been able to find although he has looked for it for years. This is *Diastrophus smilacis* Ashmead, described from "Chicago" in 1896 as producing a gall on *Smilax*. The oak openings at the edge of the prairie now transformed into the suburbs of a densely populated metropolitan district would not be suggested as an ideal region for Cynipid collecting and yet it will be interesting to compare its 125 species with the few published local lists available. In 1904 Beutenmueller listed 46 of the more conspicuous Cynipid galls in the vicinity of New York City. Stebbins listed 66 from Springfield, Mass. in 1910. Sixty-four are known for the Toronto area.

It is to make available to students of this group the writer's experience with those species of the Chicago area that have been reared or are felt to be determined with some certainty from the galls that this paper has been prepared. The emergence dates given apply to the Chicago region. Some variation will be found from year to year depending on the earliness or lateness of the season.

The generic names here used are in general those of the latest monograph on the Cynipidae, that of Dalla Torre and Kieffer, published in 1910 as Lieferung 24 in Das Tierreich. Those already somewhat familiar with generic names in this group will notice that *Disholcaspis* is now used for *Holcaspis* and *Diplolepis* instead of *Dryophanta*. The names used for the oaks are those of the seventh edition of Gray's Manual.

Gall on Smilax.

Described as irregularly rounded, abrupt pithy swellings on stem, one inch long by one-half inch in diameter. Polythalamous. Described from Chicago in 1896 and not collected since. Specimens much desired. It is suspected that there is an error here in the identification of the host plant. The adults are said to have emerged in Jan. and Feb. but the type flies in the National Museum bear the date label of May 1-8.

1. *Diastrophus smilacis* Ashm.

Gall on Fragaria.

STRAWBERRY PETIOLE GALL. A cylindrical gall on the petiole of a leaf, 20-60 mm. long by about 5 mm. in diameter, containing 8-20 cells, red in summer, turning brown later. Flies emerged June 2, 1918.

2. *Diastrophus fragariae* Beut.

Galls on Potentilla.

Fusiform or cylindrical swelling of stem or peduncle, 10-35 mm. long by 5 mm. in diameter. Polythalamous. Adults emerge Apr. 15-May 1.

3. *Diastrophus niger* Bass.

CINQUEFOIL AXIL GALL. Globular, 8-13 mm. in diameter, in axils of leaves, green in summer with rudiments of leaves at apex, fleshy, spongy within, turning brown later. Monothalamous. Flies emerge the latter half of May.

4. *Gonaspis potentillae* (Bass.)

Galls on Rubus.

On blackberry.

BLACKBERRY SEED GALL. Cluster of reddish-brown, seed-like bodies closely set about the stem sometimes for several inches, the cluster being on the weaker canes about a foot or so from the ground, each seed-body bearing several filaments and monothalamous. Adults begin to emerge early in June.

5. *Diastrophus cuscutaeformis* O S

BLACKBERRY KNOT GALL. Abrupt, elongated, pithy, subterminal stem swelling, 1-3 inches long by an inch in diameter. Surface uneven with irregular tubercles or longitudinal grooves, green or reddish-brown. Polythalamous. Adults probably emerge early in June. Not common in Chicago area.

6. *Diastrophus nebulosus* (O S)

On raspberry.

Abrupt stem swelling, up to 65 mm. long by 30 mm. in diameter, densely covered with short prickers, green in summer, turning brown later, polythalamous. The flies emerged May 1-15, 1912.

7. *Diastrophus turgidus* Bass.

Galls on Rosa.

"Root" galls.

Deeply incised on top. Diameter up to 55 mm. When mature light in weight, of a brittle spongy texture within with large deeply imbedded larval cells. The makers issue in May.

8. *Rhodites utahensis* Bass.

Irregularly lobed, not incised, smaller, tissue more compact, adults emerging later in May or early June.

9. *Rhodites semipiceus* (Harris)

Stem galls.

Fusiform stem swelling up to 50 mm. long by 13 mm. in diameter, densely covered with prickers, rarely smooth. Polythalamous. Adults emerged May 27-June 21, 1909.

10. *Rhodites dichlocerus* (Harris)

Smaller fusiform or abrupt one-sided corky enlargements of the stem, up to 30 mm. by 7 mm., with a longitudinally fissured brown surface. Polythalamous. Flies emerged May 15-June 15.

11. *Rhodites fusiformans* Ashm.

Abrupt, irregularly lobed, subterminal stem swellings, up to 35 mm. in diameter, densely covered with sharp spines. Reddish-brown. Contain 30-50 cells arranged radially along the long axis. Adults emerged Apr. 27-May 13, 1915.

12. *Rhodites multispinosus* Gill.

Scarcely noticeable enlargement at base of small lateral branches bearing many leaf scars, the distal end of twig dead. Contains up to 5 larval cells but usually only one. On sweetbriar. Adults emerged May 25 until early in June.

13. *Rhodites nodulosus* Beut.

MOSSY ROSE GALL. A globular mass of mossy green filaments appearing in June and turning brown later. Polythalamous. Adults emerged Apr. 27-May 4, 1907. An European species most common on the introduced sweetbriar rose but occasionally found on *Rosa rugosa*.

14. *Rhodites rosae* L.

Leaf galls.

SPINY ROSE GALL. Globular, 8-10 mm. in diameter, 3-10 in a cluster, the leaf obliterated if the cluster is large, covered with numerous tapering spines about as long as the diameter of the gall. Succulent in summer, often tinged with red, turning brown and persisting through the winter. Monothalamous, cavity large, wall over 1 mm. thick. Flies emerge in May.

15. *Rhodites bicolor* (Harris)

Similar but smaller, 4-5 mm. in diameter, covered with short weak spines, wall thin. On upper side of leaflets near margin, dropping with the leaves. Flies emerged May 24. Galls of this type need further study as there may be more than one species.

16. *Rhodites pustulatoides* Beut.

MEALY ROSE GALL. Globular, up to 15 mm. in diameter, several often coalescing into a mass, covered with a mealy white efflorescence. Hard, polythalamous, attached to the under side of leaf. Adults emerge about the middle of April.

17. *Rhodites ignotus* O S

REGAL ROSE GALL. Globular with a flattened top like that of a patty-pan squash, single or in clusters on under side of leaflets. Diameter 5-6 mm. Dropping with the leaves in the fall. Adults emerge May 15-June 10.

18. *Rhodites gracilis* Ashm.

ROSE LENTIL GALL. A lentil-shaped hard thickening of the parenchyma of the leaf, green, more convex on lower surface, single or in small groups, 3 mm. in diameter. Drop with the leaf. Adults emerged May 11-June 14.

19. *Rhodites rosaefolii* Ckll

Gall on Nepeta.

Globular, green, fleshy, 8-11 mm. in diameter. Galls turn brown in Aug., the larvae transforming in Sept., the adults remaining in the galls over winter and emerging in the spring. An introduced European species on the introduced European host plant *Nepeta (Glechoma) hederacea*, Gill-over-the-ground.

20. *Aylax glechomae* (L.)

Galls on Silphium.

Cells in a small group hidden in among the disk florets in the flower head and found only when the head is broken open. Adults emerge in the spring, probably in May.

21. *Aylax laciniatus* Gill.

Cells in the pith with no external evidence until the exit holes are seen. Adults of two species emerged May 15-June 24.

22. *Aylax rufus* (Gill.)
23. *Aylax gillettei* (Kieffer)

Gall on Taraxacum.

DANDELION GALL. Irregular fusiform or nodular swellings on petiole, base of peduncle or scattered along the midrib. Green and fleshy in June, after maturity becoming dry, brown and pithy. Polythalamous. Adults emerge the next spring about June 1. Another European species on an introduced European host plant.

24. *Aylax taraxaci* (Ashm.)

Galls on Lactuca.

LETTUCE TUMOR GALL. Fusiform pithy stem swellings, high up on stem, bearing many leaves or branches of the panicle. Diameter up to 30 mm., polythalamous. Adults emerged May 4-June 1.

25. *Aulacidea tumida* (Bass.)

Knotty enlargements scattered along the stem at base of leaves. Polythalamous. Flies emerge early in June.

26. *Aulacidea podagrae* (Bass.)

Cells in the pith—no external evidence until exit holes are made in the spring. Flies emerge the first week in June.

27. *Aulacidea harringtoni* (Ashm.)

Gall on Prenanthes.

Abrupt hemispherical swellings just below the surface of the ground at base of plant, often so grouped as to surround the stem, resembling a raw potato in consistency in summer, becoming corky in fall. Polythalamous. Flies emerged June 8-11.

28. *Aulacidea nabali* (Brodie)

Galls on Quercus.

A. "Root" galls - - - - - - p.
B. Acorn galls - - - - - - - p.
C. Flower galls - - - - - - p.
D. Bud galls - - - - - - - p.
E. Stem galls - - - - - - - p.
L. Leaf galls - - - - - - - p.

A. Galls on the "roots."

1. True root galls, found on the small fibrous rootlets covered with an inch or two of leaf mold underneath large forest trees.

Single or in small clusters, ellipsoidal, brown, 5 mm. long, wall thin and fleshy, monothalamous. On *Q. bicolor.* The larvae transform in the fall after the nutritive layer has been used up, the flies emerging the next spring between Apr. 15 and May 7. They are all females and oviposit at once in the swelling buds of the same tree but the alternating sexual generation is unknown.

29. *Callirhytis ellipsoida* Weld

Similar on *Q. alba.* Flies of this species were taken ovipositing in buds of *Q. alba* on May 11.

30. *Callirhytis elliptica* Weld

2. Irregularly globular, abrupt, subterranean stem swellings at the base of sprouts from stumps. Woody, 10-30 mm. in diameter, polythalamous, the cells just underneath the bark which is not greatly thickened, the bark bulging slightly over a cell causing the surface to present a pebbled appearance. Adults probably emerge in the spring. On *Q. coccinea* and *rubra.*

31. *Eumayria floridana* Ashm.

3. Cells imbedded in the greatly thickened bark at the crown of the tree.

Occurring in large numbers forming hypertrophied patches of considerable area without sharply defined limits.

On the main roots of trees of *Q. alba,* the flies emerging in spring (May 12, 1917) to oviposit in the swelling buds on the same tree. See 115.

32. agamic gen. of *Callirhytis futilis* (O S)

At the base of saplings of *Q. macrocarpa,* causing a swelling 4-5 times the normal diameter and extending for nearly a foot sometimes. Flies emerge in early Nov.

33. *Compsodryoxenus illinoisensis* Weld

Occurring in small groups of less than a dozen usually, sometimes single.

Cells in thick brown bark forming an abrupt local swelling, these hemispherical swellings sometimes confluent and surrounding the stem. At the base of stumps or trees. Polythalamous, the number of cells within more or less evident. Adults probably emerge in the spring as the larvae transform in the fall. On *Q. rubra* and *coccinea.*

34. *Callirhytis rubida* Weld

Similar local swelling, the number of cells within not so apparent. Single or confluent, on sprouts or saplings of *Q. coccinea.* Adult emerged April 25. They oviposit in the swelling buds of the same clump of sprouts at whose base the galls were found.

35. *Callirhytis marginata* Weld

4. Detachable galls or masses of galls at the crown.

Single or scattered about in small numbers.

Hemispherical, 10-15 mm. in diameter, rugose to nearly smooth, covered with normal brown bark, leaving a radiating scar when detached, woody when mature, monothalamous. At base of thrifty sprouts from stumps of *Q. alba, bicolor* and *macrocarpa.* Transformation takes place in the fall, an adult emerging April 28, the emergence probably distributed over a period of two years. The flies oviposit in buds of vigorous white oaksprouts but alternating generation is unknown.

36. *Callirhytis badia* (Bass.)

Large, polythalamous, rounded masses, up to 90 mm. long, growing out of one side of main root at base of tree or stump. When mature the interior resembles well-rotted wood in which scattered hard, thin-walled, brittle, brown larval cells are imbedded. Light as cork when dry. On *Q. alba, bicolor* and *macrocarpa.* The larvae transform in the fall, the adults emerging the next spring in late April.

37. *Callirhytis maxima* Weld

In clusters of separable elements.

Pure white or rosy when fresh in May, fig-shaped, polythalamous, fleshy, decaying or shriveling up after the emergence of the adults, June 12-26. Frequently at base of stumps of *Q. alba* on whose sprouts the oak fig gall was formed the fall before. See 83.

38. *Trigonaspis radicola* (Ashm.)

Gall not transitory and fleshy but more or less woody and persistent.

Individual galls less than 6 mm. in diameter.

Cluster spherical or elongated, 20-25 mm. in diameter, consisting of 30-150 galls, 4 by 6 mm., roughly ellipsoidal, faintly grooved. They contain adults in the fall which probably emerge some time in the spring. On *Q. rubra* in the fall at the base of sprouts.

39. *Callirhytis enigma* Weld

Clusters spherical, up to 60 mm. in diameter, made up of as many as 400 elongated wedge-shaped bodies resembling long kernels of corn. Monothalamous, the larval cell in the basal part of the gall. Adults emerge in Dec., Feb. and March. On *Q. rubra* and *coccinea.*

40. *Dryocosmus favus* Beut.

Clustered at base of vigorous sprouts, up to 30 in a group, onion-shaped, 5-8 mm. long, pointed at apex, longitudinally striate, brown, hard and brittle when mature in the fall, monothalamous. Often enclosed in a "shed" by ants which are fond of the honeydew the growing galls secrete. On *Q. ruba* and *velutina.* Adults emerge in the late fall, Nov. 23-Dec. 2.

41. *Biorhiza caepuliformis* (Beut.)

Individual galls averaging over 7 mm. in diameter.

Globular bullet galls with a distinct inner cell often free in an irregular cavity within. Up to 40 in a cluster at base of sprouts from stumps of *Q. alba.* Adults emerge in late Oct. and early Nov.

42. *Disholcaspis globosa* Weld

B. Galls on acorns.

1. Galls on or in the tissue of the cup not involving the acorn proper.

ACORN PLUM GALL. Globular, 15-25 mm. in diameter, hard, mottled brown or reddish, attached on side of acorn cup and dropping to ground in the fall. Monothalamous. Adults issue in the spring, the emergence distributed over a period of several years. On *Q. rubra, velutina* and *coccinea.*

43. *Amphibolips prunus* (Walsh)

FIMBRIATE CUP GALL. A smooth elongated gall, 4 by 7 mm., partly imbedded in a fimbriate depression in the side of the acorn cup and slipping to the ground when mature in the fall. On *Q. bicolor.* Flies emerge the second and third springs Mar. 25-Apr. 18 and oviposit in buds of *Q. bicolor.* Alternating generation unknown.

44. *Andricus incertus* Bass.

Cell in the tissue of the cup and not separable from it directly underneath the acorn causing it to become lopsided. On *Q. bicolor* in the fall.

45. *Undescribed species*

2. Galls of the type known as "pip" galls produced between the acorn and the cup, always on red oaks.

Pip galls alongside full grown acorns of *Q. rubra* slipping out to the ground in late summer. Adults emerging in late Apr. or early May the second spring. See 53.

46. agamic gen. of *Callirhytis operator* (O S)

Pip galls alongside immature acorns.

On *Q. coccinea* in spring as buds are swelling, on the partly grown acorns of the previous season. Fleshy, smooth, greenish mottled with purple, laterally compressed, rounded at end and secreting honeydew. Monothalamous. Drop in May. Adults emerge the second and third springs Apr. 22-May 11.

47. *Callirhytis balanosa* Weld

On *Q. velutina* in fall on small acorns of current season, sometimes 2-3 on one acorn, secreting honeydew. When detached somewhat triangular, flattened, the larval chamber transversely placed in upper half of gall. Flies issue early in May the second spring.

48. *Callirhytis balanoides* Weld

On *Q. velutina* and *rubra* in fall on acorns of the current season. Globular, color green to tan, 3-4 mm. in diameter.

49. *Undescribed species*

3. Galls inside the acorn.

ACORN STONE GALL. Cells thick-walled and coalescing into a stony-hard mass which more or less fills the interior of the acorn so that the cotyledons are reduced or absent. On *Q. rubra* and *coccinea* in the fall. Adults emerge in early May the second and third springs.

50. *Callirhytis fructuosa* Weld

Cells separable and with thin walls.

On *Q. bicolor.* Cells in a group of as many as 15, shaped like apple seeds, underneath or slightly to one side of the cotyledons, causing the acorn to bulge somewhat on one side. Occurs in fall in large acorns. Flies issue Apr. 25-May 16 the second and third springs.

51. *Callirhytis lapillula* Weld

On *Q. alba.* Similar, less common.

52. *Undetermined species*

C. Galls on the staminate flowers.

Woolly white mass on the flowers of *Q. rubra, velutina, coccinea* and *imbricaria* becoming tan colored as it matures in late June when the insects emerge and oviposit in the one-year-old acorns to produce the pip galls in the late summer. See 46.

53. sex. gen. of *Callirhytis operator* (O S)

Pea-shaped, smooth, green, bare, fleshy, scattered in small numbers along the flower axis, dropping with the flowers in late May or early June. Contain 4-5 cells. Flies emerge early in June of the same season. On *Q. rubra* and *coccinea.*

54. *Callirhytis pulchra* (Bass.)

D. Bud galls.

(Galls which are quite obviously modified buds and hence arising at definite places on the stem such as at the nodes, in the axils of the leaves or developing and sometimes hidden in the inside of buds. Detachable and often deciduous when mature.)

1. Over 10 mm. in diameter or in length.

Large, globular, spotted, with a thick outer wall and a central cell supported by stout radiating fibers, 11-13 mm. in diameter. In axils of leaves of large trees of *Q. rubra,* dropping about the middle of Sept., after which they turn brown and the surface becomes characteristically wrinkled. Brodie says that in Toronto adults emerge late the next Oct., all females, and oviposit in buds. Male unknown.

55. *Amphibolips cookii* Gill.

Cylindrical, 5 by 14 mm., tapering toward the blunt ends, mottled. In early spring from weak lateral buds on *Q. palustris* and *imbricaria*. Deciduous. The fly probably emerges early the next spring as one was found dead in breeding cage April 10.

56. *Amphibolips ellipsoidalis* Weld

Gall slender, elongated, fusiform, long-stalked, longitudinally grooved, up to 31 mm. long. Found in late summer sticking out obliquely upward from weak lateral buds on current season's growth, dropping in early Sept. Adult emerges the second spring after, probably in Apr. or May. On *Q. rubra*.

57. *Callirhytis gallaestriatae* Weld

2. Under 10 mm.

Gall almost wholly exposed, not much concealed by the bud scales.

Spherical, smooth, bare, milky-white mottled with purple, consisting of a thin fleshy layer outside a hard brittle brown shell. Diameter 3-6 mm. monothalamous, deciduous. Occurs as buds are opening in spring on *Q. alba, bicolor* and *macrocarpa*. The larvae transform in late fall, the adults emerging in spring.

58. *Andricus pisiformis* Beut.

Spherical, slightly elongated at apex, 4 mm., greenish-gray with longitudinal purple streaks, monothalamous. Develop from weak lateral buds near base of season's growth or from dormant buds on older twigs. After they drop about the end of Sept. the thin fleshy outer layer rots away leaving a hard thin-walled shell. Adults emerged the second spring on April 10. On *Q. bicolor*.

59. *Andricus deciduatus* Weld

Globular or kidney-shaped, thin-walled, fleshy, green or brownish, 3-5 mm. in diameter. Monothalamous. Usually occurs in terminal bud cluster in Mar. or Apr. as buds begin to swell, the flies emerging as the buds open in early April. On *Q. alba, bicolor* and *macrocarpa*.

60. *Neuroterus vesicula* (Bass.)

Conical, white or tan-colored, 3 mm. high, wall very thin and brittle. In the terminal cluster of buds in spring, flies are said to emerge in Conn, in the middle of May. On *Q. alba,* and there is a similar gall perhaps made by the same species on *Q. bicolor* and *macrocarpa.*

61. *Diplolepis gemula* (Bass.)

Conical, greenish becoming brown when mature, 3-4 mm. high, from weak dormant buds on limbs or from adventitious buds on trunk of large trees of *Q. alba* in Sept. and Oct. Deciduous. Adults emerge the second spring, transforming the fall before.

62. *Callirhytis gemmiformis* (Beut.)

Fusiform or ellipsoidal, 3 by 5 mm., greenish when young becoming yellowish with rosy stripes and covered with stellate hairs, monothalamous, the wall thin. At apex there is a slight papilla surrounded by a circlet of reflexed hairs. From weak lateral buds at base of branches on strong sprouts from stumps in May in clusters of from 2-8, deciduous. Flies emerge early the next spring probably in April. On *Q. coccinea.*

63. *Callirhytis rugulosa* (Beut.)

Melon-shaped, with longitudinal grooves like some types of cantaloupe, 3-4 mm., rose-pink, with a small tuft of hairs at the apex. On *Q. velutina.* Found but once—on May 1. Not reared.

64. *Undescribed species*

Gall at least half concealed by the bud scales about its base.

Smooth, greenish, 3 mm. high, ribbed, in June, the bud scales developing into leafy bracts which after the gall is pushed off to the ground in July become more and more leaflike and form a compact persistent mass conspicuous in winter. In terminal buds of *Q. bicolor* and *macrocarpa,* on vigorous sprouts. Adults probably emerge the next spring.

65. *Callirhytis flavohirta* (Beut.)

Greenish-brown, smooth, globular with a papilla at apex, half protruding beyond the normal bud scales. In buds of terminal cluster in the fall. On *Q. alba.* Adults emerge the second spring.

66. *Callirhytis mamillaformis* Weld

Similar on *Q. bicolor* and *macrocarpa* in the fall.

67. *Undetermined species*

Similar on *Q. rubra* in the fall.

68. *Undetermined species*

Similar on *Q. coccinea* in early spring, smooth, polished, tan-colored, scarcely protruding.

69. *Undetermined species*

Found under large trees of *Q. coccinea* in May and probably bud galls. Globular, slightly compressed, with a scar and short stalk at base, a linear indentation at the apex, no nipple, 3 by 4 mm., brownish or purplish, mottled.

70. *Undetermined species*

Gall a blister on the inner concave face of bud scale, not visible until bud is dissected, wall thin, brittle, white or tan-colored. But one or two on a scale. Occurs as buds open in early spring on trees of *Q. alba* where the hedgehog gall was found the previous fall. Adults issue early in May. See 126.

71. sex. gen. of *Acraspis erinacei* (Beut.)

E. Stem galls.

(Not obviously derived from buds.)

1. Cells in the twigs, no deformation evident.

Cells in the tissue of the twig under leaf scar, the tip protruding so slightly as to be scarcely visible until the adult begins to chew its way out in the latter half of April. Sometimes two cells under the same leaf scar. Near the terminal cluster of buds on *Q. bicolor*.

72. *Neuroterus escharensis* Weld

Cells scattered along the internodes in the wood under the normal bark. Date of emergence unknown. On *Q. coccinea*.

73. *Bassettia ceropteroides* (Bass.)

2. Woody, persistent, polythalamous stem swellings.

Horned knot gall. Abrupt irregular mass up to 2 in. in diameter covered with normal bark and consisting of tissue which cuts like cheese until the galls are full grown about the middle of May; then long, pointed horns begin to protrude from the surface and drop to the ground early in July. Each is cylindrical, 2 by 8 mm., with a larval cell at base, the adults emerging the next spring early in May. The twig beyond the gall dies and the gall becomes woody and persists on the tree for years. On *Q. rubra.*

74. *Callirhytis cornigera* (O S)

OAK KNOT GALL. Irregularly lobed, confluent stem swellings sometimes encircling twigs for several inches and eventually killing the twig beyond that point. Up to 40 mm. in diameter, covered with normal bark, polythalamous. Full grown by middle of June, the larvae transforming to adults in late fall, the adults emerging the next spring in April or May—all females. On *Q. rubra, coccinea* and *velutina.*

75. *Callirhytis punctata* (Bass.)

OAK POTATO GALL. Irregularly fusiform, tuber-like stem swellings, 10-40 mm. long by 15 mm. in diameter, deforming the terminal twigs of small trees or sprouts of *Q. alba.*

In spring at base of the new growth, fleshy, green, glaucous, the adults emerging the latter half of June. See 77.

76. sex. gen. of *Neuroterus batatus* (Fitch)

In winter a similar but woody gall covered with normal brown bark, the adults emerging the latter half of April and ovipositing in the buds. See 76.

77. agamic gen. of *Neuroterus batatus* (Fitch)

NOXIOUS OAK GALL. Irregular woody enlargement at or near the ends of twigs on trees of *Q. bicolor,* up to 40 mm. long by 25 mm. in diameter, covered with normal bark, polythalamous, conspicuous on the trees in winter. The adults emerge in early April and oviposit in the buds just as they are beginning to swell. See 104.

78. agamic gen. of *Neuroterus noxiosus* (Bass.)

OAK CLUB GALL. Terminal, club-shaped, about 15 mm. in diameter with several leaves growing from it, containing one to three larval cells. Green while growing but becoming brown and woody after the escape of the adults in early July, the old galls persisting for years. On trees of *Q. alba.*

79. *Callirhytis clavula* (O S)

Abrupt enlargement at end of the new growth on *Q. coccinea* in June, checking the growth in length and bearing several leaves, the internodes short. Green, about 15 mm. in diameter at base and gradually tapering above. Usually several in close proximity on the tree. Adults emerge in early July.

80. *Callirhytis scitula* (Bass.)

Slight enlargement on one side of the new growth of *Q. bicolor* in early May causing the branch to be dwarfed and bent over to one side, green, polythalamous, the flies emerging about the middle of May.

81. *Neuroterus distortus* Bass.

3. Detachable and often deciduous.

OAK SEED GALL. A globular or elongated woolly or spongy white mass often tinged with spots of pink, 20-30 mm. in diameter, consisting of numerous slender fusiform bodies attached by one end to a common point on the twig —probably a bud gall morphologically. Each seed-like body contains one larval cell and the distal part bears the white filaments. Occurs on trees of *Q. alba*, starting about the middle of May, the adults emerging June 29-July 12.

82. *Callirhytis seminator* (Harris)

OAK FIG GALL. A cluster of tan-colored, hollow bodies surrounding the twig for several inches at or near its upper end and occasionally scattered along the midrib of leaves, the diameter of the cluster about one inch. On strong sprouts from stumps of *Q. alba* in the fall and within reach from the ground. Individual galls are much distorted by mutual pressure, monothalamous, the larval cell in the base surrounded by fine radiating fibers. Appear about the end of June. Adults emerge on thawing days in Dec., Feb. and March, all females and wingless. Is suspected of being the agamic form of *Trigonaspis radicola* (Ashm.) See 38.

83. *Xanthoteras forticornis* (Walsh)

PINE-CONE OAK GALL. Globular cluster, up to 35 mm. in diameter, at end of twig, consisting of 25 or more wedge-shaped bodies attached by their tapering bases to a common point on twig. Hard, breaking off easily when mature, brown, monothalamous, dropping in the fall. Some flies emerge in the spring for at least three seasons. On *Q. bicolor* and *macrocarpa*.

84. *Cynips strobilana* O S

Globular cluster of fig-shaped galls on one side of the twig on strong shoots of *Q. coccinea* in May, the cluster made up of about a dozen or more galls, each 15 mm. long by 10 mm. in diameter, green, fleshy, monothalamous, the distal end blunt with a depression in the center. They turn brown and drop off in summer. The larvae transform in the galls in the fall, the adults probably emerging in early spring.

85. *Andricus formosus* (Bass.)

Seed-like bodies in rows bursting out of longitudinal cracks in the bark of vigorous young shoots in late summer, dropping to the ground in the fall. The individual galls are lenticular in shape with a scar at the base, about 6 mm. long, hard, smooth and polished. Ashmead reared the type flies from galls from N. Carolina on June 6. On *Q. imbricaria* and probably other red oaks.

86. *Andricus excavatus* Ashm.

ROUND BULLET GALL. Single or in small cluster on small twigs on trees of *Q. alba* in late summer and fall. Diameter 10-15 mm., yellow or tinged with red, corky with a thin-walled free larval cell in center. Young galls appear in July, contain pupae in late fall, and adults emerge Oct. 20-Nov. 1.

87. *Disholcaspis globulus* (Fitch)

POINTED BULLET GALL. Similar but pointed at the apex, subclasping at base, often distorted by crowding and extending along the stem for several inches sometimes. Frequently on sprouts from stumps or on small trees in large numbers in the fall. On *Q. macrocarpa* and *bicolor*. Adults emerge Oct. 20-Nov. 10.

88. *Disholcaspis mamma* (Walsh)

BASSETT'S BULLET GALL. Broadest at the clasping sessile base and tapering gradually above, the apex often lopsided, 15-20 mm. high, the larval cell basal. Single or in crowded clusters on twigs of trees of *Q. bicolor* in fall. Adults emerge in early Oct.

89. *Disholcaspis bassetti* (Gill.)

PUBESCENT BULLET GALL. Clasping, conical, single or in small clusters on twigs or on scar tissue on main trunk or large limbs of trees of *Q. coccinea* and *imbricaria* in spring. Green and fleshy when fresh in May and covered with dense short white pubescence which weathers away after the galls mature. They turn brown and drop off in July. The larvae transform in the fall and the adults emerge some time in the spring probably.

90. *Callirhytis ventricosa* (Bass.)

BANDED BULLET GALL. Reddish-brown, globular, 7-10 mm. in diameter, in rows from vertical slits in the bark usually near top of vigorous sprouts from stumps of *Q. rubra, velutina* and *coccinea,* beginning to develop about Aug. 1 and dropping in late Sept. Adults emerge the next and the succeeding fall in late Sept. or early Oct.

91. *Dryocosmus imbricariae* (Ashm.)

Cluster of small barrel-shaped green or purplish galls bursting out of cracks in the bark of 2-3 year old twigs, the blunt galls sticking out in all directions for a distance of an inch or two along the twig. Each is 3 mm. long by 2 mm. in diameter, longitudinally grooved and when growing secretes honeydew from a gland in the truncate and depressed distal end. On *Q. rubra, velutina* and *coccinea.* They begin to develop in late May or early June and unless attacked by guest flies drop off early in July. Adults probably emerge in early spring. Attacked by guest flies the gall fails to drop, continues to grow, becomes woody and covered with normal bark and persists for years.

92. *Callirhytis gemmaria* (Ashm.)

Gall unknown but probably a bud or stem gall. A fly of this species was taken at Evanston, Ill., on April 9, 1910 ovipositing in bud of *Q. alba.*

93. *Bassettia gemmae* Ashm.

F. Leaf galls.

1. Gall an integral part of the tissue of the leaf (a thickening of vein or parenchyma or prolongation of a vein) and detachable only by tearing the tissue of the leaf, including here the hollow galls, those with a free-rolling

cell inside and the oak apples with a central cell supported by radiating fibers.

a. Oak apples. Spherical galls containing a central larval cell supported from the thin outer wall by fine radiating fibers or by a spongy network.

LARGE SPONGY OAK APPLE. Galls appear with the leaves in spring, becoming 40 mm. in diameter, green until full grown early in May, turning brown about the time the flies, males and females, emerge the latter half of June. On *Q. velutina.*

94. *Amphibolips spongifica* (O S)

Similar but the adults, all females, emerge in Nov. Probably an alternating generation of the above but the life history needs further study.

95. *Amphibolips confluentus* (Harris)

LARGER EMPTY OAK APPLE. Green with scattered purplish spots, 18-32 mm. in diameter, produced singly on under side of the leaf of *Q. rubra.* Adults emerged June 11, June 25, and July 6 in different seasons.

96. *Amphibolips inanis* (O S)

SMALLER OAK APPLE. Diameter 14 mm., a third of the sphere projecting from the upper surface of the leaf, the rest on under side, seldom more than one on a leaf, green, not spotted. On *Q. rubra* in May and June, the adults emerging early in July.

97. *Andricus singularis* (Bass.)

Similar but smaller, diameter about 8 mm., on *Q. coccinea* in June. Adults emerged July 8-15.

98. *Andricus osten sackenii* (Bass.)

b. Midrib or petiole swellings.

OAK PETIOLE GALL. Somewhat globular, conical above with a depression at apex, hard, green, polythalamous, the larval cells radiating out from the center. On the petiole or basal part of midrib, usually several in close proximity on the tree. In May and June, the adults emerging in late June. On *Q. alba, bicolor* and *macrocarpa.*

99. *Andricus petiolicola* (Bass.)

Abrupt smooth midrib swelling on lower side of leaf on basal half, 25 mm. long by 12 mm. wide, green, fleshy, polythalamous, appearing in June the flies said to emerge in autumn or the next spring. On *Q. velutina, coccinea* and *imbricaria.*

100. *Callirhytis pigra* (Bass.)

Englargement of petiole and basal part of midrib, green, smooth, polythalamous, appearing in June, 20 mm. long by 13 mm. in diameter, the adults emerging during July. On *Q. rubra.*

101. *Callirhytis tumifica* (O S)

Smooth fusiform swelling along midrib of *Q. macrocarpa* in spring. Green, fleshy, polythalamous, the adults emerging about June 20.

102. *Callirhytis flavipes* (Gill.)

Slight local thickening of midrib on leaf of *Q. bicolor* with a rosette of leafy bracts both above and below. Green, fleshy, containing 1-6 cells, only one on a leaf, usually on the basal third, first appearing in May when the leaves are about one-third grown. Adults emerge in late June.

103. *Andricus foliosus* Weld

NOXIOUS OAK GALL. Fleshy smooth green swellings of midrib on under side causing the leaves to curl. Developing with the leaves in early spring, full grown during June, adults emerging June 12-July 3. On *Q. bicolor.* See 78.

104. sex. gen. of *Neuroterus noxiosus* (Bass.)

Swollen base of the petiole of *Q. imbricaria,* 6 mm. long by 2 mm. in diameter, remaining attached to the twig during the winter.

105. *Undetermined species*

c. Woolly galls of small size on under side of leaves of *Q. bicolor* and *macrocarpa* in large numbers in the fall, showing on the upper side only as smooth shining blisters. Often deforming all the leaves near the top of thrifty shoots. Adults emerge the next spring about April 15.

106. *Neuroterus floccosus* (Bass.)

(For detachable woolly galls on leaves see 2 b on p—)

d. Prolongations of veins beyond the margin of the leaf.

Gall fusiform, green, long-stalked, total length 15 mm., no free cell inside.

On *Q. alba* and *bicolor* in May. Adults emerged June 10-23.

107. *Andricus chinquapin* (Fitch)

Similar in appearance but has a separate larval cell inside (not free-rolling for it fills the cavity). On *Q. coccinea* in May. Adults emerge the last of June.

108. *Diplolepis pedunculata* (Bass.)

e. Galls with a free-rolling larval cell inside.

Globular, 10-12 mm. in diameter, wall thick, succulent, green with opaque white spots. On *Q. rubra* and *velutina* as leaves develop in early spring. Occasional on the staminate flower axis. Adults emerge during the first two weeks in June.

109. *Diplolepis palustris* (O S)

Hemispherical, slightly elongated, sessile by its flat face on the lower side of leaf of *Q. rubra* in spring. Greatest diameter 6 mm., wall very thin, green, veiny and translucent. Flies emerge about the last of May.

110. *Diplolepis cinereae* (Ashm.)

Elongated, blister-like, at edge of leaf, the conical tip prolonged on upper side of leaf into a sharp point, the walls very thin, green, veiny and translucent. In May on *Q. rubra, velutina* and *coccinea.* The flies emerge early in June.

111. *Diplolepis notha* (O S)

f. Deformed and much reduced leaves in early spring as buds open.

Cluster of thickened petioles without leaf blades, each about 5 mm. long and containing a dozen or so rounded cells. Slightly pubescent and pinkish. On *Q. alba* as buds open in the spring. Adults emerge the last of May.

112. *Neuroterus minutus* (Bass.)

Swollen leaf petioles and dwarfed and deformed leaves of *Q. macrocarpa* in May. Adults are said to emerge in May or June.

113. *Neuroterus vernus* Gill.

g. Galls in the parenchyma of the leaf, projecting on one or both surfaces, one or many celled.

Galls 3 mm. or more in diameter, not confluent into masses, 1-3 celled at most.

Gall hollow, spherical, 3 mm. in diameter, projecting equally on both sides of the leaf, green, fleshy, cavity large, solitary on leaf. In May on *Q. alba*. Flies probably emerge about the middle of June.

114. *Andricus utriculus* (Bass.)

OAK WART GALL. Lenticular, projecting more on the lower side of leaf, usually several on a leaf. Each contains 2-3 larval cells supported by radiating fibers. On *Q. alba* and *bicolor* in June. Adults emerge about the middle of July. See 32.

115. sex. gen. of *Callirhytis futilis* (O S)

Lenticular, more prominent on lower side of leaf, the upper surface depressed, hard, lighter in color than the leaf, but one or two on a leaf, typically containing two cells. On *Q. rubra* in May. Adults probably emerge in early July.

116. *Callirhytis rugosa* (Ashm.)

Individual galls less than 3 mm. in diameter or else coalescing so as to form large thickened patches of hypertrophied leaf blade.

Confluent so as to form an abrupt thick swollen area from 10-30 mm. long and 7-11 mm. thick. Green, smooth, somewhat translucent, usually but one on a leaf, polythalamous. On *Q. alba* in May. Adults emerge during the first half of June.

117. *Neuroterus majalis* (Bass.)

Confluent or single, hard, not succulent, upper surface of patches papillose, many such warty patches on leaf. On *Q. rubra* in June. Adults emerge in late June.

118. *Callirhytis modesta* (O S)

Cells isolated, more prominent on upper surface, scarcely projecting below, elliptical in outline, 1 mm. long, very numerous on leaf, exit hole below. On *Q. bicolor* in June. Adults emerge the last of June.

119. *Neuroterus papillosus* Beut.

Cells separate, numerous, elliptical, 1-2 mm. long, showing on both sides of the leaf but more distinct on upper. On *Q. alba* in June and similar galls in the fall. Flies emerge from the overwintering galls April 1-23.

120. *Neuroterus perminimus* Bass.

Cells separate but in more or less definite rows along the midrib or a main vein, more prominent on upper side, a faint papilla in center below, round in outline, about 1.5 mm. in diameter. Exit hole on the lower surface. On *Q. alba* in the fall.

121. *Undetermined species*

Cells lenticular, adjacent to a vein in rows, more conspicuous on lower side which is covered with sparse rosy hairs, the wall thinner above. In early spring when leaves are one-third grown on *Q. macrocarpa*. Adults emerged May 30.

122. *Neuroterus fugiens* Weld

2. All leaf galls, single or in clusters, which when mature are deciduous or are easily detachable without damage.

a. Acraspis galls. Stony hard, whitish, more or less spherical, with a reticulated rough and often spiny surface. On white oaks in the fall, dropping with the leaves, the adults all females, wingless and emerging in late fall.

Spiny oak gall. Globular, 5-15 mm. in diameter, on under surface of leaf on midrib of *Q. macrocarpa*. Yellowish-green, monothalamous, the surface tuberculate, each tubercle conical and prolonged into a long hair of same color as gall or often red. Solitary or in a small group. Flies emerge after Nov. 1.

123. *Acraspis villosa* Gill.

Ellipsoidal, 3 by 4 mm., scattered on lower or sometimes upper surface of leaf of *Q. macrocarpa*, often one or two dozen on a leaf. Surface rough with blunt tubercles but not spiny. Monothalamous. Adults emerge about the middle of Nov.

124. *Acraspis macrocarpae* Bass.

Oak pea gall. Spherical, 5-8 mm. in diameter, two-celled, on under side of leaf of *Q. alba* on a vein. Surface reticulated by fissures into polygonal areas each bearing a slight papilla, yellowish, often tinged with red on one side when developing in June, turning brown in fall. Adults probably emerge in late Nov.

125. *Acraspis pezomachoides* (O S)

HEDGEHOG GALL. Two to five-celled, ellipsoidal, 8-15 mm. long, usually on upper side of leaf on midrib, often several in a row, the surface tuberculate and bearing conspicuous red hairs. On large trees of *Q. alba*, starting to develop in late June. The flies emerge about Nov. 1 just before the leaves fall and oviposit on the same tree in the buds of the terminal cluster. See 71.

126. agamic gen. of *Acraspis erinacei* (Beut.)

b. Woolly galls on leaf. Occur in autumn. Deciduous or dropping with leaves.

OAK WOOL GALL. White woolly mass, 5-25 mm. long, on midrib above or below, containing 2-10 brown seed-like cells attached at one end. Falls with the leaf. On *Q. alba*. Adults emerge the next spring in May.

127. *Andricus flocci* (Walsh)

OAK FLAKE GALL. Similar but somewhat smaller more fluffy woolly masses scattered in large numbers on the under side of the leaf of *Q. bicolor* and *macrocarpa* attached to veins. They drop with the leaf and the wool weathers away during the winter exposing the 1-12 brown elliptical cells lying parallel with the leaf surface. Adults emerge the next spring during the first half of April.

128. *Diplolepis ignota* (Bass.)

Hemispherical brownish woolly mass on midrib on under side of leaf of *Q. rubra* and *velutina*. Made up of a cluster of easily detached separate angular galls which drop to the ground in the fall in Oct. before the leaves, each covered with a dense coating of wool. They are then fleshy and apparently solid as the larval cavity is very minute. Adults emerge the second and third springs in April.

129. *Callirhytis lanata* (Gill.)

c. Midrib clusters on leaf, the individual galls not so densely pubescent as to obscure the outline. These galls all develop in the late summer and drop to the ground before the leaves fall in the autumn. At this time they are fleshy, cutting like cheese, and apparently solid as the larval cavity is very minute. During the winter or several winters on the ground the thick nutritive layer is used up by the larva leaving but a shell.

Galls angular.

A globular cluster, 8-20 mm. in diameter, on under side of petiole at its junction with the leaf blade, consisting of a dozen or more reddish-brown galls, closely pressed together, tuberculate at the distal end, flattened at the sides, tapering to the point of attachment, dropping to the ground in late Sept. or Oct. before the leaves. On trees of *Q. alba*. The emergence of the files is in March or early April and distributed over a period of five or six years, none probably appearing until the second spring.

130. *Cynips weldi* Beut.

An elongated cluster, 20 mm. long by 10 mm. wide, on under side on basal half of leaf of *Q. bicolor*. About a dozen galls in the closely packed cluster, color light brown. They start to develop about Aug. 1 and begin to drop in late Sept. Adults issue the next spring in the latter half of April.

131. *Cynips nigricens* Gill.

Galls not angular.

Globular, tapering below into a short stalk for attachment. In an elongated mass 6-18 mm. long consisting of from a few to about 30 closely packed light brown galls on basal third of leaf on under side. Individual galls 4-6 mm. in diameter, the basal half rusty, distal half bare and smooth, dropping in Oct. On *Q. alba* and *macrocarpa*. Emergence is in late April but does not begin until the second spring and is distributed over at least three seasons.

132. *Cynips dimorphus* Beut.

Similar in size and shape but red in color, in an elongated less compact cluster on upper or lower side of large leaves on thrifty shoots of *Q. rubra,* dropping in Oct. Pubescent under lens. Adults emerged Apr. 22-May 11 the second spring and some hang over to emerge still later.

133. *Dryocosmus piperoides* (Bass.)

Similar in shape but smaller, 2-3 mm. in diameter, whitish, sparsely covered with sprawling hairs, dropping in

Oct. In loose elongated clusters of 2-12 galls on under side of the larger lower leaves on vigorous sprouts from stumps of *Q. alba.* Galls collected in Oct. 1914 gave adults in Nov. 1915 and some hang over to emerge a year later.

134. *Diplolepis capillata* Weld

BLACK OAK WHEAT. Individual galls about size and shape of a kernel of wheat with a fleshy knob at upper end, greenish, smooth, bare. When young concealed in the swelling midrib but later bursting out of a crack in a compact cluster of from a few to 40 galls often rupturing the leaf blade so as to be visible from above, dropping in Oct. On *Q. rubra* and *velutina.* Galls collected in Oct. 1916 gave adults Mar. 23-Apr. 22, 1918.

135. *Dryocosmus deciduus* (Beut.)

d. Galls of other sorts attached separately, one or many, on a leaf.

Galls 5 mm. or more in diameter.

OAK GRAPE GALL. Large, spherical, 12-18 mm. in diameter, greenish-white, translucent, attached to under side of leaf in May, resembling a white grape. Monothalamous, smooth, bare, succulent, sour, shriveling to a shapeless black mass after the adult emerges early in June. On *Q. rubra* and *coccinea.*

136. *Amphibolips nubilipennis* (Harris)

Spherical, 6-11 mm. in diameter, covered with short felt-like grayish pubescence, the central cell supported by a layer of short dark brown radiating fibers and the outer wall thick. Attached to veins on the under side of leaf, often several on a leaf, dropping in late Sept. or Oct. and then turning brown. On *Q. alba* and *macrocarpa.* From galls collected in Oct. 1916 some adults issued Nov. 23-Dec. 11, 1916, more Nov. 1-19, 1917, more Dec. 2, 1919, all females and wingless.

137. *Philonix nigra* (Gill.)

Galls less than 5 mm. in diameter.

Spherical with a fleshy protuberance at the apex, 3-4 mm. in diameter, smooth, bare, greenish or tinged with red, bursting out of a crack in the side of midrib or main vein on under side of leaf in the fall, dropping before the leaf, but few on a leaf. Adults emerge the second or third seasons in June or July. On *Q. rubra, coccinea* and *velutina.*

138. *Dryocosmus rileyi* (Ashm.)

Spherical or slightly ellipsoidal, not depressed, 3 mm. in diameter, smooth, bare, yellowish-green or tinged with red. On upper or lower side of leaves of *Q. rubra*, dropping before the leaves in the fall. From galls collected in Oct. 1916 adults emerged Mar. 13-Apr. 6, 1918.

139. *Zopheroteras sphaerula* Weld

Spherical but depressed, pure white, bare, 3-4 mm. in diameter. On under side of leaf of *Q. alba* in the fall, dropping before the leaf. Adult probably emerges the second spring.

140. *Biorhiza rubina* Gill.

Similar, depressed, pure white, 4 mm. in diameter on under side of leaf of *Q. coccinea* in fall, dropping in Oct.

141. *Undetermined species*

WHITE OAK SPANGLE GALL. Button-shaped, 3-4.5 mm. in diameter, with a heavy rounded ring of tissue on under side between pedicel and rim, concave above with a slight nipple in center, covered with a whitish bloom. In large number on under side of leaves of *Q. alba,* dropping in the fall. The flies emerge in late March the second spring.

142. *Xystoteras poculum* Weld

SPANGLE GALL. Concave above with no papilla in center, convex below without ring-like ridge, covered with whitish bloom, 3 mm. in diameter. On *Q. bicolor* and *macrocarpa* in August. Not reared.

143. *Undetermined species*

JUMPING NEUROTERUS GALL. Small ellipsoidal galls in cup-like depressions on under side of leaf in large numbers, dropping in July or Aug. and then exhibiting the jumping movements for some time. Showing on upper surface of leaf as smooth convex elevations of a lighter color. Galls 1 mm. in length, truncate or saucer-shaped above with a papilla in center, light yellow in color. Adults emerge some time the next spring. On *Q. macrocarpa* and *bicolor.*

144. *Neuroterus saltarius* Weld

Globular, pure white, bare, smooth, 1.5 mm. in diameter, scattered on under side of leaf of *Q. alba* in the fall.

145. *Undetermined species*

Globular, red, finely pubescent with a scar at apex, 1 mm. in diameter, very numerous on under side of leaf of *Q. alba* in the fall.

146. *Undetermined species*

Galls on Oak Arranged by Hosts.

Quercus alba.

Root—	
Ellipsoidal, 5 mm., brown, on rootlets	30. Callirhytis elliptica Weld
Cells in thick bark	32. Agamic gen. of Callirhytis fultilis (O S)
Button-shaped, rugose, 10-5 mm.	36. Callirhytis badia (Bass.)
Potato-like, brown	37. Callirhytis maxima Weld
White fleshy cluster in May	38. Trigonaspis radicola (Ashm.)
Cluster of bullet galls	42. Disholcaspis globosa Weld
Acorn—	
Cells inside acorn	52. Undetermined species
Bud—	
Pea-like, mottled, in spring	58. Andricus pisiformis Beut.
Fleshy green or brown vesicle in spring	60. Neuroterus vesicula (Bass.)
Small, pointed, white, in spring	61. Diplolepis gemula (Bass.)
Small, pointed, brown, in fall	62. Callirhytis gemmiformis (Beut.)
Green, inside bud in fall	66. Callirhytis mamillaformis Weld
Blister on bud scale in spring	71. Sex. gen. of Acraspis erinacei (Beut.)
Stem—	
Oak potato gall	76-7. Sex. gen. and agamic gen. of Neuroterus batatus (Fitch)
Oak club gall	79. Callirhytis clavula (O S)
Oak seed gall	82. Callirhytis seminator (Harris)
Oak fig gall	83. Xanthoteras forticornis (Walsh)
Round bullet gall	87. Disholcaspis globulus (Fitch)
Gall unknown—probably bud or stem	93. Bassettia gemmae Ashm.
Leaf—	
Oak petiole gall	99. Andricus petiolicola (Bass.)
On prolonged vein	107. Andricus chinquapin (Fitch)
Dwarfed leaves in early spring	112. Neuroterus minutus (Bass.)
Hollow, green, spherical, 3 mm.	114. Andricus utriculus (Bass.)
Oak wart gall	115. Sex. gen. of Callirhytis futilis (O S)
Succulent thickened patch of blade	117. Neuroterus majalis (Bass.)

QUERCUS ALBA—(Concluded.)

Elliptical cells in parenchyma, 1-2 mm.	120. Neuroterus perminimus Bass.
Round cells in blade in rows near vein	121. Undetermined species
Oak pea gall	125. Acraspis pezomachoides (O S)
Hedgehog gall	126. Agamic gen. of Acraspis erinacei (Beut.)
Oak wool gall	127. Andricus flocci (Walsh)
Cluster on petiole in fall	130. Cynips weldi Beut.
Midrib cluster globular brown galls	132. Cynips dimorphus Beut.
Midrib cluster globular whitish galls	134. Diplolepis capillata Weld
Globular, 6-11 mm., felt-like	137. Philonix nigra (Gill.)
Depressed, pure white, in fall	140. Biorhiza rubina Gill.
White oak spangle	142. Xystoteras poculum Weld
Globular, white, 1.5 mm.	145. Undetermined species
Globular, red and hairy, 1 mm.	146. Undetermined species

Quercus bicolor.

Root—	
Ellipsoidal, brown, 5 mm., on rootlets	29. Callirhytis ellipsoida Weld
Button-shaped, rugose, 10-5 mm.	36. Callirhytis badia (Bass.)
Potato-like, brown	37. Callirhytis maxima Weld
Acorn—	
Fimbriate cup gall	44. Andricus incertus Bass.
Cell in cup under acorn	45. Undescribed species
Cells inside acorn	51. Callirhytis lapillula Weld
Bud—	
Pea-like, mottled, in spring	58. Andricus pisiformis Beut.
Gray, spherical, 4 mm., in fall	59. Andricus deciduatus Weld
Fleshy green or brown vesicle in spring	60. Neuroterus vesicula (Bass.)
Small, pointed, white, in spring	61. Diplolepis gemula (Bass.)
Smooth, among leafy bracts	65. Callirhytis flavohirta (Beut.)
Green, inside bud, in fall	67. Undetermined species
Stem—	
Cells under leaf scar	72. Neuroterus escharensis Weld
Noxious oak gall	78. Agamic gen. of Neuroterus noxiosus (Bass.)
Slight enlargement of new growth	81. Neuroterus distortus Bass.
Pine-cone oak gall	84. Cynips strobilana O S
Pointed bullet gall	88. Disholcaspis mamma (Walsh)
Bassett's bullet gall, conical	89. Disholcaspis bassetti (Gill.)
Leaf—	
Oak petiole gall	99. Andricus petiolicola (Bass.)
Rosette of bracts on leaf	103. Andricus foliosus Weld
Midrib swellings in spring	104. Sex. gen. of Neuroterus noxiosus (Bass.)
Small, woolly, numerous, in fall	106. Neuroterus floccosus (Bass.)
On prolonged vein	107. Andricus chinquapin (Fitch)
Oak wart gall	115. Sex. gen. of Callirhytis futilis (O S)
Elliptical cells in parenchyma	119. Neuroterus papillosus Beut.

QUERCUS BICOLOR—(Concluded.)

Oak flake gall, woolly	128. Diplolepis ignota (Bass.)
Midrib cluster in fall	131. Cynips nigricens Gill.
Spangle galls	143. Undetermined species
Jumping Neuroterus gall	144. Neuroterus saltarius Weld

Quercus macrocarpa.

Root—	
Cells in thick bark	33. Compsodryoxenus illinoisensis Weld
Button-shaped, rugose, 10-5 mm.	36. Callirhytis badia (Bass.)
Potato-like, brown	37. Callirhytis maxima Weld
Bud—	
Pea-like, mottled, in spring	58. Andricus pisiformis Beut.
Fleshy green or brown vesicle in spring	60. Neuroterus vesicula (Bass.)
Small, pointed, white, in spring	61. Diplolepis gemula (Bass.)
Smooth, among leafy bracts	65. Callirhytis flavohirta (Beut.)
Green gall inside bud in fall	67. Undetermined species
Stem—	
Pine-cone oak gall	84. Cynips strobilana O S
Pointed bullet gall	88. Disholcaspis mamma (Walsh)
Leaf—	
Oak petiole gall	99. Andricus petiolicola (Bass.)
Midrib swelling	102. Callirhytis flavipes (Gill.)
Small, woolly, numerous, in fall	106. Neuroterus floccosus (Bass.)
Dwarfed leaves in spring	113. Neuroterus vernus Gill.
Cells along veins in early spring	122. Neuroterus fugiens Weld
Spiny oak gall	123. Acraspis villosa Gill.
Ellipsoidal Acraspis gall	124. Acraspis macrocarpae Bass.
Oak flake gall, woolly	128. Diplolepis ignota (Bass.)
Midrib cluster of globular brown galls	132. Cynips dimorphus Beut.
Globular, 6-11 mm., felt-like	137. Philonix nigra (Gill.)
Spangle galls	143. Undetermined species
Jumping Neuroterus gall	144. Neuroterus saltarius Weld

Quercus rubra.

Root—	
Globular, brown, bark thin	31. Eumayria floridana Ashm.
Local swelling in bark	34. Callirhytis rubida Weld
Cluster small oval galls	39. Callirhytis enigma Weld
Cluster wedge-shaped galls	40. Dryocosmus favus Beut.
Onion-shaped, in group	41. Biorhiza caepuliformis (Beut.)
Acorn—	
Acorn plum gall	43. Amphibolips prunus (Walsh)
Acorn pip gall	46. Agamic gen. of Callirhytis operator (O S)
Green, globular, 3-4 mm., in fall	49. Undescribed species
Stony mass inside acorn	50. Callirhytis fructuosa Weld
Flower—	
Woolly white mass	53. Sex. gen. of Callirhytis operator (O S)
Like green peas	54. Callirhytis pulchra (Bass.)

QUERCUS RUBRA—(Concluded.)

Bud—	
Large, spotted, in axils, in fall	55. Amphibolips cookii Gill.
Fusiform, long-stalked, ribbed	57. Callirhytis gallaestriatae Weld
Green, inside bud in fall	68. Undetermined species
Stem—	
Horned knot gall	74. Callirhytis cornigera (O S)
Oak knot gall	75. Callirhytis punctata (Bass.)
Banded bullet gall	91. Dryocosmus imbricariae (Ashm.)
Cluster small ribbed galls in spring	92. Callirhytis gemmaria (Ashm.)
Leaf—	
Larger empty oak apple	96. Amphibolips inanis (O S)
Smaller empty oak apple	97. Andricus singularis (Bass.)
Midrib swelling	101. Callirhytis tumifica (O S)
Spherical, 10-2 mm., free-rolling cell	109. Diplolepis palustris (O S)
Hemispherical sessile blister	110. Diplolepis cinereae (Ashm.)
Elongated, pointed blister at edge	111. Diplolepis notha (O S)
Hard, lenticular, two-celled	116. Callirhytis rugosa (Ashm.)
Papillose patches on leaf	118. Callirhytis modesta (O S)
Woolly mass on midrib	129. Callirhytis lanata (Gill.)
Midrib cluster globular red galls	133. Dryocosmus piperoides (Bass.)
Midrib cluster, green, like wheat	135. Dryocosmus deciduus (Beut.)
Oak grape gall	136. Amphibolips nubilipennis (Harris)
Globular with fleshy knob	138. Dryocosmus rileyi (Ashm.)
Rosy sphere, 3 mm., in fall	139. Zopheroteras sphaerula Weld

Quercus coccinea.

Root—	
Globular, brown, bark thin	31. Eumayria floridana Ashm.
Local swelling in bark	34. Callirhytis rubida Weld
Local swelling in bark	35. Callirhytis marginata Weld
Cluster wedge-shaped galls	40. Dryocosmus favus Beut.
Acorn—	
Acorn plum gall	43. Amphibolips prunus (Walsh)
Pip gall in spring, honeydew	47. Callirhytis balanosa Weld
Stony mass inside acorn	50. Callirhytis fructuosa Weld
Flower—	
Woolly white mass	53. Sex. gen. of Callirhytis operator (O S)
Like green peas	54. Callirhytis pulchra (Bass.)
Bud—	
Cluster small greenish galls in spring	63. Callirhytis rugulosa (Beut.)
Globular, inside bud in spring	69. Undetermined species
Globular, under trees in spring	70. Undetermined species
Stem—	
Cells in twig—no gall	73. Bassettia ceropteroides (Bass.)
Oak knot gall	75. Callirhytis punctata (Bass.)
Terminal swelling of new growth	80. Callirhytis scitula (Bass.)

QUERCUS COCCINEA—(Concluded.)

Cluster fig-shaped galls in spring	85. Andricus formosus (Bass.)
Pubescent bullet in spring	90. Callirhytis ventricosa (Bass.)
Banded bullet gall	91. Dryocosmus imbricariae (Ashm.)
Cluster small ribbed galls in spring	92. Callirhytis gemmaria (Ashm.)
Leaf—	
Small oak apple, 8 mm.	98. Andricus osten sackenii (Bass.)
Midrib swelling	100. Callirhytis pigra (Bass.)
On prolonged vein	108. Diplolepis pedunculata (Bass.)
Elongated, pointed blister at edge	111. Diplolepis notha (O S)
Oak grape gall	136. Amphibolips nubilipennis (Harris)
Globular with fleshy knob	138. Dryocosmus rileyi (Ashm.)
Depressed, white, in fall	141. Undetermined species

Quercus velutina.

Root—	
Onion-shaped, in group	41. Biorhiza caepuliformis (Beut.)
Acorn—	
Acorn plum gall	43. Amphibolips prunus (Walsh)
Pip gall on young acorn in fall	48. Callirhytis balanoides (Weld)
Green, globular, 3-4 mm., in fall	49. Undescribed species
Flower—	
Woolly white mass	53. Sex. gen. of Callirhytis operator (O S)
Bud—	
Melon-shaped, 4 mm., in spring	64. Undescribed species
Stem—	
Oak knot gall	75. Callirhytis punctata (Bass.)
Banded bullet gall	91. Dryocosmus imbricariae (Ashm.)
Cluster small ribbed gall in spring	92. Callirhytis gemmaria (Ashm.)
Leaf—	
Large spongy oak apple, adults in June	94. Amphibolips spongifica (O S)
Large spongy oak apple, adults in November	95. Amphibolips confluentus (Harris)
Midrib swelling	100. Callirhytis pigra (Bass.)
Spherical, 10-2 mm., free-rolling cell	109. Diplolepis palustris (O S)
Elongated, pointed blister at edge	111. Diplolepis notha (O S)
Woolly mass on midrib	129. Callirhytis lanata (Gill.)
Midrib cluster, green, like wheat	135. Dryocosmus deciduus (Beut.)
Globular with fleshy knob	138. Dryocosmus rileyi (Ashm.)

Quercus imbricaria.

Flower—	
Woolly white mass	53. Sex. gen. of Callirhytis operator (O S)
Bud—	
Cylindrical, in spring	56. Amphibolips ellipsoidalis Weld
Stem—	
Seed-like, in cracks in bark in fall	86. Andricus excavatus Ashm.
Pubescent bullet in spring	90. Callirhytis ventricosa (Bass.)
Leaf—	
Midrib swelling	100. Callirhytis pigra (Bass.)
Swollen petiole	105. Undetermined species

Quercus palustris.

Bud—	
Cylindrical, in spring	56. Amphibolips ellipsoidalis Weld

Summary

Galls on plants other than oak		28
Galls on oak		
Root galls	14	
Acorn galls	10	
Flower galls	2	
Bud galls	17	
Stem galls	22	
Leaf galls	53	118
Total numbered galls in key		146
Undetermined	14	
Alternating generations	5	
		19
Total number of determined species in the Chicago area		127
On plants other than oak	28	
On oak	99	

PAPERS IN CHEMISTRY AND PHYSICS SECTION, JOLIET.

THE FLUORESCENCE MICROSCOPE.

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White light as we all know is composed of a mixture of color ranging from violet through indigo, blue, green, yellow, orange to red, the violet waves being the shorter, and the red the longer. When white light is passed through a prism it is broken up into these component colors and the result is known as the visible spectrum. By suitable means, there can be shown to exist at each end of the spectrum other wave lengths known as ultra violet if shorter than 3800 au, infra red if longer than 7600 au. These can be rendered visible by the power possessed by certain substances to convert these invisible wave lengths into visible ones. If the invisible infra red rays are focused by means of a suitable condenser on a piece of blackened platinum the platinum soon becomes heated to redness and emits light. This phenomenon is called calorescence or thermoluminescence and is due to the conversion of the long invisible infra red rays into shorter and visible rays.

If we now turn our attention to the other end of the spectrum we will find there are a number of substances having the property of converting the short invisible wave lengths into longer and visible ones but this time without heat being developed. Two phenomena will be observed here and will be called Fluorescence or Phosphorescence according to the way the substance under examination acts.

FLUORESCENCE—If the substance under examination emits light while under the influence of the ultra violet radiations but cease to do as soon as the exciting cause is removed the phenomenon is called Fluorescence.

PHOSPHORESCENCE—If on the other hand the emission of light by the radiated substance continues after the exciting cause is removed, it is called Phosphorescence.

Both these phenomena have been known to exist for many years but so far no satisfactory explanation for their existence has been given.

It is not the purpose of this paper to discuss the many theories relative to Phosphorescence and Fluorescence but to act as an introduction of the Fluorescence Microscope. This apparatus consists of an arc lamp provided with a suitable condensing system, a series of filters and the microscope. The arc light is fitted with carbons so prepared to deliver a light rich in ultra violet. The condensing system is of quartz which is transparent to ultra violet—the filters, 2 in number, consist: one of 2 plates of quartz mounted in a suitable holder between which is a layer of 25% copper sulphate solution. This effectively removes the light waves at the red end of the spectrum. The second filter is two plates of UV glass separated by a layer of P. nitroso dimethyl anilin. The UV glass cuts out the yellow, orange, green and blue while the P. nitroso dimethyl anilin removes the violet. The stage below the microscope is equipped with a total reflecting prism of quartz and the microscope has an Abbe condenser of the same material. Quartz microscope slides are also used in these experiments.

The objectives and eyepiece of the microscope are of the ordinary glass system, quartz not being necessary here as we are dealing with visible radiations.

Since the visible light has been filtered out of the optical system it is necessary to devise some means of showing when illuminant on the optical system is in alignment. For this purpose we use a plate of uranium glass. This is placed in the place provided for it above the quartz prism and the beam of light adjusted until this uranium glass fluoresces brilliantly over this center area. It is then removed from the prism and placed above the Abbe condenser and at this point we should have a brilliant spot of light directly over the center of the condenser. This being accomplished, the microscope is ready for use. The substance to be examined is now mounted on the quartz slide and placed on the stage of the microscope in the usual manner and if it has any fluorescent properties it will become luminous, the light emitted being characteristic of the subject under examination.

The question now arises—since this light is visible to the naked eye, why use a microscope. This is for two reasons: One—Substances which are not usually considered fluorescent may contain minute quantities of substances which are fluorescent. These may be too small to be seen with the naked eye but will be revealed by the microscope. Two—Many substances, particularly ore minerals are composed of a variety of chemical substances. When these are subjected to ultra violet radiation, the entire mass will fluoresce a single color, but examined under the microscope may be resolved into a number of different colors, each color coming from a different substance.

Minute quantities of impurities in apparently pure chemicals can be detected by this method.

Many of the algae show up beautifully when fluoresced, the chlorophyl appearing a brilliant red.

The number of substances fluorescing to ultra violet light is very great and are found in every line of research. Very little is actually known regarding the application of this phenomenon and much work will have to be done before any definite statements are made regarding the practical application of this type of microscope, or of the interpretation of the findings. However, this opens up a very wide field for research in almost every line of endeavor and gives great promise for the future.

THE SEPARATION OF OLD YTTERBIUM FROM GADOLINITE.

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In 1902, Dennis and Dales published a paper on Yttrium group separations (Journal of Amer. Chem. Soc. Vol. 24, No. 5, May, 1902). In this paper was presented one method which was shown to offer unusually rapid separation of the members of the yttrium group. Hardly enough material (Yttrium group oxides from sypilite) was at hand to permit of making a very extensive study of the most interesting fraction, which is the last one. The process referred to (reference page 430) is the one there called Fractionation with Ammonium Carbonate and dilute Acetic Acid. It is my purpose to show that nearly pure ytterbium oxide can be obtained from gadolinite by this method with comparatively few fractionations, and also to gain an idea of the approximate quantity of ytterbium oxide which can be thus obtained.

Preparation of Material.

The material used in these experiments was Gadolinite, partly because it was available and partly because it was the mineral from which Ytterbium was originally obtained. Twelve pounds of the solid dark Gadolinite was first crushed and ground to a fine powder in order to get it into a form in which it could be easily digested. The powdered material was put into large sized porcelain evaporating dishes, enough being taken to fill each dish half full. Enough Aqua Regia was then added to cover the powdered mass. The mineral was then stirred well and evaporated on air bath, nearly to dryness. Con. hydrochloric acid was added and the mass evaporated down again. The treatment with con. hydrochloric acid was repeated until no trace of chlorine was indicated when tested by the starch and potassium iodide paper method.

During the first evaporation to dryness a solid cement-like mass formed which was very slow in dissolving and was treated separately with Aqua Regia and afterwards with Con. hydrochloric acid. Continued application of this method with heat resulted in its all being broken up.

When all the material was freed from chlorine the mass was covered with con. hydrochloric acid, heated about an hour, stirred, and the whole poured into a large cylinder. Enough water and hydrochloric acid (one-half each) was added to double the volume. This was all well stirred and allowed to stand several hours for the solid part to settle. The silica settled quickly, but the silt and greenish mass (probably iron silicate) settled very slowly and formed a distinct layer on the surface of the silica. The acid solution contained a part of the rare earths of the yttrium and cerium groups; also glucinum and iron and some other impurities.

After settling quite clear the acid solution was siphoned off and just neutralized with ammonium hydroxide. A permanent brownish precipitate showed when the solution was slightly alkaline. Just enough acid was added to dissolve this precipitate. Then 25cc excess of the acid was added for 5 liters of solution, which made about the correct per cent of acidity for precipitation of the earths present. This solution was then set away while other extractions were made on the same residue. About half of the rare earths present in the gadolinite ore were extracted by the first aqua regia treatment. The process of extraction was repeated six times with profit. When these extractions were completed and the resulting solutions made slightly acid as above, the cerium and yttrium groups of earths were precipitated by adding an excess of solid oxalic acid and stirring with air. The solution required about three hours of this treatment to get complete precipitation. The oxalate precipitates settled readily to the bottom.

The supernatant liquid was siphoned off from the above. This solution contained iron and glucinum as they do not form precipitates with oxalic acid in dilute acid solutions. If too much hydrochloric acid is added before treating with oxalic acid, some of the cerium and yttrium group oxalates may not precipitate completely, as some are slightly soluble in dilute acid solutions. To be sure that all of the cerium and yttrium oxalates were all precipitated the solution was partially neutralized with ammonium hydroxide and treated again with oxalic acid crystals. No glucinum will precipitate as long as the solution is acid with oxalic acid or hydrochloric acid. Some cerium and yttrium groups of earths were recovered by this treatment. When all the cerium and yttrium earths were removed, the glucinum and iron were precipitated from the solution by adding an excess of ammonium hydroxide. This precipitate was saved on account of the glucinum which it contained. The remaining solution was discarded as it contained only ammonium salts and some impurities.

The white oxalates secured as described above were washed a number of times in large cylinders by siphonation with distilled water. They were finally washed in a Buchner funnel with distilled water using strong linen fibre filter papers.

The oxalates were removed on the filter paper to an air bath, heated at a temperature of 105 degrees C. or higher until thoroughly dry. This required several hours. A temperature of 140 degrees C. did no harm to the precipitate. Heat may be applied until the paper begins to char. Too great a temperature would partially convert the oxalates into oxides and make the mass hard to dissolve later.

The oxalates were then powdered very fine in a mortar and ignited in small quantities in a quartz evaporator. The powder must be stirred all the time in order to prevent the lower portion from becoming over-heated. A light gray color indicates that the oxalates have been converted into carbonates, which is the form desired. Too much heat will convert the carbonates to oxides, which because of the cerium present makes it hard to dissolve. On the other hand, if not heated enough, the oxalates will not be destroyed. If a small amount of oxalate precipitate is left over it will be destroyed later by nitric acid.

The carbonates of the earths secured as described above were then treated with concentrated nitric acid and hydrogen peroxide. One liter of concentrated nitric acid was put in a large porcelain evaporating dish, heat applied and the earths added as long as they would dissolve. (1.5 kgm of Carbonate for 1 liter of nitric acid.) About 50cc of hydrogen peroxide was added to put the last of it in solution. Several hours time with heat was required to dissolve the carbonates. The solution with a slight trace of sediment was then put into large cylinders and allowed to settle two days. Some of the sediment dissolved in that time. The material left on the bottom of the cylinder then was mostly carbon and oxides that were difficultly soluble (probably mostly cerium di-oxide). This strong acid solution was filtered through a double filter in a Buchner funnel. The solution was then neutralized with ammonium hydroxide. Acid and alkali were added slowly to get the exact neutral point. The solution was stirred continuously with air to aid in getting this result. Two days' time was allowed for this treatment to be certain of the neutral point. When exactly neutral, the solution was subjected to the alkaline sulphate treatment for the removal of the cerium group. An excess of sulphate was added and stirred for two days to get complete reaction. Time seemed to be a factor in getting this reaction. One treatment with alkaline sulphate was not sufficient to remove all of the cerium group. In fact, seven treatments were necessary before the absorption spectra of old didymium disappeared. The alkaline sulphate used was mostly potassium sulphate, but some sodium sulphate was used. After each sulphate treatment the earths had to be precipitated and washed free from sulphate. The precipitation and washing of the hydroxides was tried, but was found to be too tedious. The precipitation of the earths as oxalates was found to be the most satisfactory. The oxalate precipitate was washed free from sulphate, filtered on a Buchner funnel and dried in an air bath. The oxalates were then powdered, roasted to carbonate and the carbonates dissolved in nitric acid. After the above described treatments the solution then left was supposed to contain only yttrium group elements.

Fractionations.

When the last treatment was finished the yttrium group earths were left dissolved in nitric acid. The earths were precipitated from this solution by ammonium hydroxide and washed. These hydroxides were dissolved in saturated ammonium carbonate solution. The high atomic weight material dissolves very readily. That of lower atomic weight dissolves more difficultly and cerium and didymium hydroxides if present remain largely undissolved. I found that the ammonium carbonate solution would dissolve more earths if it had some ammonia water added to it (1 to 10). This was doubtless due to the presence in the solution of carbamate or other carbon compounds from the solid ammonium carbonate used. The best results were obtained by adding the earth hydroxides in small quantities to the ammonium carbonate solution and stirring until the solution was saturated. When the ammonium carbonate solution was poured onto the earth hydroxides a much larger quantity of ammonium carbonate was required to effect solution, as a sort of coating was formed over the mass of hydroxides which would not readily dissolve. The excess of earths remaining in each jar after the solution was saturated, was filtered off. This would not dissolve readily in ammonium carbonate so it was dissolved in nitric acid, reprecipitated with ammonia and then dissolved in fresh ammonium carbonate solution.

After all the earths were dissolved in saturated ammonium carbonate they were fractioned with acetic acid solution. First the ammonium carbonate solution of the earths was treated with concentrated acetic acid to destroy the excess of ammonium carbonate present. The acid had to be added slowly and the mixture stirred well on account of bubbling. The appearance of a very faint cloud indicated the end point. In working with a sample of the solution it was found necessary to give considerable time to this treatment because when the acid was added rapidly to a cloud a large precipitate would fall on standing several minutes. After bringing the whole solution to a faint cloud a sample of it was tried with different quantities of one-thirtieth strength acetic acid solution (1 acid to 29 water) to determine what proportion of this strength acid was necessary to obtain maximum precipitation. At this point Dennis and Dales used the amount of one-thirtieth acetic acid solution necessary each time to give maximum precipitation. This gave from 4 to 6 fractionations, but the last one, while the most interesting, was very small. In an effort to increase the amount of this last fraction without impairing the efficiency of the fractionation, I used a quantity of one-thirtieth strength acetic acid less than that required for maximum precipitation. In the first part of the work one-fifth the amount of one-thirtieth strength acetic acid necessary for maximum precipitation was used. This amount was estimated in the following way:

Example.

18 tubes—10 cc each (clouded as described above).
Added 1 cc of 1-30 acet. to 1st tube.
Added 2 cc of 1-30 acet. to 2nd tube.
Added 3 cc of 1-30 acet. to 3rd tube.
Added 4 cc of 1-30 acet. to 4th tube, etc.

I found the maximum precipitation in the 15th tube. Thus 15cc of one-thirtieth strength acetic acid in 10cc of sample gave maximum precipitation. I used one-fifth that amount or 3cc of one-thirtieth strength acetic acid for each 10cc of sample. This was added slowly to prevent too rapid bubbling. A granular precipitate slowly settled to the bottom forming the first fraction. This was filtered off. On trial it was found that this same amount of acetic acid would not produce a precipitate in the remaining solution, but that it was necessary to bring the solution to a cloud again. After determining the amount necessary then for maximum precipitation in the clouded solution, it was treated in the same way with one-fifth that amount. The precipitate thus formed was filtered off and was known as fraction number two.

The ammonium acetate then in the solution prevented further fractions from being properly extracted from this solution, because the earths are readily soluble in ammonium acetate. The remaining carbonate present was destroyed with nitric acid and the earths removed from the solution by precipitating with ammonium hydroxide.

The earth hydroxides were filtered in the Buchner filter and again dissolved in saturated ammonium carbonate solution. The ammonium carbonate solution was again brought to a faint cloud to destroy the excess of carbonate. Tests were then made as before to determine how much one-thirtieth strength acetic acid was necessary to give maximum precipitation. This time only one-tenth of the estimated amount was used. The precipitate thus obtained formed the third fraction. The fourth fraction was obtained from this solution using the same plan as used in getting fraction number two except that one-tenth the calculated amount of dilute acetic acid solution was used the same as in fraction number three.

The small amounts of earths then remaining in solution formed the last two fractions. The carbonate solution in which they were dissolved was destroyed as before with nitric acid and the earths precipitated as hydroxides. The hydroxides were put into solution in ammonium carbonate and the fifth fraction extracted the same as the third. The earths remaining in solution then were taken as the sixth fraction. This was supposed to contain the most of the ytterbium, as the low atomic weight metals are supposed to precipitate first.

This series of fractions just described was known as Series 1. Three other series of fractionations were run upon different fractions of the first series in order to get out all the ytterbium possible. The second series consisted of six fractions. The material used for this series of fractionations was obtained by putting together the largest part of the earths obtained in fractions 1 and 2 of series 1. Only a small amount of each fraction was saved as a sample and for atomic weight determinations. Series 3 consisted of 4 fractions and was made from a combination of the fifth fraction of the first series and the sixth fraction of the second series. Series 4 consisted of six fractions and was made from a combination of the third and fourth fractions of the first series and the fourth and fifth fractions of the second series.

Atomic Weight.

The sulphate method was used in determining the atomic weight. The particular modification of this method that was used was the dissolving of the oxides in dilute hydrochloric acid and converting to sulphates by the addition of dilute sulphuric acid. The liquid was evaporated as far as possible on the water bath. Then the excess of sulphuric acid was driven off by heating the platinum crucible and contents in an asbestos nest in a large iron crucible.

Series 1—Fractionation

Fraction	Wt. Gm.	Color of Oxide	At. Wt.
1	550	strong buff	100.5
2	135	buff	100.2
3	85	mild buff	109.8
4	20	nearly white, rose tint	138.0
5	3.28 oxide	white, slight rose tint	153.0
6	3.65 oxide	white	173.5

The buff color is due to Terbium content. Its oxide is deep brown, but in small quantities gives buff.

Series 2—Fractionation

Made from a combination of 1st and 2nd fractions of Series 1.

Fraction	Wt. Gm.	Color of Oxide	At. Wt
1	300	very strong buff	99.1
2	105	strong buff	101.7
3	90	buff	104.1
4	35	slight buff	113.9
5	8	white, rose tint	114.6
6	3.42	white, slight rose	146.7

Series 3—Fractionation

Made from a combination of 5th fraction of 1st series and 6th fraction of 2nd series.

Fraction	Wt. Gm.	Color of Oxide.	At. Wt.
1	2 oxide	white, slight rose	130.1
2	1.5 oxide	white, slight rose	142.3
3	1.5 oxide	white, slight rose	154.6
4	1.6 oxide	white	163.2

Series 4—Fractionation

Made from a combination of fractions 3 and 4 of the first series, and fractions 5 and 6 of the second series.

Fraction	Wt. Gm.	Color of Oxide
1	60	Buff
2	50	Buff
3	25	Light Buff
4	10	Light Buff
5	1.5	Very light buff
6	1.0	White, slight rose

The sixth fraction in this series gave an atomic weight of 146.

The last fraction in each series was examined with the spark spectrum. Each fraction examined showed the presence of ytterbium. As would be expected, the last fraction of the first series gave the strongest test, showing nearly pure ytterbium.

Conclusion.

The research has shown that the method employed of fractioning yttrium group earths with dilute acetic acid in ammonium carbonate solution is a very satisfactory method. The last fraction of the first series gave an atomic weight of 173.5. When these experiments were finished this value was thought to be too high for pure ytterbium, but later atomic weight determinations show the correct atomic weight of ytterbium to be 173.5, which is exactly the atomic weight secured for this fraction which is supposed to be the fraction containing the purest ytterbium. In the past, thousands of fractionations have been made in order to separate out a single rare earth element. By the process presented here, very pure ytterbium was evidently prepared from Gadolinite in six fractionations.

THE EVOLUTION OF THE INCANDESCENT LAMP.

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The year 1820 probably marks the first attempt at making an actual incandescent lamp. In that year De la Rue built a lamp consisting of a coil of platinum wire in a glass tube the ends of which were covered with brass caps and from which the air could be exhausted.

In 1840 Sir William Robert Grove made an experimental lamp by attaching the ends of a coil of platinum wire to copper wires, the lower parts of which, or those most distant from the platinum, were well varnished for insulation. The copper wires were fixed erect in a glass of distilled water and another cylindrical glass placed over them, so that its open mouth rested on the bottom of the former glass. This prevented draughts of air from cooling the incandescent platinum, and the small amount of oxygen in the tumbler reduced the amount of oxidation of the platinum that would otherwise occur. He lighted the auditorium of the Royal Society with these lamps during one of his lectures, the current being supplied by a large number of cells of his improved primary battery.

During the thirty odd years following Grove's demonstration, several experiments, of more or less significance, were made on incandescent lamps. In 1845, J. W. Starr, a young American, invented two lamps. One had a platinum strip the length of which could be adjusted to fit the strength of the battery used. The other consisted of a carbon rod operating in the vacuum above a column of mercury as in a barometer.

In 1859, Professor Moses G. Farmer of the Naval Training Station at Newport, Rhode Island, lighted the parlor of his home at Salem, Massachusetts, with strips of platinum operating in air. The platinum strips of these lamps were narrowed at their terminals to increase the resistance of these points so that the strips were uniformly incandescent throughout their entire lengths. The terminals conducted the heat away from the burner tending to lower the temperature of the platinum at the points of contact which was offset by the greater resistance at these points.

In the year 1872, a Russian scientist by the name of Lodyguine made a lamp consisting of a "V" shaped piece of graphite operating in nitrogen gas. He lighted the navy dockyard at St. Petersburg with two hundred of these lamps.

Kosloff, another Russian scientist, in 1875, made a lamp having several graphite rods for burners which operated in nitrogen gas. They were so arranged that one rod operated at a time, and when it burned out, another was automatically put in circuit. During the same year, Konn made a similar lamp having the graphite rods operating in a vacuum.

Up to this time the development of the incandescent lamp was more of an experimental nature than commercial. The arc lamp had come to take its place in the field of commercial artificial lighting.

While the arc lamp was being commercially established, and though proving to be adaptable to various forms of industrial lighting, it was at once seen that it was too large a unit for household use. Of the many inventors who attacked the problem of making a smaller unit, the first of prominence was William Edward Sawyer, assisted by Albon Man.

In 1877, Sawyer developed his "electric candle" consisting of a rod of preferably white refractory substance, such as clays, lime, etc., around which was coiled a platinum wire or wires. An electric current heated the wires to incandescence. The heat of the incandescent platinum wires was transferred to the refractory substance, causing the latter to glow with a soft light.

Sawyer early realized that platinum was too costly a substance and the results too unsatisfactory to permit it to ever be developed for practical commercial use. Sawyer abandoned the idea in favor of carbon. In the year 1878, Sawyer made several lamps embodying a carbon burner operating in an atmosphere of nitrogen gas.

In February, 1878, Sawyer made a lamp consisting of a piece of gas-retort carbon heated to incandescence by an electric current in a Florence flask, through which a stream of ordinary illuminating gas was kept flowing. This atmosphere was employed because it contained no oxygen to unite with and destroy the carbon while in an incandescent state.

An experiment made on March 6, 1878, in which paper was accidentally carbonized while being used as a convenient receptacle for a fine line of powdered graphite, first suggested that this material might perhaps be made into carbon useful in incandescent electric lighting.

Sawyer and Man spent considerable time experimenting on the carbonization of paper. One time Man took a piece of paper embedded in graphite in a closed vessel and carbonized it by subjecting it to a high temperature in his kitchen range. He then took the carbon structure, all that was left of the paper, and placed it in a flask charged with hydro-carbon gas and brought it to incandescence by passing an electric current through it. The latter part of this experiment, that of heating to incandescence in an atmosphere of hydro-carbon gas the filament of carbonized paper, developed into a very important process in the manufacture of carbon lamps. This process was called "flashing," "re-carbonizing" or "treating" and was later developed to a very high degree of perfection. Before treating, all filaments, those of Sawyer's and Man's carbonized paper filaments and the later carbonized cellulose filament, varied more or less in diameter. At the points of smaller diameter the resistance was greater, and therefore the heat was greater, thus augmenting disintegration. In the process of treating, the filament was suspended in an atmosphere of hydro-carbon vapor, which was at a considerably reduced pressure and brought to incandescence by passing an electric current through it. The hot filament decomposed the vapor, depositing graphite on the filament. Due to the increased heat at the thinner portions of the filament, those portions were built up more rapidly than the thicker portions, until in a few seconds the entire filament was of a practically uniform thickness. This treating process considerably lengthened the life of the filament by giving it a uniform resistance throughout its length. Perhaps the most valuable and important result of the hydro-carbon treatment consisted in its capacity for giving to the filament surface the highest possible power of luminous radiation.

After spending considerable time experimenting with carbonized paper, wood and other fibrous materials, Sawyer and Man, had by June, 1878, constructed incandescent lamps capable of burning for many days. One lamp was run for many weeks at a luminosity of from one hundred to two hundred candle-power.

Thomas A. Edison began experimenting with the incandescent lamp in the Spring of 1878. Edison first made many experiments to confirm the failure of Sawyer and Man and others. Convinced of the seeming impossibility of carbon, he turned his attention to platinum as a light giving element. After considerable experimenting, he made a lamp having a long coil of fine platinum wire mounted on pipe clay. This was put in a one-piece all glass globe from which the air had been exhausted to effect a high degree of vacuum.

This lamp was expensive to make and to renew. By this time Edison was beginning to realize the impracticability of using platinum for the burner and, as had his predecessors already deemed it expedient to do, was turning his attention to carbon. After several trials he finally was able to carbonize a piece of ordinary sewing thread, with which he made a carbon filament vacuum lamp. On October 21, 1879, current was turned into the lamp and it lasted 45 hours before it failed. A patent was granted on this lamp January 27, 1880. All incandescent lamps made today embody the basic features of this lamp. The efficiency of the lamp was about 1.4 lumens per watt. Edison immediately began searching for the best material for a filament and soon found that carbonized paper gave several hundred hours life. The first commercial Edison incandescent lamps had carbonized paper filaments. The first commercially successful installation of the Edison incandescent lamps was made on the steamship Columbia, which started May 2, 1880, on a voyage around Cape Horn to San Francisco, California.

The carbonized paper filaments were quite fragile. Carbonized bamboo was found to be not only sturdy but it made an even better filament than carbonized paper. Carbonized bamboo filament lamps were introduced early in 1880. The filament material for this lamp was selected from about 6000 specimens gathered from many parts of the world. The average life of these lamps was 792 hours, though occasionally some would burn as long as 3000 hours.

The efficiency of these lamps was about 1.6 lumens per watt.

The year 1886 marked the introduction of the squirted cellulose filament lamp. The filaments of these lamps were made according to what was known as Swan's Squirting Process. By this process a perfectly structureless and uniform thread was produced by pressing a viscid solution of nitro-cellulose or of cellulose through glass jets into a coagulating liquid. The thread as it emerged from the jet had sufficient tenacity to maintain continuity until it was deposited in a coil on the bottom of the vessel containing the coagulating liquid which was usually alcohol of a certain strength. The coil was transferred to washing vessels and treated until nothing remained but a beautifully smooth and transparent length of pure and structureless cellulose thread. This cellulose thread was dried under tension, passed through polishing dies and carbonized. The squirted cellulose filament lamps not only had a longer useful life than the former carbon lamps, but were much more uniform in quality. The efficiency was increased to 2.5 lumens per watt.

In 1893 the filaments of the carbonized bamboo lamps were "treated" by the hydro-carbon process developed by Sawyer and Man.

In 1896 the squirted cellulose filaments were also "treated." By this time lamps were being made in relatively large quantities. The treated cellulose filament lamps had a longer life and their efficiency was about 3.3 lumens per watt.

Dr. Auer Von Welsbach, the German scientist who had produced the Welsbach gas mantle, invented an incandescent lamp having a filament of the metal osmium. It was commercially introduced in Europe in 1905 and a few were sold, but it was never marketed in this country. It had an average efficiency of 5 lumens per watt. Osmium is very rare and difficult to obtain. It is also very brittle, so that the lamps were extremely fragile.

In 1905 the Gem Metalized Filament Lamp was put on the market. The filament of this lamp was carbon which had been so changed by subjecting it to the intense heat of an electric furnace that it more nearly resembled a metal in its resistance characteristics; hence the term "Metalized

Filament." Like the metals, the filament of the Gem lamp had a positive temperature co-efficient, causing an increase in resistance with increased temperature. This feature gave the lamp in a measure, the self regulating quality of the high efficiency metallic filament lamps that were later developed. The Gem lamp could be burned on a slightly fluctuating voltage with comparatively small variation in light output. The efficiency of these lamps was 4 lumens per watt.

Von Bolton produced the tantalum lamp which was put on the market in this Country in 1906. The metal tantalum had been known to science for about a century. After considerable experimenting, he finally obtained some of the pure metal and found it to be ductile so that it could be drawn out into a wire. It has a low specific resistance so the filament had to be much longer and thinner than the carbon filament. It had a good maintenance of candlepower during its life, having an average efficiency of about 5 lumens per watt. The life on alternating current was considerably shorter than on direct current, due to more rapid crystallization of the filament.

The first tungsten lamp was placed on the American market in 1907. It had a pressed tungsten filament, produced by making a paste of tungsten powder and a carbonaceous material and squirting the paste into a thread through diamond dies. The pressed tungsten filaments were quite fragile. These lamps had an efficiency of 8 lumens per watt.

After several years of experimenting, Dr. W. D. Coolidge of the Research Laboratories of the General Electric Company, made the remarkable discovery that under proper conditions of working, the crystals of the metal tungsten were drawn out into fibres and in that state the tungsten filament was no longer brittle but ductile. His first success was obtained by repeatedly drawing a tungsten filament under careful heat conditions through heated dies. On the basis of this discovery a commercial process was developed and drawn tungsten filament lamps were put on the market in 1911.

This improvement brought the efficiency of vacuum lamps to about 10 lumens per watt.

Soon after the introduction of the tungsten filament vacuum lamp, chemicals were put in these lamps to improve their maintenance of candlepower during their life. "Getters" was the name given to these chemicals. One of the getters used had thallic chloride as a base. This salt dissociated with heat, releasing chlorine gas which combined with the tungsten as it vaporized from the filament while the lamp burned. The otherwise black deposit of tungsten on the inside walls of the bulb was converted into tungsten chloride which is light in color, thus cutting off less light from the filament during the life of the lamp. Many improvements have been made in the use of getters. By the method now in use, the getter is put directly on the filament and when the lamp is lighted for the first time, the getter vaporizes, condensing on the inside walls of the bulbs, coating them with an invisible layer ready to take care of the vaporizing tungsten as it strikes the bulb. By the use of getters the mean efficiency of lamps throughout their life is improved by about 10 per cent.

The higher the temperature at which an incandescent lamp filament can be operated, the more efficient it becomes. The limit is reached when evaporation of the tungsten becomes so rapid as to appreciably shorten the life of the lamp. If, therefore, the evaporating temperature can be slightly raised, the efficiency will be greatly improved. This was accomplished by Dr. Irving Langmuir by operating a tungsten filament in an inert gas, namely, nitrogen. This gas principle had been tried by Edison and others many years before but it was not successful with the straight filament on account of heat losses through the gas in the bulb. To overcome the excessive heat losses, the filament was coiled, thus presenting a smaller surface to the currents of gas and thereby reducing this loss. The gas-filled lamps were commercially introduced in 1913.

The first gas-filled lamps were the 750 and 1000 watt sizes. To offset the heat that is constantly being conducted away by the gas of these lamps, an increased amount of electrical energy is required. In the vacuum lamp, this heat loss is held to a minimum, the filament tending to stay hot on the principle of the vacuum bottle. This loss in a gas-filled lamp becomes relatively great in a filament of small diameter, as the surface in proportion to the volume of the filament increases with decreasing diameter. Hence, there is a point where the gain in temperature is offset by the heat loss. Below this point the efficiency of the gas-filled lamp decreases. By the end of the year 1914, the smallest gas-filled lamp was the 200 watt size. However, in 1915, the use of nitrogen gas in the gas-filled lamps was discontinued and argon gas was used. Argon has a poorer heat conductivity than nitrogen, thereby reducing the heat loss of the lamp which becomes of increasing importance the lower the wattage of the lamp. The present day gas-filled lamps contain argon gas. It is now possible to make an efficient commercial lamp as low as 50 watts for 115 volt circuits. The present standard 1000 watt gas-filled lamp has an efficiency of 21 lumens per watt. The 1000 watt projection lamp has an efficiency of 26 lumens per watt.

STANDARDIZATION OF ACIDS WITH CARBONATES AND WITH BICARBONATES.

JAMES H. RANSOM, JAMES MILLIKIN UNIVERSITY, DECATUR, ILLINOIS.

The original purpose of the investigation was to compare the results of standardizing acids with carbonates and bicarbonates. Usually the instructions are to convert a good grade of the bicarbonate into carbonate and with the latter as primary standard titrate the acid against a known weight of it. The method is time-consuming and, in the hands of inexperienced students at least, is not always satisfactory. Any inaccuracy has been thought to be due to incomplete conversion of the bicarbonate during the heating. If the purity of the bicarbonate could be relied upon it would seem to be a better method to titrate directly with the bicarbonate. The reason for not doing so has probably been due to the belief that the purity of the bicarbonate could not be relied upon. It occurred to the author to compare the results in the normality of some acid by titrating it against a number of bicarbonates and the carbonates made from them. And since in the titration of carbonates they are first converted completely into bicarbonates, using phenolphthalein as indicator, when one-half the total volume is used it seemed desirable to observe whether the change in color of indicator occurred when one-half of the total volume was used. The results were so different from the theory that it seems desirable to include data on both points. In the titration of carbonates phenolphthalein was used in the first half and methyl orange in the second part. With bicarbonates only the latter indicator was used.

The preliminary work was carried out with a fairly good grade of sodium bicarbonate, and was titrated with sulphuric acid of nearly two normal. While the results were in the same direction as those obtained later with purer material and a more dilute acid it is felt that the possible errors are so great as to warrant their not being included in the published report. It was soon seen that it would be necessary to establish the normality of the acid to be used by some independent method. Consequently a solution of hydrochloric acid of approximately two-tenths normal was prepared and its strength accurately determined as follows: Duplicate samples of silver nitrate, of high purity were precipitated with excess of hydrochloric acid and the weight of the silver chloride compared with that of the nitrate. The ratio, AgNO3: AgCl in the duplicates was 1: .8434 and .84367. Theory for pure silver nitrate is .84377. A standard solution of this nitrate was then prepared and the solution titrated against a solution of sodium chloride made by dissolving 5.846 gms of very pure salt in a liter of solution. As a result of nine closely agreeing titrations the normality of the salt solution was found to be .1005 using two-tenths normal silver nitrate, and .10007 against one-tenth normal silver nitrate. The two-tenths normal silver solution, considering it to be exact within experimental error, was then titrated against the acid solution previously prepared, after neutralizing the acid with sodium hydroxide, using potassium chromate as indicator. The average of ten closely agreeing results gave a normality of .194 for the acid. With this acid and a sample of "certified" sodium bicarbonate, obtained especially for the purpose, the following work was carried out. At first, ordinary distilled water was used as solvent for the bicarbonate, the volume being indefinite but between 200 and 350 cc for each determination. Later the water was freshly boiled but not measured; and finally accurately measured volumes of the freshly distilled and cooled water were used and protected with sodium hydroxide from absorption of carbon dioxide. With each table the conditions are indicated. The bicarbonate was dried at 50° to 70° and tested for alkali reaction with phenolphthalein, (p. p below) giving negative results. In titrating the burette was filled to the zero mark for each

TABLE I.
ORDINARY DISTILLED WATER IN INDEFINITE VOLUMES.
Methyl orange (M. O.) used as indicator.

Exp. No.	Wt. of NaHCO3	Vol. HCl M. O.	Wt. NaHCO3 per cc HCl	Normality found
1	.5625	35.1	.0160256	.1908
2	.5733	35.7	.0160588	.1911
3	.4778	29.8	.0160335	.1909
4	.3905	24.33	.0160501	.1910
5	.2867	17.94	.0159816	.1902
6	.3962	24.6	.0161057	.1917
7	.3834	23.85	.0160755	.1913
8	.3371	20.95	.0160907	.1915
9	.3638	23.00	.0160130	.1906
Average of 9 results			.0160483	.1910

titration and nearly the same volume used in order to eliminate errors due to inexact calibration.

While these titrations were being carried out a quantity of the same bicarbonate was heated in a sand bath to 300 until constant weight was secured. 8.9597 gms. bicarbonate on heating two days lost 3.2980 gms. The theoretical loss for the pure carbonate is 3.3065 or .09 of one per cent more.

TABLE II.

Titration of Sodium Carbonate Made from the Bicarbonate Used Above. Ordinary Distilled Water, Indefinite Volumes.

Exp. No.	Wt. of Na2CO3	Vol. HCl P.P.	Vol. HCl M.O.	Ratio P.P:M.O.	Vol. HCl Total	Normality found	Average
1....	.2056	10.05	10.75	1:1.07	20.8	.1865	
2....	.2477	12.10	12.70	1:1.05	24.80	.1884	....
3....	.2695	13.40	13.60	1:1.01	27.00	.1883	.1877
Freshly boiled, distilled water, indefinite volumes.							
4....	.3085	14.95	15.85	1:1.06	30.80	.1889	
5....	.2634	12.50	13.55	1:1.08	26.05	.1907	
6....	.2981	14.65	14.90	1:1.01	29.55	.1903	
7....	.2924	14.22	14.68	1:1.03	28.90	.1908	
8....	.2895	13.80	14.90	1:1.07	28.70	.1903	.1902
200cc of freshly boiled, distilled water was used.							
9....	.3290	16.51	16.05	1: .97	32.56	.1906	
10....	.2771	13.62	13.78	1:1.01	27.40	.1908	
11....	.2634	12.77	13.23	1:1.03	26.00	.1911	.19083
300cc of freshly boiled, distilled water was used.							
12....	.2898	13.40	15.00	1:1.12	28.40	.1925	
13....	.2184	10.45	11.05	1:1.06	21.50	.1916	
14....	.3180	14.65	16.60	1:1.13	31.25	.1920	.19203
400cc of freshly boiled, distilled water was used.							
15....	.1895	9.35	9.77	1:1.04	19.12	.1895	
16....	.3583	17.10	18.10	1:1.05	35.20	.1920	
17....	.2258	10.70	11.70	1:1.09	22 40	.1910	
18....	.2244	10.60	11.55	1:1.09	22.15	.1911	.1909

Average ratio of volumes, P.P.:M.O. 1:1.054

Data for potassium carbonate and the bicarbonate. In tables 3 and 4 ordinary chemically pure potassium carbonate was used after heating it for some time to 255° and allowing it to cool in a desiccator. For table 3 the acid used was approximately one-tenth normal while in table 4 the acid was approximately two-tenths. Since the problem now was to study the relative volumes in the first half of the titration (phenolphthalein as indicator) as compared with the last half (methyl orange as indicator) the exact normality of the acid was not important. In the first experiment of table 3 and the last three experiments of table 4 ordinary distilled water was used. In the others freshly boiled distilled water was employed as solvent for the carbonate. In experiment 1 of table 3 the volume for the phenolphthalein titration is evidently far wrong though the total is only slightly too high. For some reason the relative volumes in the two parts of the titration are not constant as would be expected. This part of the work was done in the first part of the investigation and it is possible that the end point for phenolphthalein was not as accurately judged as in later work.

TABLE III.

Exp. No.	Wt. of K2CO3	Vol. HCl P.P.	Vol. HCl M.O.	Ratio P.P.:M.O.	Vol. HCl total	Normality found	Average
1.....	.5131	32.31	42.49	......	74.8	.09941	
2.....	.1766	12.4	13.5	1:1.09	25.9	.09881	
3.....	.1411	9.58	11.32	1:1.19	20.90	.09785	
4.....	.1230	9.2	9.05	1: .98	18.25	.09767	
5.....	.0768	5.45	6.3	1:1.15	11.75	.09474	

Disregarding the last which is far too low the average normality is .09843, and the greatest variation from this is one per cent.

TABLE IV.

Exp. No.	Wt. of K2CO3	Vol. HCl P.P.	Vol. HCl M.O.	Ratio P.P.:M.O	Vol. HCl total	Normality found	Average
1.....	.2706	9.00	9.5	1:1.06	18.5	.2119	
2.....	.3545	11.7	11.8	1:1.00†	23.5	.2180	
3.....	.2138	7.2	7.2	1:1.00	14.4	.2152	
4.....	.2126	7.00	7.2	1:1.03	14.2	.2169	
5.....	.3509	10.9	12.6	1:1.15	23.5	.2164	
6.....	.3023	9.6	10.4	1:1.08	20.00	.2190	
7.....	.4160	12.2	15.5	1:1.27	27.7	.2176	.2164

If No. 1 is omitted the average normality is .2172, and the greatest variation from this average is less than one per cent, while the variation between the lowest and highest is less than two per cent. In the first four experiments of this table the volumes in the two parts of the titration are nearly the same, and much nearer than in any of the rest of the work. They are within experimental error of what theory demands.

The following work was done with potassium carbonate made by heating to 300°, the highest grade of purity of the bicarbonate. In the first four experiments ordinary distilled water was used as solvent. With the others freshly boiled water was used. The carbonate is quite deliquescent and so after heating the carbonate was cooled in a closed weighing bottle enclosed in a desiccator. The acid used had a normality .194.

TABLE V.

Exp. No.	Wt. of K2CO3	Vol. HCl Phe. Phth.	Vol. HCl M.O.	Ratio P.P.:M.O.	Vol. HCl total	Normality found	Average
1.....	.4029	14.3	16.2	1:1 15	30.5	.1908	
2.....	.6444	23.8	25.15	1:1.05	48.95	.1904	
3.....	.2522	8.82	10.72	1:1.21	19.54	.1870	
4.....	.4690	17.08	18.52	1:1.08	35.60	.1911	
5.....	.5098	18.30	20.50	1:1.12	38.80	.1904	
6.....	.3588	13.15	14.15	1:10.7	27.30	.1901	
7.....	.3010	11.00	12.20	1:1.11	23.2	.1880	
8.....	.3614	13.30	14.10	1:1.06	27.4	.1911	
9.....	.4094	14.9	16.10	1:1.07	31.00	.1914	.19007

Average of the last four in which the water had been boiled, .19025. Omitting the two which are abnormally low, for some unknown reason, the average of the seven is .1908. In every case the volume of acid in the first part of the titration is appreciably less than in the second part. The volume in the second part is quite consistently nearly 1.1 times that of the first part. The notable exception is where the calculated normality is unusually low indicating that the volume used was too high, possibly in the second part.

The following titrations of the acid (used above) were made directly with the potassium bicarbonate from which the carbonate used in table 5 was prepared. Ordinary distilled water was used as there seems no reason why free carbonic acid in the water should effect the volume of acid needed.

TABLE VI.

Exp. No.	Weight KHCO3	Volume HCl	Wt. perce HCl	Normality found	Average
1..........	.9263	48.5	.019099	.1910	
2..........	.5832	30.6	.019059	.1906	
3..........	.7194	37.6	.019133	.1913	
4..........	.4554	23.72	.019198	.1919	.1912

Discussion of results:

The normality of acids as determined from titration against either carbonates or bicarbonates, at least this is true for dilute solutions of hydrochloric acid, has a smaller value than when determined from precipitation methods. In the case at hand the normality of hydrochloric acid as determined from precipitation of silver chloride, or when titrated against standard silver nitrate had a normality of .194. When titrated against either sodium bicarbonate or potassium bicarbonate the normality found was .191; and when either of the carbonates, made from the bicarbonates, was used the normality was slightly less. Not only was the average less, but not one of the single determinations equaled the theoretical value, .194.

In titrating carbonates in the presence of two indicators, phenol phthalein for the first action, $Na2CO3+HCl$—$NaHCO3+NaCl$, and methyl orange for the second action, $NaHCO3+HCl$—$H2CO3$—$NaCl$, in all but two or three titrations the volumes in the second part were larger by 1.05 to 1.1 times, though the agreement was not close in the various cases. The normality of the acid calculated on the basis of the first part of the titration of sodium carbonate with phenol phthalein was on the average .1957, or slightly more than the theoretical, .194. The lowest value was .190, and the highest, .203. With potassium carbonate the corresponding average was .1996, the lowest again being .196 and the highest .207.

Conclusions:

If any conclusions are justifiable from the data presented they seem to be the following:

1. The normality of acids as found from the titrations of either carbonates or bicarbonates is below the real normality.

2. The normality found through the bicarbonates is slightly above that found through the carbonates.

3. The normality found through that part of the titration in which phenol phthalein is used as indicator is slightly above the real normality. This seems to mean that the volume of acid used in this part is less than that needed to convert the carbonate into the bicarbonate, while the volume needed to convert the bicarbonate into carbonic acid is considerably too much. The question arises, therefore, whether these indicators are the proper ones to determine the end point in carbonate titrations.

4. The water used as solvent for the carbonates should be free from carbon dioxide. At least more consistent results are secured if it is.

5. The volume of water used as solvent, beyond a reasonable minimum, does not greatly affect the result.

A MODIFICATION OF THE KJELDAHL NITROGEN PROCEDURE.

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In the ordinary method of determination of nitrogen by the Kjeldahl method, it has been customary, after completion of the digestion with sulphuric acid, to add a strong solution of sodium hydroxide. Laboratory directions given in the quantitative methods all state that the sodium hydroxide solution should be added in such a way that mixing does not occur until connections are made in the distilling apparatus and then by shaking or rotating the flask.

It has been the experience of the writer, and of others with whom he has talked on the subject, that at this point in the procedure, two objectionable possibilities are presented. It is difficult for the beginner, at least, to cause the two layers in the flask to mix slowly, and if it does take place too rapidly, the violence of the action causes some of the solution to shoot up into the condenser tube, thereby, of course, ruining the results; and even in a few cases the action has been known to have force enough to break the flask, presenting a decided element of personal risk to the worker.

Experiments have been conducted here in the Joliet Junior College laboratory, and we seem to have found a modification of the procedure which eliminates these dangers.

Our method is as follows: after completion of the digestion and subsequent cooling, dilute with 200-250 cc. of water with cooling, quickly introduce into the flask 50-75 grams of sodium hydroxide in the stick form and immediately make connections for distilling.

The sticks of sodium hydroxide quickly and quietly dissolve, and in our experiments the action has never been violent enough to cause more than moderate boiling of the mixture. In addition, this operation may be performed so quickly that very little, if any, ammonia is lost, as shown by results obtained.

We feel that we can recommend this change in the common procedure.

FUTURE SOURCES OF SULPHUR AS PLANT FOOD.

George A. Olson, Agricultural Director, The Gypsum Industries, Chicago.

Sulphur has always played and will continue to play a very important role in all life processes whether they be of vegetable or animal nature. Its use as a valuable plant food preceded that of commercial fertilizers and the history of early American agriculture is replete with information showing that sulphur in the form of gypsum has been beneficial in various ways to crops.[1]

It was surmised more than a century ago that the beneficial substance in gypsum was vitriolic acid or what we now recognize as the SO_4 radicle and not calcium, for the reason that plants did not respond to applications of burnt or slacked lime in a similar good manner.

The early investigators were unaware that the gypsum could induce definite chemical, bacterial and physical changes in the soil which would explain the ofttimes phenomenal result secured. Based on subsequent investigations it was discovered that such changes did occur and were partly, if not entirely, causes for enhanced yields. The most frequent cause for the increase of crops, however, was that gypsum provided the plants with available sulphur.

By comparing the sulphur content in Wolf's ash analyses the present methods of determining sulphur, it is now obvious that many investigators were misled regarding the quantity of sulphur that would be required to meet crop needs. Ideas regarding the sulphur requirements of plants underwent a rapid evolution when it was shown that only an insignificant part of the total sulphur was retained in the ash. Bacon has stated,[2] "From obscurity sulphur gained prominence over night and it was indeed startling to realize that, on the average, plants required more sulphur than phosphorus."

Previous to the discovery of the large amount of sulphur required by various crops, Dymond, Hughes and

[1]Crocker, William, The History of Agricultural Gypsum. Published by The Gypsum Industries, Chicago, Ill., 1922.

[2]Bacon, Raymond F., Relation of Sulphur to Fertilizers and Plant Growth, American Chemical Society, Milwaukee, September 13, 1922.

Jupe,[3] following observations with soils at Essex, England, deduced: "There is not enough sulphuric acid in the soil or supplied by rains for heavy yielding crops rich in albuminoids, either for the production of greater yields or highest feeding value and for such crops it should be included in the artificial manure."

Since no checks were made to determine the value of sulphur as plant food in early fertilizer experiments conducted in the United States it was impossible to ascertain the response of plants to sulphur treatment. This can be appreciated when one considers the composition of a 4-8-6 fertilizer containing in part ammonium sulphate, acid phosphate, and sulphate of potash. In a mixture of this kind the total ammonia nitrogen is 80 pounds; potash, 120 pounds; phosphoric acid, 160 pounds; and the sulphur trioxide, 394 pounds. Fertilizer manufacturers have supplied sulphur in large amounts in their mixtures.

In the west where the soils have not been treated with sulphur-containing fertilizers, it has been possible to differentiate between the importance of this element and with phosphorus. Olson and St. John[4] in the state of Washington, increased the yields of legumes 100 to 200 per cent with applications of gypsum and sulphuric acid. Reimer and Tartar[5] in Oregon obtained similar results and proved beyond any question of doubt that there was a real need for sulphur as plant food material.

[3]Dymond, T. S., Hughes, F., and Jupe., C. W. C., The Influence of Sulphates as Manure upon the Yield and Feeding Value of Crops., Journal Agricultural Science, 1:217-229, 1905.

[4]Olson, George A. and St. John, J. L., An Investigation of Sulphur as Plant Food, Washington Experiment Station, Bulletin 165, 1921.

[5]Reimer, F. C. and Tartar, H. V., Sulphur as a Fertilizer for Alfalfa in Southern Oregon, Oregon Experiment Station Bulletin 163, 1919.

Increase Per Acre Over the Cost of Materials Produced by Applications of Phosphorus, Gypsum and Lime.

NET INCREASE OVER CHECK

Crop	Phosphorus	Gypsum	Lime
Alfalfa	$8.14	$49.99	$4.08
Sweet Clover	6.30	38.25	2.85
Meadow Mixture	(a) .71	21.53	(a) 4.21
Red Clover	4.22	18.55	(a) 1.09
Wheat	(a) .23	18.89	4.53

a-Loss.

Likewise it has been shown that there is in Idaho soils a sulphur poverty. McDole and Christ[6] have stated:

"While phosphorus and lime have produced some increase in production, the gypsum has proved to be the most profitable material to use."

A very good idea of the value of the gypsum as a source of sulphur is manifested in the following table which appears on page 20 of Bulletin No. 136 of the Idaho Agricultural Experiment Station.

If acid phosphate which is approximately one-half gypsum had been applied instead of mono-calcium phosphate and gypsum the possibilities are that the increased yields would have been credited to phosphorus. From this and other similar experiments, there are reasons to believe that many of the results with acid phosphate have been misinterpreted in the past.

On page 26 of Soils Report 33 of the Illinois Agricultural Experiment Station it is shown that wheat, straw, corn stover, oat straw, soy bean hay, and alfalfa hay contain 9 to 100 per cent more sulphur than phosphorus. The amount of sulphur which is annually leached from soils and carried down streams into salt waters is enormous as compared with phosphorus.

The Ohio River[7] carries away annually about 2,200,000 tons of sulphur in solution which is equivalent to the sulphur in approximately 12 million tons of gypsum. This loss of sulphur is more than three times the quantity that is applied in the form of fertilizer. In the drainage of the Mississippi Valley approximately 6,700,000 tons of sulphur in solution annually are emptied into the Gulf of Mexico. In addition there are about 3,400,000 tons more in the sediment which annually empties into the Gulf of Mexico. In the United States as a whole the writer has estimated that 20,000,000 tons of sulphur are dissolved in the waters which pass down stream and empty into the Gulf of Mexico, the Atlantic and the Pacific Oceans.

Besides the enormous loss of sulphur other plant foods are carried away in solution and sediment to augment the ocean salinity and build up the ocean floor. In the Mississip-

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[6]McDole, G. R. and Christ, J. H., Farming Practices for the Cut-Over Lands of Northern Idaho., Idaho Experiment Station Bulletin 136, 1925.

[7]McHargue, J. S. and Peter, A. M., The Removal of Mineral Plant Food by Natural Drainage Waters, Kentucky Experiment Station, Bulletin 237, 1921.

pi Valley, it has been estimated that $4,000,000,000 of plant nutrients are lost per annum.

The taking away of our upland forests and the careless method of tilling these and other rolling lands are the direct causes for the floods and the destruction of lives and property. It is also the cause for the waste of enormous quantities of plant food materials and soil.

Knowing the causes they can be remedied. The lost soil materials such as gypsum and other calcium salts, which in the natural state helped to keep the soil open and receptive to water must be replaced and the lands unsuitable for agriculture must be reforested. The rolling land suitable for agriculture must be terraced, strip farmed, put into clover crops or grasses. By these practices it is possible to reduce losses of soil and plant food minerals and to avoid damages by floods.

We have accounted for enormous losses of sulphur and as the future welfare of our nation depends so much on the fertility of our lands it is well to consider the sources of supply of sulphur which have helped to prevent plant starvation.

There are about 600,000 tons of sulphur in the fertilizers which are annually added to soil. The principal source, however, comes from the burning of coal. The amount returned to the land if all of the sulphur in coal were volatilized would be approximately 13,400,000 tons annually or 6,000,000 tons less than is carried away in our drainage system. It is more than likely that the amount of sulphur escaping into the air does not exceed 7,000,000 tons annually or 12,400,000 tons less than is removed. This is in accord with Sir A. D. Hall's views[8] that the rains on the average wash three times as much sulphur out of the soil as is carried down from the air.

Most of the coal is consumed in the industrial centers and these are also the places where most of the sulphur in the rain water appears. The polluting of the air with smoke is objectionable from a health standpoint. Not only are the visible rays which we call light shut off but also the violet light rays which medical science has discovered are essential

[8]Hall, A. D., The Soil, and Introduction to the Scientific Study of the Growth of Crops New York, 1915.

to life. There is also great economic waste in permitting the carbon to escape as smoke.

It has been demonstrated that coal can be converted into fuel oil and according to views expressed by experts connected with the United States Federal Bureau of Mines this oil will soon take the place of coal as fuel and the skies in the great municipalities will then be as clear as those in the open country. Simultaneously more of the ultra violet light rays and less of the sulphur will be made available.

For economic reasons the trend in the manufacture of fertilizers is toward the production of highly concentrated plant foods, such as ammonium phosphate, potassium phosphate, phophoric acid, urea, ammonium nitrate, and leuna saltpeter. In the state of Ohio[9] it is already noted that the farmers are purchasing more units of nitrogen, potassium and phosphorus per ton of fertilizer than before, and competition will require additional units of these elements. It will have the tendency to eliminate sulphur as one of the products, because it is considered economically unprofitable at the present time to transport sulphur great distances. With the elimination of sulphur in the fuel the needs for this plant food may be more keenly felt and as a result effort will be made to recover it in the waste products. Fortunately such changes in our supply of sulphur as are bound to occur will not seriously affect agriculture. This is due to the fact that we have large deposits of gypsum strategically located near various farm centers in the United States.

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[9]Barnes, E. E., Trend of Fertilizer Sales in Ohio, Ohio Experiment Station, Bimonthly Bulletin, March-April, 1927.

SOME OBSERVATIONS ON FUEL OILS AND THEIR ANALYSES.

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Custom has made the specific gravity of oils the most important factor in their classification. The first question that is asked by the average customer is for information regarding the "gravity" of the oil. Reports of production and sales are made in this common term of classification. The importance of the specific gravity of an oil, as an estimate of its value, is probably due to the opinion that the temperature of flashing, firing and distillation are lower for light oils than for heavy oils. This opinion is based upon experience with "straight run" oils or fractions distilled from a particular crude oil. The oil mixtures marketed under the very broad term of "Fuel Oil," present a different problem in estimating the properties from the hydrometer reading.

A scientific foundation for an industry eliminates the necessity of opinion in matters of vital importance. The value of an opinion, however, depends entirely upon the amount of experience upon which it is based. An opinion, that is given with a background of many years of experience, should not be underestimated and is well worth careful consideration. This experience factor can be eliminated only by careful experimentation and study, in correlating the facts.

Data on Oils From the Entire Country.

In reviewing the results of several hundred tests on fuel oils of all types, it seems that a comparison of the properties of these oils should show the relationship of the properties of fuel oils that are commonly used. The group of analyses, which are tabulated in this paper, were made on samples that have been received from about half of the states of the Union. They represent oils that are being used in oil burners from the Atlantic seaboard to the Pacific coast and from the Gulf to Canada, including oils from widely separated localities.

The Method of Tabulation.

The best method of tabulation, of the results of these analyses, appears to be on the basis of the specific gravity of the oil, corrected to 60 degrees Fahrenheit and expressed in degrees Baume. The specific gravity of the oil is a definite measure of the number of pounds a gallon of oil weighs. This method of arrangement of the analyses should give some insight into the relationship of the properties of heavy and light oils.

In comparing oils of known specific gravity, we expect that the oil of higher Baume value to be more clean and clear, and, in general, to be more satisfactory in the operation of the burner. Records of these properties of the oils have been made but they are difficult to place in a table of data and they will be discussed only in comparison.

The variations in the analyses of the oils under consideration are shown in table 1. The first column gives the specific gravities of the oils, in Baume degrees, and these values are placed in order of their increasing magnitude. Under each of the properties of the oils the numbers are the temperatures in Fahrenheit degrees, the first number being the low value and the second is the high value found for oils of the given specific gravity. All of the oils that were analyzed gave results within the limits shown in table 1. The low values of each of the properties do not, in general, represent the same oil, for the variation in the properties were not constant. The percentages given in the column under "end point" represent the percentage of the oil of unknown end point.

Sufficient Data for Average.

In order to determine whether a sufficient number of analyses have been considered, to be valuable as a basis for a comparison, the mean and average values were made for a large number of the properties. The mean value is procured by arranging the results, for oils of the same specific gravity, in the order of their values and taking the one with an equal number of analyses above and below it. This value is compared to the average results and dividing by the number of oils analysed. Two of these comparisons will illustrate the correlation of the data in table 1. The oils of 34 degree Baume gravity have a mean flash point of 190°F. and an average flash point of 192°F., the correlation of the data being practically one percent. The mean flash point of the 37° Baume oils is 178°F while the average flash point of these oils is 180°F. The correlation of the data for this group of oils is 1.1 percent. These results indicate that a sufficient number of analyses are included in the table to represent this class of oils. The correlation of the oils of 30° Baume and below do not not give as good results and their properties seem to vary through wide limits. The observations made of these oils during the analyses, impress one that the properties have a definite relation to the type of oil analysed and that the mixtures, composing the oils, are as widely divergent as the properties shown by the analyses.

A Comparison of the Properties.

It is interesting to compare the oils of different specific gravities, which we would consider of very much different value, for we often find that the facts may be the reverse of our opinion of the oils. We find an oil which is included in table 1 with the 28° Baume group that has properties which compares favorably with oils which have a specific gravity 10° higher. This is also true of oils in the 29° Baume group and is not an isolated example. On the other hand, we find oils of 37° and 38° Baume that, from analysis, we would estimate as a very much lower specific gravity. In Table 2 a comparison of these oils is made which gives a striking illustration of the lack of coordination between the specific gravities of the oils and the results of their analyses.

The Appearance is Not Helpful.

A careful record was kept of the appearance of all of the oils analysed and the color, transparency, opalescence, etc., of the samples were tabulated and the oils classified according to the above properties. From this data no conclusions could be drawn regarding a relationship of the appearance of an oil and its analysis. The opinion that a clear oil has lower temperatures of flashing, firing and distillation does not seem to be indicated by the data. In fact, a dark colored and opaque oil may be much higher grade than a clean straw-colored oil of the same gravity. The possibilities of this variation is shown by a comparison of the appearance of the oils in table 2. The 28°, 37° and 38° Baume oils in this table were of light color and clear while the 29° Baume oil was black and opaque.

Conclusion.

A study of a large number of analyses of fuel oils does not show any close relationship between the specific gravity and appearance of the oil or the results of the analyses. The oils studied were representative of the class of oils sold in all parts of the United States for use in oil burners. The label "Fuel Oil" seems to be acceptable for any oil mixture or conglomeration that can be put together.

A more practical classification or grading of fuel oils could be made if based upon the proper standards. The specifications for standard oils of each degree Baume could be used as a basis for classification. Fuel oils that conform to these average qualities could be designated as a "Class B" grade. The oils of the same degree Baume which gave lower temperatures of distillation, etc., could be designated as "Class A" while the poorer oils, of the same specific gravity would be "Class C". The advantage of a classification of this type, would be the differentiation between oils that are properly purified and the oil garbage which, at present, can be dumped on the market at a par with the better oils.

The standardization of any part of an industry should be based upon a large quantity of experimental data and experience. The limits of each class of oils should be set by first studying many oils of known mixtures and a study of their fitness for use in the present designs of oil burners. The task would not be an easy one but an intelligent classification of oils would be a big advantage in helping the consumer to purchase fuel oils and know the exact quality of the oil that he buys.

	28°	29°	37°	38°
Flash Point	178	154	214	237
Fire Point	194	192	235	250
Distillation:				
Starting	375	329	298	484
End	645	690	690	750

Degree Baume	Flash Point		Fire Point		Starting Point		End Point	
	Low	High	Low	High	Low	High	Low	High
41	136	173	151	192	266	375	550	590
40	156	179	172	189	300	410	490	565
39	155	233	173	249	218	410	515	28%
38	148	237	174	250	245	484	465	40%
37	151	214	162	235	282	455	525	28%
36	160	219	167	253	360	440	530	45%
35	154	228	173	252	322	450	540	9%
34	159	262	172	279	360	500	525	60%
33	147	239	158	250	365	452	600	33%
32	162	213	184	227	255	455	7%	35%
31	173	246	188	260	341	476	6%	47%
30	197	298	204	311	400	563	32%	82%
29	154	195	192	210	329	375	28%	42%
28	178	240	194	260	375	581	6%	65%
27	199	234	218	258	386	565	22%	77%

PROGRESS IN SCIENCE.

JOHN B. MECHAM, JOLIET, ILLINOIS.

PART I.

We live in an age of progress, a time when old creeds, old dogmas and false theories are giving way to the light of truth; the veil of darkness is gradually lifting and man is now favored as never before by having some really accurate notions of the world in which he dwells. Thus, as the search for truth advances, the plane of civilization is raised. In the words of the wise old saying, "Today is better than yesterday; tomorrow will be better than today."

Professor John Dewey once said, "The future of our civilization depends upon the widening spread and deepening hold of the scientific habit of mind." The work of discovery has been going on from year to year until now it is said that we have eighty-eight known chemical elements, and these are the outcome of an organic evolution. Science has no equal in the revelation of knowledge in the world and it is progressing in spite of anything man may place in its way, for it is following nature's law.

How futile to oppose it. It would be as reasonable to attempt to turn back the tide as to try to change its course in its onward march. Truth is what the world needs and the working of the principle of evolution is nature's method of revealing the truth. The highest ambition of the scientist is to help make known the truth. Surely, searching for knowledge is no crime at the present day, for it truthfully may be said that the object of science is to discover and proclaim in truth and in fact the phenomena of the cosmos, thereby resulting in blessings to the inhabitants of the earth.

Thanks to the age of freedom of thought the days of Bruno are gone. The days of Galileo are also gone. Even he, after having been compelled to admit against his better reason and judgment the statement which he did not believe, and after placing his name on the dotted line exclaimed, "Epur si muove" (the earth) "still it does move." But while we note with satisfaction the advance science is making, let us not forget that even to this day the three hundred years conflict for intellectual freedom against ignorance and superstition, which began in the days of those intellectual giants Bacon, Des Cartes and Galileo, has not entirely closed. It has been a conflict against ignorance, tradition and vested rights. "One of the most dangerous pieces of legislation ever passed," said Reverend Shailer Mathews, "is the Tennessee law prohibiting instruction of the evolutionary theory of man's origin." Following the action of Tennessee, observe the trend in Mississippi, Georgia, Oklahoma and elsewhere. Doubt not that our national legislature at Washington may yet be appealed to by anti-evolutionists. Has it come to this? Are we going back to the dark ages? Are people to be robbed of their birthright to do their own thinking?

To some people the name science has an alarming sound. The very utterance of the word causes them to have serious forebodings; they seem to think that something terrible is going to happen when the name science is mentioned. Some people have become so much disturbed upon hearing of new discoveries that they appear to fear that the scientist will, through the disintegration of the atom, start a conflagration that will explode this old earth of ours. They have doubtless come honestly by such belief, never having acquainted themselves with the mission that science is performing in the world. The evidences are all around them and still they fail to observe them. Are they getting nearer the truth when they shut their eyes and close their ears to the book of nature and declare that those who read from nature and nature's laws are wrong? Is the man who delves into the bowels of the earth and brings forth evidences of its age to be scourged for his efforts simply because he arrives at conclusions that differ from those who shut the book and will not read? He who points his telescope towards the stars in search of worlds unknown, who strives with earnest zeal to bring a little nearer the solution of the mystic deep, perchance to discover a world of beings not unlike himself—is not his work worthy of recognition and praise? He who plods with unfaltering tread in search of truth through the fields of the great unknown, making discoveries by the use of the spectroscope that are adding to the plane of knowledge, resulting in benefits and happiness to the human race, is he to be scorned because he cannot accept the dictum of him who has steeled his mind against investigation and proof of nature's yet unsolved problems? Are the scoffers of science any more certain that they are right in their assumed position regarding the origin of men simply because they have read the Book of books and have placed their own interpretation thereon than their neighbor who is likewise familiar with the same great record and has an interpretation that differs from theirs? If both are candid, fairminded, intelligent and sincere, imbued with the desire to know the truth, one should have the same right to his interpretation as the other.

Mr. Donald A. Laird in the columns of Life gave the repartee which passed between the Bishop and Mr. Huxley. The Bishop, turning to Huxley with smiling insolence, begged to know whether it was through his grandfather or his grandmother that he claimed his descent from the monkey. Mr. Huxley, calmly and deliberately rising, replied that he was not ashamed of having a monkey for an ancestor but he would be ashamed to be connected with a man who used great gifts to obscure the truth. The cut was deep; the effect was tremendous; the Bishop said no more.

However, a brighter day for the natural sciences has dawned and they are coming into their own, and while as much cannot be said for the social sciences, hope lies in intelligence for the future. The old ways have been tried and found wanting.

When this old earth, called the "geocentric sphere of the universe," became a wandering planet circling around a central sun, the cause of truth advanced to higher ground. All attempts since 1450 A. D. to enslave the world either physically, mentally or spiritually have ended in failure.

The human race will be advancing toward true culture and greatness when with sober thought and sincerity of purpose it takes courage to question all things, weigh all things, prove all things, making knowledge and understanding seasoned with love for fellow man the foundation upon which to build a higher, a better and a more advanced civilization.

We live in an ever changing world. The changes resulting from recent discoveries are so great that the rank and file of people are not ready to receive them. The leaders in science and investigation have made too rapid strides for the people. The great discoveries of radio activity, whereby the music of the spheres has been harnessed by the hand of man resulting in sweetest harmonies that charm the world, the X-rays, the divisibility of the atom, the discovery of the electron, have swept the multitude off their feet. The explorations of the physicists and chemists in the world of atoms and molecules, electrons and protons have been crowned with miraculous triumph in the modern fields of science. The harnessing of electrons i. e. causing them to flow through wires as an electric current whereby lamps are lighted, engines propelled, cars run, factories operated and great systems of transportation carried on are among the marvels of the age that have been wrought by scientists and all for the convenience, advancement and betterment of the human race. A most important phase of scientific investigation of the material universe came with the discovery of radium in 1898, a new property of matter.

No idea has been so powerful in the fashioning of knowledge as the simple but profound thought of evolution that the past is the parent of the present, and the present the parent of the future. Evolution has influenced all the sciences forcing its devotees to think of everything as with a history behind it.

The solar system, the earth, the great cordilleras and the mighty ocean, the rocks, the crystals, the fauna and the flora, even man himself, all must be seen and recognized as the outcome of a long process of development.

The spectroscope, that most wonderful instrument with which the scientist is able to solve many of the questions pertaining to the stellar world, that but a few years ago were unsolved, to it we owe our knowledge of the composition of the sun and stars. It is said that the spectroscope will detect the millionth part of a milligram of matter and still the limit is not reached, that it will detect the nature of the forms of matter trillions of miles away and that it will measure the velocity with which these forms of matter are moving with slight variation. Must we not confess, as has been said, that it is the greatest instrument ever devised by the brain and hand of man.

Science teaches that things came through a logical order; that there is a controlling power and that this power controls all things; call it God or what you will, that this power has often been misunderstood and that science is striving for the truth. "Seek the truth and the truth shall make you free" is a most salutary doctrine for both science and religion.

The scientist does not claim to know whether the universe is finite or infinite, temporal or eternal and he makes no claim where there are no facts to warrant him. So far as is known in science today there is no evidence of spontaneous generation.

The scientist having divorced nature from chance, it follows as a logical sequence that nature's order of procedure is not to be turned and twisted to suit the whims, fancies and prejudices of man, but rather its course appears immutable, unchangeable despite the false theories of men.

Although man is but an infinitesimal part of that vast world, still it appears that he is endowed with a mind and a capacity that raises him to a station far above all other sublimary creatures. It behooves man therefore, as an intellectual human being to try to form true conceptions of the diversity of the things that go to make up the great system of nature's complexity.

The true scientist will not go so far as to assert that such has always been the case nor will he dogmatise that so and so is the only way, but when he is asked to concede that such always has been the case and the only way, he has a right to weigh the proof.

But I shall not carry these suggestions further; it is not my purpose on this occasion in the few minutes allotted to discuss the science of government nor the conflict of the age-old question, science and the Bible, but I will express my conclusions in these few words, that I believe there is no conflict when rightly understood and that hope rises in the belief that this is gradually becoming recognized.

PART II.

What I shall offer concerns recent discoveries in the field of one of the oldest, most wonderful and at the same time most progressive of the sciences pursued by man. The field of its operations is so vast and its discoveries so astounding that the intellect is almost lost in wonder when it sweeps forth into space to view an infinitesimal fraction of the vast universe.

Viewing the subject on broad lines, I shall refer to a recent discovery of scientific research in this all-absorbing subject which leads beyond the universe in which we live.

The data that has been taken, the discoveries that have been made, come from authority sufficiently eminent to dispel any doubts that another galaxy, another universe has been sighted.

I now call your attention to an aerial tour which you are invited to take with me through the most stupendous route ever taken by man into the depths of space to catch a glimpse of the discovery in astronomical science recently taken through the great one hundred inch reflector located at Mount Wilson, the largest telescope in the world.

Dr. Edwin Hubble of Mount Wilson recently pushed out the limits beyond our universe and brought a little nearer the mysteries in endless space of the great heavenly objects, among others the great spiral nebulae. I may say before starting on our trip that it is said this wonder of wonders, as it may be described, appears like a luminous haze or cloud in the sky with numerous faint stars appearing at the outer edge, located from earth's viewpoint in the constellation Andromeda.

Our journey will be somewhat extended although deep with interest all the way but I warn you that we shall travel at a rate of speed that may chill your circulatory system owing to the rarification of the ethereal air through which we shall pass, and remind you that a life insurance policy payable to your wife may be in order, for there is a rule in law that after an absence of seven years, death is presumed. However, let no one be alarmed for I guarantee that we shall return safely, which is more than the men who propose visiting the moon are able to offer at present.

First, you will think of the solar system with its sublimity and beauty, eight planets revolving round a central sun, that great body, the source of light and heat with a diameter of 865,000 miles. If its rays were withheld for one month from the earth, it is said, life thereon would cease. That monarch of the sky lies bathed in an azure blue, bespangled with diamonds whose beauty and brilliance transcends the genius of man to describe. No wonder that the great composer of harmony was inspired to write "The Heavens are telling the Glory of God." Throw open the windows of your imagination, for it will do you no harm to lay aside thoughts of business and let your minds roam for a while through the fathomless depths of immensity's realm.

You have not had an opportunity of taking just such a trip as this perhaps and to all that is passing I shall ask your close attention.

Moving out from the central orb, old sol, we pass the first, the smallest and nearest neighbor, planet Mercury which is thirty-six million miles away, taking three and one-half minutes to reach.

Lead on and salute with a smile bright Venus, the Goddess of Love and Beauty, whose distance is sixty-seven million miles from our central sun and whose beauty we so often behold as morning or evening star, and which, like Mercury, sometimes passes in transit because it lies within the earth's ecliptic.

We are now passing old earth on our right, ninety three million miles distant from our starting point, taking eight minutes to reach, which was once supposed to be the center of the universe, to doubt which brought on a controversy that lasted long and serious, leading on to far off Mars, the God of War, which revolves around the sun in six hundred eighty-seven days, with its two moons discovered in 1877, the planet that on the 22nd of August, 1924, approached within thirty-five million miles of our earth at perihelion and which was viewed by astronomers with great satisfaction, the nearest it will be for 120 years. We shall ski through her canals and prove whether or not Lowell might have said a world peopled with beings not unlike ourselves, although our latest authority doubts the probability. Here, glance back to earth which we passed but 14 minutes ago and observe that she appears like a faint star in the distance. Does your mind grasp the thought of the grand panorama wherein millions of worlds like streams of light are moving before you with lightning speed and brilliance unsurpassed?

Keep your imagination working; we are moving now with lightning speed. Continue the long and bumpy road, stopping a moment to view the remains of a once supposed wandering world, often looked for but never found, fragments of which were called the asteroids, goddesses familiar to Homer in his day. Modern research tells us that they are not the remains of a planet, but rather scattered meteoric material which was prevented from becoming consolidated into a single world by the attraction of the giant wanderer in the solar system. Advance, paying our respects to the largest known planet, old Jupiter, nearly thirteen hundred times larger than our earth, with his nine satellites, where moonlight never fails to light the pathway of the mythological god of power, and hear his thunder bolts as they roll away and make the very heavens tremble.

It is interesting to note that the outer moons of Jupiter revolve around the planet in the reverse order to other moons, and it was the discovery of the moons of Jupiter by Galileo, January 7, 1610, that solved the perplexing question and proved the theory that the earth and other planets revolve around the sun, a boon that science has bestowed upon the human race, proving that the sun and not the earth was the center of the solar system, the reverse of which had been held for 2000 years.

Here lead on to distant Saturn with her eight moons and her three ring circles. Pluck off one of these rings composed of meteoric iron and stone to lay a track to Uranus. Saturn with her rings appears as one of the most interesting of the planets. Work fast for she revolves on her axis once in ten hours, thus making the hours for labor very short. We are now about 480 million miles from our starting point and approaching the once outward rim of the solar system; here ponder a moment, wondering what lies beyond for it was here that science paused and pondered for many years whether or not any other planet lay beyond.

The irregularities in the motion of Uranus led Leverier to suspect that another planet existed outside of Uranus. Resuming our journey, we are now traveling on that almost endless trail, tired, silent and discouraged when someone shouts: "Look out there! Be Careful!" There comes a comet headed straight for the sun, a molten mass like a million rockets, seething and hissing with lightning speed as we pass through its tail. Were we back on earth we would call it a meteor shower. Baade's comet was a strange phenomenon which was headed from the sun, which is contrary to the observed law of comets, and nobody as yet knows why. Newton's laws of motion were almost overcome.

Advancing, we are hopeful that the last far off wanderer will be reached. Galle of Berlin University was rewarded for his search, for Neptune was discovered the 23rd of September, 1846. A peculiar thing about Neptune is that it revolves upon its axis from east to west, just the reverse of the other planets and takes 165 years to revolve around the sun. We shall take ample time to warm ourselves and plenty of rations, for the journey that now awaits us is long and winding and dark and would be dreary but for the way leading into the galaxy of stars which lie before us and through which we must pass as the night of space rolls on, remembering that the distance we have gone is but the radius of that heleocentric system for belief in which men suffered and died. Dr. Shapley of Harvard College estimates that the group of stars which astronomers call the galaxy is about 300,000 light years from side to side, a light year being the distance light travels in one year at the rate of 186,000 miles per second, a distance of 6 billion miles, but hold your estimates a little longer.

Resuming our journey we are now about to take a leap into the dark; we have gone two billion seven hundred ninety-two million miles and our brilliant old sun has faded into a dim, distant star, while dear old earth has long since vanished from sight. We are now to venture into a region where we shall have no longer clear lights to guide us. We now bid "goodbye" to moons and planets and are going out to roam among the suns of the stellar world. Tremendous as are the distances of the solar system, the widest sweep of the planetary orbits sink into insignificance compared with the distances which separate from us even the nearest fixed star. Buckle up your belt, take up the slack, for the absolute cold of 458 degrees Fahrenheit through which we have passed has had a tendency to reduce your weight, turn on the power and let her go, forsaking the horns of Neptune, for he, even he, is yet relatively near our starting point. Pass on and out into the stellar world where all is dark and few travelers have been, to whose expanse the distance now traveled is, in comparison, just begun. Go on and on and on; go on; forget that we have passed Alpha Centaura, the nearest fixed star, more than twenty-five trillion miles from our starting point as onwards we pass along the glittering road where diamonds are falling and fading from sight. We have passed the confines of Vega, Capella, Canopas, Betelgeuse and the horns of Orion. Betelgeuse leaped into prominence in 1920 when Michelson measured its diameter which he estimated to be more than two hundred million miles, and it is stated that its size has probably been under-estimated. Recently it has been exceeded by Myra whose diameter is now thought by Michelson to be 250 million miles. Lend one thought to these mighty distances. Even these, however, are exceeded by Antares the largest star known to astronomy which is estimated to have a diameter of four hundred million miles and whose brightness is estimated at 5000 times the brightness of our sun. Does it seem like wisdom for the opponents of science to deny the unveiling of the wonders of the universe to the youth of the land and place an age limit of it all at 6000 years? Such a claim becomes an insult to human reason and intelligence. How wonderful are the works of Deity. Continue the magic flight until we have pierced and passed the star clusters, the nebulae, the star dust out of which it is believed worlds are formed, yea, the Magellanic clouds and the great white way consisting of myriads of suns many of which are moving at the rate of 200 miles per second encircling the heavens whose diminishing incandescent gleam shall have faded into night, and remember that we have even now but reached a fractional part, the one-fourth part of that vast expanse we yet must pass to come within a glinting gleam of that yet unexplored universe to which light in its travels to reach, moving at the enormous speed of one hundred eighty-six thousand three hundred miles per second, would require more than one million years to span. Immensity, infinity itself—wake up men! Wake up! Old earth is vanished from sight. Our sun's lost in the fathomless deep; our stars are faded into night. We have nothing left but ourselves and space, even time is forgotten and gone; Einstein's Theory is but theory after all; the faint star cloud, the last cluster to pass, has now faded into night. And so it is! It must be true for all have fallen fast asleep while here I sit steering this car through endless space, a distant universe to find.

Roll on, thou deep and dark ocean of space, with speed of thought roll on. Roll on while the stars, the suns, and the galaxies have faded into night, while the dream comes over us that all is lost—but see! A gleam of hope! Another world is coming into view. Like a fleecy cloud she comes! She comes with lightning flash. She comes to view; behold a star; behold, a sun; behold, a myriad of suns; behold, an island universe (?)— and so it is!

Out there, above, below, beyond, outstretched a boundless universe. Far as the unpierced depths that limit swift imagination's flight, unending orbs are mingled in mazy motions, immutably fulfilling eternal nature's laws in a wilderness of perfect harmony. Eureka is our reward, for here we pass the outward portal of this new universe. All honor to Hubble who hath led us on. We shall soon be there for now the brakes are closing down, we have reached the first lap of our journey, the object of our tour and the name of this unexplored universe, the great spiral nebulae, no longer peering through the constellation, Andromeda, but shining in all its refulgence and beauty.

I have brought you here and have dealt with this subject, not as idle speculation, but rather to afford a little recreation for men of thought, and some suggestion of the immensity of the universe in which we live, through which we came. The thought of Deity was greater, nobler and wiser than to leave the destiny of cosmos to the narrow whims and prejudices against His laws and handiwork for, it is now believed outside, beyond, around and above all that we know or see, there are other suns and worlds and systems. Yea, even so like this, a universe we now behold transcending in distance anything hitherto known to the mind of man. And now as we wait a moment, may we not query that if we had the great reflector with which to make the observation, would not our own galaxy of stars from whence we came appear not unlike the great nebulae that we have traveled so far to reach? I should like to pause and ponder with you the transcendent beauties of this vast universe and to roam at will through endless space, but I promised you that we would return and in view of the fact that the way is long and air craft slow, I shall take you back, not in the same way, not at the same speed at which we came, but with the speed of thought which has safely brought us here and will safely take us back to our native planet and without stopping along the road to gather the gems that have strewn our pathway. The next station will be dear old earth and here we are, all out, safe and sound. We have been gone more than one million years, have traveled twelve quintrillion miles. What the next era shall bring we know not. We are lost in wonder and only may say turn on the lights and let the flame of intellectual freedom burn that it may lead mankind to a higher and nobler station than he has yet attained. Let the truth be made known to all people until the dross of ignorance and superstition are purged and burned away.

PAPERS IN GEOGRAPHY AND GEOLOGY SECTION, JOLIET.

RICE GROWING IN THE UPPER MISSISSIPPI VALLEY.

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A chance remark has recently been responsible for a very great northward extension of the rice industry. Four years ago, a disgusted tenant of river-bottom land was talking with his landlord about prospects on the farm which was about two miles from Elsberry, Missouri, and 68 miles north of St. Louis. Said the tenant, who had once been a Louisiana rice farmer, "This would make a better rice farm than anything else." While he spoke, his eyes rested upon wet weedy fields. The landlord was wide awake; "Do you mean it?" he asked. "Yes, if you will move it south where it is warm enough for rice to grow," the dialogue went on. The owner of the farm, Alvin Rowe of Galesburg, Ill., was a manufacturer of gates and other farm equipment. He had occasion, soon after, to make a trip to Louisiana, Texas, and Arkansas. While there he made it his business to investigate the rice industry. On his return, he had fully determined upon an experiment in rice growing, which he proceeded to carry on much to the disapproval of his Missouri neighbors. They all said, "This is too far north for rice"; the Missouri-Arkansas boundary district being farthest north for rice at that date (1923).

Mr. Rowe had prepared on his farm at Elsberry, Mo., a plot of sixty-five acres which were seeded with six different varieties of rice with the results shown in the following summary of the experiment:

Acres	Variety	Results
15	Honduras	Straw grew 5 to 6 ft.; failed to fill or ripen
15	Colora Jap	Yield 113 bu. per acre (short grained) poor sample
15	Lady Wright	Yield 98 bu. per acre (long grained) very satisfactory
10	Storm Proof	Yield 92 bu. per acre (straw weak)
5	Mortgage Lifter	Not harvested—poor sample
5	Blue Rose	This plot on porus soil—could not keep it wet.
65	Total.	

As a result of this and subsequent tests, Mr. Rowe decided that rice can be successfully grown there and that Lady Wright is the best variety for the latitude of the corn belt. This variety matures in a period of from 115 to 120 days; it has a vigorous upstanding straw and it is a long grained rice which commands a better price than the short grained varieties.

Later a short grained variety was tried; this was The Early Prolific; the yield was heavy but the inferior sample and lower price did not cause it to displace Lady Wright in the favor of Mr. Rowe or in that of his neighbors.

The trial above led Mr. Rowe and several of his neighbors to plant a total of 700 acres in rice the next year (1924) all of which was supplied with water by means of a plant installed by Mr. Rowe. In 1925 there was a total of 2100 acres which was increased to 3000 acres in 1926, all supplied with water by Rowe's pumping plant. Other neighbors cooperated to install other pumping plants after Rowe's initial and subsequent success, until there was, in 1926, a total of 10,000 acres of rice crop in that neighborhood. Four hundred acres of rice were raised on the river at Quincy, Ill., in 1926. Mr. J. Morton of The Morton Salt Company, has a large tract of land on the Illinois River near Canton, Ill., part of it being the drained lands of Thompson's Lake, some years ago well known as a duck hunter's paradise. The owner, after getting in touch with Alvin Rowe, seeded 210 acres of rice in 1925; this tract yielded 55 bu. per acre. Subsequent yields on this land are not at hand. Rice growing may now be said to have become an established industry in the corn belt latitudes of the middle west.

The Returns.

Mr. Rowe has had various yields—one field of 24 acres yielded 72 bu. per acre (rice weighs about 45 lbs. to the bushel). 100 acres yielded 7000 bus.; 9 acres of Jap (short grained variety) yielded 1130 bus. A field of 140 acres returned a gross sum of $22,000.00 in 1925. This rice graded No. 1 and No. 2 and sold at $1.74 per bushel, F. O. B. Elsberry.

The Preliminaries for Rice Growing.

The first steps in rice growing include leveling. An engineer is employed to run contour levels, a rod man works with him across the proposed rice field stopping with target at 100 ft. intervals. A man with team and plow follows the contour markings immediately behind the engineer and his assistant so that from 60 to 80 acres of river bottom land are leveled per day. The finished dykes which may be thrown up by the use of a small road grader or even a plow are from 10 inches to 24 inches high. On bottom lands, they are from 10 feet to 1,000 feet apart. The rise of each contour line above the lower is three inches. Water is pumped to the highest plot and when a given depth is secured the excess passes to the level below through a wooden distributing box and gate which prevents washing. These small levees do not seriously interfere with the use of the binder or tractor which cross them in field operations at the will of the operator.

Methods of Growing Rice.

The ground is plowed and seed bed prepared as for wheat. Seeding may begin about the same as for the planting of corn, i. e., May 1st to 10th. The seeding may be done by means of an end-gate broad cast seeder but a much more even stand will be obtained by using a wheat drill set to place the seed at a depth of two inches. The plants are allowed to reach a height of eight inches before flooding—the rice in this early stage stools out with 3 to 7 branches (as many as 67 stools coming from one rice plant have been counted). Each stalk produces from 170 to 200 grains of rice in the form of a panicle. After flooding is begun, water is kept at a depth of from two to four inches for a period of 90 to 100 days. The rule is 10 gals. of water per minute per acre. There should be a heavy clay subsoil which will prevent loss of water downward. Mr. Rowe's land is a heavy gumbo 15 feet thick. In Arkansas, rice is successfully raised on land having a hard pan subsoil. Mr. Rowe found that he was unable to pump water fast enough to irrigate certain of his lands having a sandy subsoil. Allowance for evaporation is necessary.

Pumping ceases ten days to two weeks before cutting.

Harvesting.

Various varieties of rice require different growing periods. The Lady Wright, chosen by Mr. Rowe, requires about 4 months. Sown about the middle of May, it was ripe about Sept. 15th; however, due to wet autumn, some of it was not harvested until the following January after which it threshed as a very fair sample. This fact shows one of the points of the commercial excellence of rice, viz.: its keeping qualities under adverse moisture condition such as prevailed in the fall of 1925, also in 1926.

Methods of Harvesting.

This grain is harvested by the use of a rice binder which is simply the wheat binder with certain adaptions. It is drawn by a tractor which has minor changes including extension lugs of 34 inches in length, filled wheels to keep the mud from crowding between the spokes and a power take-off (a revolving shaft furnishes the power from the tractor to drive the binder mechanism). One change in the binder is the use of an 8-foot platform joined to binding mechanism designed to care for the wheat furnished from a ten-foot platform. The binder head is speeded up to care for the very large quantities of long rice straw. Standard binder twines are used. A bundle carrier collects the sheaves which are set up into rather smaller shocks than is the practice in the case of wheat. Land which has been so recently flooded is, of course, soft below when the tractor is taken into the field. This is not reported as one of the troubles of harvest, however.

Threshing.

The regular grain separator is used with slight changes as in the screens, adjustment of concave, spike teeth, etc. However, Mr. Rowe greatly lowered the cost of threshing by adopting the practice of the Dakotas and Western Canada where the basket rack and drop feeder are used to save in number of men. Also, this keeps teams idle a much smaller proportion of the time. J. Russel Smith is authority for the statement that by the use of machinery, the American rice producer has a much lower unit cost of production than the Chinese with hand methods and a labor cost of 20 cents per day.

Rice Paddy.

The rice, as it leaves the thresher, is covered with a brown skin and this grain is known as paddy rice or paddy. It is difficult to remove this covering without the use of special machinery. The nearest rice mill containing such machinery is at Memphis, Tenn., where most of the Elsberry rice is sent, after being inspected by buyers who as representatives of southern rice mills make bids on the newly threshed crop. It is said that The Elsberry rice growers are contemplating the erection of a rice mill as a co-operative enterprise. The cost of the mill is said to be about $50,000.

Advantages of the North in Rice Production.

The advantages of the northern rice producing area are:

(1) A heavier yield; 30 bushels is a good average yield for in Louisiana and Texas the heads of southern rice plants average 6 inches in length; in the Elsberry district the average length is 12 inches.

(2) The southern planter is greatly troubled by red rice, very much like the wild oat of the northern wheat farmer; it is necessary for the southern rice grower to have his land remain without rice crop every second year and to mow or pasture the red rice which continues to grow through the mild winter. The growers in the Elsberry district have been careful to secure seed free from weeds, but should the plant get started it will be killed by frost. It is well known that plants are most successful in the belt of highest latitude in which they can be grown; as many plants and insect enemies are thereby eliminated.

(3) There is an increasing local demand for rice in the north, also a very limited acreage of land suitable for rice culture. (The realtor near the Mississippi River now checks his listings of bottom lands with the soil map to determine whether or not its sub soil will allow of rice culture.)

(4) There is less danger of overproduction in rice than of other crops because of the limited suitable area. (By raising this crop the acreage of wheat and corn, in which there is overproduction, will be cut down.)

RELATIVE HUMIDITY AND FOREST FIRES.

D. R. BERGSMARK, UNIVERSITY OF CINCINNATI.

Fire is a natural phenomenon and is controlled by natural factors. Various factors of the atmosphere such as air pressure, temperature, precipitation, wind movements, electrical condition, and humidity, all have been studied in their relation to forest fires. Other factors, however, have also been considered. For example, experiments have shown that fires will burn more rapidly uphill than on level ground.[1] Man himself has been a factor of major significance. He is both actively and passively concerned. The environmental factors are beyond his control. But he is responsible for most of the fires, and he frequently adjusts himself differently in areas which have been burned over than in similar unburned regions.

Of the meteorological elements mentioned above, some are especially significant in their relation to forest fires. Winds, high temperature, and low humidity, either singly or in combination, are particularly effective in producing a high fire hazard.[2] The element, however, that seems to claim the distinction of being the controlling factor in fire hazard is relative humidity. Temperature and wind only accentuate the influence of low relative humidity. "Humidity is now recognized as being of special significance in connection with the starting and spread of forest fires. It is being studied perhaps more intensively than any other factor connected with the problem."[3]

Relation of relative humidity to temperature, winds, and precipitation.—Owing to the fact that temperature, winds, and precipitation are important factors in connection with the fire hazard, they are frequently given a place of undue importance.

Experiments have shown that high temperatures may occur during periods of high relative humidity and con-

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[1]Osborne, W. B. Jr., 1925. "Primary factors governing action of forest fires." The Timberman. Vol. 26, 190.

[2]Norquist, C. E. 1925. "Weather conditions as related to fire control." The Timberman, 26:132.

[3]Calvert, E. B. 1925. "Weather forecasting as an aid in preventing and controlling forest fires. Monthly Weather Review, 53:187.

sequently have no drying effect.[4] An extreme fire hazard, however, will exist during periods of low temperature if the humidity is low.[5] The common belief that high temperatures cause rapid evaporation is simply a result of the fact that we usually have a comparatively low relative humidity when temperatures are high. Occassionally, however, we have high temperatures and high relative humidity. Under such conditions the materials of the forest are not highly inflammable, and instead of evaporating may be actually absorbing moisture from the atmosphere. Of course, temperature is one of the components of relative humidity; but if we know the relative humidity we have already taken into account the effect of temperature.

It is a well established fact that strong winds may occur during periods of low as well as high relative humidity. Hence, a strong wind may actually extinguish a fire if it brings in air which contains much moisture. A strong wind, on the other hand, occuring during a period of low humidity causes the most serious combination of factors. "All of the great historic forest fires have occurred during periods of low relative humidity. In a few cases the wind was extremely high, but in the great majority of cases, the records show that the winds were not at all abnormal."[6]

The author has observed in northern Wisconsin (1) that forest fires would die down under increasing winds when those winds were carrying in moisture-laden air, and (2) that winds lose their velocity a short distance within a stand of heavy timber. The latter may be substantiated by experiments conducted at the Wind River Experiment Station. An anemometer operated for an entire season at the Wind River Station and located 200 yards inside of a dense stand of mature timber failed to show any wind velocities of over two miles an hour, although velocities of 15-20 were frequently recorded a short distance out in the adjacent burn.[7]

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[4]Hofmann, J. V. and Osborne, Wm. B. Jr.: Relative Humidity and Forest Fires, 5.

[5]*Ibid*, 25:57.

[6]Hofmann, J. V.: "Relative Humidity and forest fire prevention and control." The Timberman, 25:56.

[7]Osborne, W. B. Jr. "Primary factors governing action of forest fires." The Timberman, 26:190.

Fire fighters have observed that under similar burning conditions a fire located on a steep slope and without wind will burn uphill nearly as fast as a similar fire would spread on level ground and backed by a moderately strong wind. This fact becomes extremely significant in areas where the timber is located on steep slopes.[8]

Winds, however, are of great significance to foresters in some parts of the country. Mr. Beals, of the weather bureau service, found that there was a definite relationship between easterly winds and forest fires west of the Cascade Mountains. Furthermore, he has studied the ways in which forest fires may create their own winds.[9]

A deficiency of rainfall does not necessarily indicate a fire hazard, but a forest area is well protected as long as the relative humidity remains high. The effect of rains is not a lasting one. Rains make the forest safe from fire for only a short time if periods of low humidity occur. "The ameliorating effects of precipitation are immediate and, within limits, are directly proportional to the amount. However, the dampening effects of light rains on forest materials under the shelter of heavy stands of timber are negligible and the effect of moderately heavy rainfall is somewhat dissipated in a surprisingly short time."[10]

The relation of relative humidity to fire fuels.—The relationship of relative humidity to forest fires is established through the fire fuels or forest litter upon which the fire feeds. Forest fuels consist of needles, branches, twigs, windfalls, bits of bark, moss, grass, etc.

Relative humidity, being the percentage of saturation of the air, largely governs its absorbing and evaporating power. Consequently the relative humidity is the greatest factor in controlling the moisture content of those forest fuels which are directly exposed to the air and determines the degree of their inflammability. The inflammability of the forest fire materials is the most important factor which controls the fire hazard. Since relative humidity has a direct bearing on the degree of inflammability, and since

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[8] *Ibid.*

[9] Beals, E. A. "The value of weather forecasts in the problem of protecting forests from fire." Monthly Weather Review, 42:111-119.

[10] Norquest, C. E. "Weather conditions as related to fire control." The Timberman, 26:132.

this can be determined, a record of relative humidity therefore can be used as an indicator of the fire hazard.[11]

The inflammability point for the various fuels is not the same. Light fuels such as moss and dead weeds may be dry enough to ignite with a match; while twigs, duff, and branchwood are too wet to burn. Light fuels such as fern, firewood and pearly everlasting have shown very rapid changes in moisture content with changes in relative humidity. Thus where those materials occur in abundance, hourly and daily records are very significant. Records show that a period of humidity of 35 per cent or lower for only one day will cause a fire hazard in open areas of fern, firewood, pearly everlasting and other weeds and grasses in the early spring before these dead materials are covered by a new growth of weeds, grasses, and shrubs.[12]

In some areas the light fuels are the ones which deserve the most careful attention. C. S. Cawan says: "If the logging operator can get rid of the light material, such as twigs, needles, and splintered debris, on the ground, he has got rid of 90 per cent of his hazard, that is, the material which would readily light from the carelessly thrown cigarette, cigar, or match. The larger material does not readily ignite from a chance spark; it must be dried and set alight by the flame and heat from the smaller material or kindling before it becomes a source of danger."[13]

J. T. Gisborne has shown the importance of duff moisture content in the forest fire problem. He found that in most of the valuable timber of northern Idaho the top quarter to half-inch layer of duff exhibits the effects of weather elements as they affect dryness and inflammability in the forest. Top layer duff picks up or loses moisture about as the average important fuel in this type, and is itself one of the most important receivers and carriers of fire.[14]

Air-dry litter is marked by deliquescent, that is, it takes up moisture from the air, independently of precipitation. And even during the hot season it takes up from 5 to 6 per cent of its own air-dry weight every night. This ex-

[11]Hofmann, J. V. and Osborne, Wm. B. Jr. "Relative Humidity and Forest Fires, 1."

[12]Hofmann, J. V. and Osborne, Wm. B. Jr. "Relative Humidity and Forest Fires, 6."

[13]Cawan, C. S. "The loggers hazard in its relation to fire weather." The Timberman 26 No. 9:134.

[14]Gisborne, J. T. "The importance of duff moisture content in the forest fire problem." Journal of Forestry, 21:809.

plains to a very large extent the well-known fact that fires burn more slowly by night than by day.

Not only kind of forest material but amount as well should be taken into account when calculations of the danger point are made from relative humidity records. For example, in western Washington the hazardous point is reached when the relative humidity falls 35 or below, whereas in eastern Washington, the hazardous point is not reached until the relative humidity falls to 20 or below. The difference is explained by the fact that forest growth and underbrush are not as dense in the pine region of eastern Washington as in the fir region of western Washington. Hence there is much less inflammable debris present.[15]

Experimental evidence of the relationship of relative humidity to forest fires in various parts of the country.— The above records from Washington, indicate that the danger point varies from one part of the country to another, and variation is closely related to the kinds of forest materials which are found.

Studies conducted by the Wind River Forest Experiment Station on the effect of relative humidity on forest fires showed that fires did not spread when the relative humidity was above 60 per cent. That they spread very slowly and only in very favorable material when the relative humidity was between 50 and 60 per cent. When the humidity was between 40 and 50 per cent fires picked up, varying from a few running fires to fires that smoked up and did not spread. With a humidity of 30 to 40 per cent, fires gained some headway and some rapidly spreading fires occurred. A humidity below 30 per cent caused fires to spread beyond control. Crown fires occurred when the humidity dropped to 25 per cent or lower.[16]

In Connecticut, records of the number of fires per day for the years 1922, '23, and '24, show that there were less than ten fires per day when the relative humidity was between 60 and 70; about 15 per day when the relative humidity was between 50 and 60; and over 30 per day when the relative humidity was between 40 and 50 per cent.[17]

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[15]Cronemiller, L. F. "Relative humidity and forest fires." The Timberman, 26, no. 5:64.

[16]Hofmann, J. V. "Relative humidity and forest fire prevention." The Timberman, 25, No. 1:56-58.

[17]Moss, A. E. "Forest fires and weather." Journal of Forestry, May, 1926, 556.

In Idaho a study of the records in connection with 192 man-caused fires shows that 62 per cent of them occurred on days when the relative humidity had fallen to 20 or below, and 30 per cent of them when the humidity lay between 20 and 30 per cent. It therefore appears that the danger of fire from matches, cigars, and cigarette butts, is not high when the humidity remains above 30 per cent, is fairly high when the humitity is between 20 and 30 per cent, and is very high when the humidity falls below 20 per cent.[18]

Strikingly significant is the record kept of the great Berkeley fire. This fire destroyed over 50 square blocks of dwellings in the city of Berkeley, the seat of the University of California. At 5 o'clock on the 17th of September, 1923 there was a sudden rise of over 60 per cent in the relative humidity, and the fires in the city, which had seemed uncontrollable, were extinguished in a short time.[19]

Application of relative humidity records.—Thus far we have seen the importance which relative humidity possesses as a factor in relation to forest fires. It remains for us to note the more favorable adjustments which may be made to check the fire hazard.

Definite knowledge in regard to the inflammability of forest materials as indicated by the relative humidity of the present moment, is of inestimable value in all phases of protection and suppression work.

The following adjustments to meet the fire situation are worthy of careful consideration.

1. The smoldering fires must be put out immediately, while they are small, when they can be handled at small expense and before conditions change.

2. Slash burning should be performed when the relative humidity is high, and all fires should be extinguished immediately when the relative humidity is low. Spring is the best time in which to dispose of slash, because the slash is dry enough to burn in the spring while the lower layers of duff still contain sufficient moisture to protect the

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[18]Norquest, C. E. "Weather conditions as related to fire control." The Timberman, 26, No. 9:132.

[19]Alexander, Geo. W. "Weather and the Berkeley fire." Monthly Weather Review, 51:464.

seed that is stored in the forest floor from the heat of the fire.

3. Burn first near rights-of-way. It is not the custom or habit of human beings to wander through a slash area when they can follow an old trail. This means that the danger from fire, which is largely a man-caused one, is not very far from the rights-of-way or trails.

4. Burn the light materials. If the logging operator can get rid of the light material, such as twigs, needles and splintered debris, he has got rid of 90 per cent of his hazard, that is, the material which would readily light from a carelessly thrown cigarette, cigar, or match. The larger material does not readily ignite from a chance spark.

5. A greater number of hygro-thermographs, hygrographs, or sling psychrometers should be distributed throughout the forest areas so that more careful records may be kept of relative humidity, the important factor in forest-fire control.

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STRATIFIED INDIAN MOUNDS IN WILL COUNTY.

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Fifteen miles from Joliet above the mouth of the Illinois River are certain Indian mounds which I have excavated extensively, resulting in discoveries of considerable importance. The mounds rest upon a limestone gravel deposit near the edge of a bluff 30 feet above and overlooking the Des Plaines River. This elevated position with gravel affording perfect drainage beneath was an ideal condition for the preservation of human relics buried below ground level, although those higher up in the mound body were less favored because of the dark soil there.

The mounds are distinctly stratified, a most unusual occurrence. Their construction broadly resembles a chocolate cake, the earth layers being separated from each other by thin dark seams of mineralized vegetable matter with grass and weeds at the surface taking the place of frosting. The thin seams denote long pauses in construction, each being an old surface where grass and weeds once grew just as they now grow on top. Each layer between the seams contains bones and relics of men distinct racially and in their civilizations except near the surface where various types intermingled. Short, Meso and Long-heads are terms indicating ratio of greatest skull width or breadth above the ears, to greatest skull length measured from forehead to back of neck. This skull ratio or cephalic index as it is called, is much used by anthropologists in determining important racial characteristics. The Middle layer is given over exclusively to a rather small and feeble people with short heads. Further down are even smaller people, also short-headed. Still lower in gravel are larger mesos, or ones with heads of medium length. Beneath them so well concealed in gravel that my discovery of them was purely accidental, are rather small Long-heads. The sequence of Short-heads overlying Meso-heads and the latter superimposed upon Long-heads without mixture of types is a condition we would hardly expect to find except in isolated races or those dating back into ancient times. As far as I know such a sequence has not heretofore been found in Indian

Mounds of this country. That the people of the locality I have explored are all Indians from the oldest to the most recent, I am fully convinced; at least various peculiarities of the skulls, teeth and limb-bones are similar to those commonly met with in our various so-called Indian races. The civilization of the Middle layer is one that experts would diagnose at first glance as Stone Age Iroquoian. This is interesting if true, in that it throws light upon the origin of tribes that went to make up the powerful Iroquoian confederacy which played such a prominent part in our French and Indian and Revolutionary Wars. Their civilization before white men appeared has been traced no farther west than Ohio.

Except upon the surface where colonial silver ornaments have been picked up, the deposit from top to bottom is purely aboriginal without a single suggestion of the White Man's influence. The people of the Upper layer were mostly Short-heads with a few Mesos. Although the men were as a rule powerfully built, I found no tall ones, the greatest stature observed being about 5 feet 6 inches and most of them shorter. They lay in various postures, some upon their backs, others upon their sides with legs straight or slightly bent. Cobblestones occasionally covered head and shoulders. None had been burned or mutilated. Relics were few—flint and chert arrowpoints 1½ to 2 inches long and notched or stemmed at the base. None had pipes and I could find no sign of cloth, wood, fruit or grain, although I searched diligently.

Going deeper in the Upper Level, skeletons and relics became more abundant. The men were powerful but taller, 5 feet 8 inches and under. There were Short-heads, Mesos and Long-heads as above and they lay in the same postures but they had more things with them, small clay pots, tools and ornaments of bone and copper and many bones of animals, among which were the dog, evidently domesticated. The pots, squat and bowl-shaped with short constricted necks, were unglazed and without decoration engraved or painted. In each one was an uncarved river clam-shell used as a spoon. The copper objects consisted of several small hatchet-heads rudely hammered to shape. The bone-work showed many polished pieces and much variation in form. Some were large pins, others neck pendants used for personal adornment. Games were represented by deer ankle bones probably dice, cut and bored elk toe bones and polished stone tablets with bone cylinders. This latter game, which may be likened to marbles or tiddle-de-winks with the stone tablet as "shooter" seems to have been a popular one with the young ladies, for three of them had each a set placed beneath her head. Long draw knives, probably used for dressing hides and small notched pegs, possibly needles, represented domestic implements. For the hunt and war, long sharp pointed cones bored for sockets served as arrowpoints. A single bone fish-hook without barb or eyelet but otherwise similar to our modern steel hook, was evidence enough that these people ate fish and caught them as we do. They may also have used nets or traps, but nothing remained to so indicate. A small spade-like tool of elkhorn, a round polished stone and an antler point lying together beneath one skull strongly suggest pottery manufacture, the spade-like tool being used to shape and pat the clay outside against the round stone held against the inside, the antler-point being an engraving tool for surface decoration after the pot, still in a plastic state, had been brought to the desired shape. Other odd-shaped bone pieces are more problematical although the fact that they were cut from soft rather than hard material would have made them useless as tools.

The Upper layer rested upon a thin black seam of carbonized vegetable matter. Passing down through this into the Middle layer I encountered 18 inches of brown pebbly soil resting upon a 6 inch earth and ash-layer, the latter being sandwiched in between two more thin black seams. The Middle burials lay closely beneath the Ash Layer and below ground level. All of the skeletons were Short-heads, physically feeble and none over 5 feet 4 inches tall. They lay upon their backs generally with face to the east. They were big-eyed, broad-nosed and long faced with wide prominent cheeks, projecting teeth and weak lower jaws. Some had very wide heads with narrow temples. Male adults were few, women and children predominating. Many young women were accompanied by tiny infants. One had two beside her. Everywhere in the mound I found signs of care and reverence for the dead. Clay pots containing bits of bone and clam-shell spoons were placed beside each head, the latter adorned with a meager ornament of bone, copper or shell and an ash-bed covering all. In eleven cases, all of children, one hand was within the accompanying pot, evidently placed there by the mother to make sure that her child would find the food close by. None of the males had pots, lying only with a bundle of flint arrowpoints, a lance-head and stone tomahawk beside them. These weapons were all mounted on wooden shafts as attested in one instance where the wood had left long dark marks on the gravel. No sign of cloth, grain or pipes as yet. Apparently the people of this Middle layer were meat, fish and clam eaters and did not smoke. The earth over them was full of charcoal, clam-shells and the bones of birds, turtles, fishes and animals. I found many unshaped bones under human skulls with stone and bone implements placed there intentionally. Deer, elk, puma, bear, beaver, mink, wildcat, otter, raccoon, goose, wild turkey and many others were represented. I could find no remains of dogs, common in the layer above. The Short-heads of the Middle Layer are the ones previously referred to as possible forerunners of the great Iroquoian Confederacy. The main characteristic of their civilization classed elsewhere as Iroquoian is the use of the small triangular arrowpoint without base notches or stem. This occurred in the Middle layer to the exclusion of other forms. These arrowpoints are made of white chert; keen-edged, sharp-pointed and very thin and small. No other kind has better penetration, a most important consideration for ones compelled to offset physical inferiority with superior weapons so that a stiff bow and powerful arm were not absolutely essential for piercing power. This selection of efficient tools for war and chase was also true of the stone hatchets or tomahawks, which were made long to gain weight and slender to increase penetration. They are keen-edged and highly polished.

The only other stone tools found are hammerstones and bones for smoothing wooden arrowshafts. The former were nothing more than large pebbles of quartz or chert held in the bare hand and used on one side then the other until a blunt edge finally resulted. No grooved stone axes appeared; no gorgets, plummets, banner-stones, pierced tablets or other showy pieces classed as positively non-Iroquoian. The second type of stone tool in the mounds is a roughly shaped sandstone block with a deep groove on one surface. Fitting this groove to the wood and moving the stone to and fro, the aboriginal archer could make his arrowshafts smoother and straighter. The absence of stone mortars and pestles for grinding grain were in keeping with the lack of agricultural tools and anything else suggesting vegetarianism.

The bone culture of the Middle Layer is crude, the pins and ornaments being only roughly shaped. Copper pieces consist of discs worn at the ears and bead necklaces. Clamshells were cut and pierced to wear as pendants or the thick parts carved into beads for wear around the neck. Shell spoons found in pots were cut to form stub handles or notched with saw-teeth on their lower margins. The pottery is quite artistic both in shape and decoration. Some vessels had loop handles or rim lugs and most of them bore parallel rows of meanders, festoons or diagonals with dots or dashes, engraved upon the outside surface before drying. I call these "antler-point" pots, believing that the engraving was done with the tips of deer horns, common in the mound. The pottery decoration is quite pleasing artistically in spite of its extreme simplicity. It is the only form of art observed. Faces and figures of men or beasts are entirely lacking. In preparing his clay-paste, the potter incorporated a large percentage of rock or clam-shell, pulverizing and mixing this in to assist shrinkage and prevent cracking as the vessel dried in the sun or near a slow fire. Most of those found with skeletons were thin-walled; only 1/16 inch in places, although fragments in the camp-refuse thrown upon the mound are much thicker—¼ to ½ inches—also more coarsely made. The finer type appeared to be more a funeral urn than the coarser, though more durable, was less artistic and intended solely for use.

Although peaceful interments, some skeletons bore marks of battle. One male skull had a small triangular chert arrowpoint embedded in the left temple. Another with round hole in the forehead and a bone arrowpoint close by suggests a second violent death. In one female adult skull was a chisel-like stone hatchet with blade driven into the face. A young woman with a child had a small triangular chert arrow-point in the left shoulder-blade and a bone arrowpoint in the forearm. There were other similar cases. Disease affecting the limb bones was often evident. Many legs and arms had been broken and healed in life usually resulting in deformity. One long bone of a left hand carried a small triangular chert arrowpoint embedded in the base. The point had entered the palm of hand and protruded at the back of wrist. It was apparent that the one thus stricken had vainly endeavored to remove the missile which was broken at point and base, but it was stuck fast and so remained in life with the bone enlarging around it.

At the foot of the Middle layer were a few very small people without any relics whatsoever and lying in sprawling postures. They were Short-heads. The greatest male adult stature observed was not over 5 feet.

The Lower layer burials in gravel from 3 to 4 feet below ground level were Meso-heads overlying Long-heads, and strangely enough, this relative position was maintained in every instance, the Long-head always being undermost. The Meso-heads were fairly tall and robust, the greatest male adult height being 5 feet 8½ inches. These were narrow-nosed, long-faced men with big teeth and massive jaws. All lay upon their sides, usually the left with knees drawn up. None had pots or relics of any kind, not even clam-shells, charcoal or animal bones. The gravel about them was absolutely bare. The Long-heads were somewhat smaller than the Mesos. Their bones are hard and heavy and well-preserved. The skeletons lay in crouching postures on the left side, face to the north. They had no pots, nor implements of bone or copper. Two adults had worn chipped flints near the heads; too crudely shaped, however, to be recognizable as tools. One old man wore a shell tube at his throat. A woman was accompanied by two notched shells resting upon her face. It is interesting to note that the three shell ornaments are not freshwater but marine species. They once lived in the ocean. This last female burial was quite elaborate, relatively considered. She lay upon her left side like one asleep. An infant was pressed closely to her side. Her head rested upon a mosaic of limestone pebbles in the center of which was an oblong granite block veneered with a seam of metamorphic rock—all unfabricated but carefully selected and arranged. Like other deep Long-head burials, this one was literally encased in a gravel vault which under the closest scrutiny could not be detected from above. I came upon one quite by accident and so after that I always dug deeply with the hope of discovering another. I found eight at various times, all crouching Long-heads in concealed graves. Who they were and where they came from is a matter for experts to determine; and there are other problems of interest. The crouching posture adhered to by the Mesos and Long-heads with faces looking northward was too prevalent to have been a chance occurrence. It has been suggested that these were northern people possibly Eskimos, but this is mere conjecture. The entire absence of pipes, grain, fruit-pits, nut-shells and agricultural implements throughout the mound implies that all of the people were meat-eaters and did not smoke. A kernel of grain, one plum-stone and a single fragment of stone or clay pipe would have proved the contrary, but I could find none, although tiny objects such as teeth of mice and copper plate beads 1/16 inch in diameter were readily recognized.[1] My only assistant in the work of excavation was Albert Tennik of Joliet. Business gave us no time for digging except on Sundays and holidays and only 80 days have been spent upon the site, although the work is continuing and with remarkable success. Two mounds only 60 feet in diameter and 6 feet high contained more than 300 human skeletons, 70 clay pots and numerous relics of polished stone, chipped flint, bone, copper and shell. The ground around the mounds has yielded an additional 100 skeletons and other relics. It is not my province here to discuss the structural features of the mounds and other details explaining on what grounds my conclusions as to the stratification of the mounds is based. A longer and more technical description with illustrations will soon be published in "The American Anthropologist."

[1] Since this article was written, I have spent a season of excavating the pits around the mounds and these correlating with the mounds have disclosed several stone pipes and caches of charred corn with some acorns, showing the pit people, therefore the mound people of the upper and middle levels did smoke and had vegetable food.

PLEISTOCENE AND RECENT HISTORY OF ALEXIS QUADRANGLE AND VICINITY.[1]

HAROLD R. WANLESS, UNIVERSITY OF ILLINOIS.

Introduction.

This paper summarizes the results of Pleistocene studies made in connection with the geologic mapping of the Alexis quadrangle, Mercer and Warren counties, Illinois, for the Illinois State Geological Survey, and discusses a significant Pleistocene section in the Milan quadrangle, which has been described by Savage and Udden.[2] The section is redescribed here, because it shows two gumbotils, and the original description preceded the introduction of the term gumbotil into Pleistocene literature. The writer wishes to acknowledge the assistance given by Dr. M. M. Leighton, who visited these sections with him, and made many helpful suggestions in interpreting them.

The Pleistocene deposits exposed in the Alexis area belong to the Kansan and Illinoian glacial stages and the Yarmouth, Sangamon, and Peorian interglacial stages.

Kansan Glacial Stage.

The oldest known Pleistocene deposit in the Alexis quadrangle is till of the Kansan glacial stage. Where exposed, it is usually a black or dark blue gray, highly carbonaceous and calcareous till. It contains more large boulders than the overlying Illinoian till. One granite boulder 8 feet in diameter was found in the Kansan till of the Alexis guadrangle. The drift is believed to belong to the Keewatin center of glaciation, as no jasper conglomerate or other rocks characteristic of the Labrador center have been discovered in it. The direction of ice advance was from the west or northwest.

Yarmouth Interglacial Stage.

The Yarmouth interglacial stage is represented by soil and gumbotil formed from the Kansan till where it was

[1]Published by the courtesy of the Chief, Illinois State Geological Survey.

[2]Savage, T. E., and Udden, J. A., Geology and mineral resources of the Edgington and Milan quadrangles: Illinois State Geological Survey, Bull. 38, pp. 164-165, 1922.

exposed to weathering on poorly drained upland surfaces. This gumbotil is ashy gray in color. A freshly broken chunk shows a pitted surface. This gumbotil is best developed in an exposure in the Milan quadrangle, 1½ miles northwest of Cable, in a number of gullies on the north side of a creek valley.[3]

Pleistocene section measured from outcrops and augur borings, ¼ mile east of the middle of the west line of sec. 8, T. 15 N., R. 1 W.

	Thickness		Depth	
	Ft.	In.	Ft.	In.
12. Loess, Grassy slope at top, not gullied (Peorian)	11	0	11	0
11. Loess, calcareous (Peorian)	7	6	18	6
10. Gumbotil, grayish brown (Illinoian)	1	6	20	0
9. Till, calcareous, brownish above, blue gray below (Illinoian)	16	6	36	6
8. Sand, containing some pebbles with diameters as large as ¼ inch, grading to fine sand without pebbles at base	2	10	39	4
7. Silt, sandy, light gray, grading to fine sand near base, calcareous	1	8	41	0
6. Sand and silt, white, noncalcareous		6	41	6
5. Silt, white, calcareous		6	42	0
4. Sand, brownish, noncalcareous		3	42	3
3. Soil, black, noncalcareous (Yarmouth)	1	9	44	0
2. Gumbotil, gray, with minute quartz and chert pebbles (Kansan)	2	6	46	6
1. Till, dark blue gray, strongly calcareous (Kansan), Reported 30 feet by Savage and Udden	4 exposed		50	6

Kansan gumbotil is also exposed at two or three localities in the Alexis quadrangle below the Illinoian till, but the relations are not so clear as they are in the section described above.

Another type of Yarmouth sediment occurs in the southern part of the Alexis quadrangle. In a number of recently cut gullies on the south side of Henderson Creek, a thick bed of reddish cross-bedded sand overlies the Kansan drift and underlies the Illinoian drift. The most typical section of these beds is described on page 256.

The reddish color and noncalcareous character of the sand (No. 3 of table on page 256) suggest that it was exposed to weathering with frequent wetting and drying for a long time before the Illinoian till covered it. It may have been an outwash deposit from the receding Kansan ice-sheet. Many farm wells obtain water from sands and gravels below the Illinoian till. Stumps and logs are reported in farm well drillings at depths of 30 to 40 feet.

[3]Savage, T. E., and Udden, J. A., *op. cit.*, p. 167.

Pleistocene section in a gully on the south side of Henderson Creek, about 700 feet southwest of the NE. cor. sec. 10, T. 12 N., R. 3 W.

	Thickness		Depth	
	Ft.	In.	Ft.	In.
11. Soil (Recent)	1	9	1	9
10. Loess, brown to buff, leached (Peorian)	10	6	12	3
9. Loess, gray to buff, calcareous (Peorian)	8	9	21	0
8. Silt, sandy, brown to chocolate colored, noncalcareous, with humus and carbonized plant traces (Late Sangamon)	2	9	23	9
7. Gumbotil, brownish, with pitted surfaces, and a few chert pebbles (Illinoian)	1	10	25	7
6. Till, rusty colored, very sandy, reacting slightly with acid (Illinoian)	15	0	40	7
5. Boulder concentrate at base of till (Illinoian)	1	0	41	7
4. Silt, sandy, light yellow, cross-bedded, noncalcareous (Illinoian or Yarmouth)	1	0	42	7
3. Sand, reddish, cross-bedded, irregularly color banded (Yarmouth)	18	0	60	7
2. Till, light blue gray, leached, (not typical gumbotil) with slight gravel concentrate at surface (Kansan)	4	6	65	1
1. Till, black or dark blue gray, highly calcareous, weathering whitish, as a result of efflorescence of calcium salts (Kansan)	20 exposed		85	1

It is believed that the Yarmouth sands and soils and the Kansan gumbotil are much more extensive in this region than their exposures indicate. The amount of dissection during Yarmouth time is not clearly indicated, but it is believed that the larger stream valleys were developed then.

Illinoian Glacial Stage.

Outwash deposits from the advancing Illinoian ice-sheet seem to be shown in the calcareous silts, sands, and pebble beds (Nos. 5-8 in the section near Cable, in the Milan quadrangle, described above). Illinoian till covered the entire area of the Alexis quadrangle. Proof that this till belongs to the Labrador center of glaciation is found in occasional pebbles of jasper conglomerate which are probably from the Lorraine quartzite, northeast of Lake Huron. Many large blocks of coralline limestone containing colonies of *Chaetetes milleporaceus* are prsent in the till at two localities. This limestone is believed to be the Lonsdale limestone (Pennsylvanian) which is exposed near Illinois River from Peoria north to La Salle. Fragments of Burlington limestone and chert are found in the Illinoian till in the southern part of the quadrangle. The direction of movement of the Illinoian glacier, as determined from these constituents, must have been from the east or southeast. Thus the direction of Illinoian ice invasion was directly opposite from that of the Kansan invasion.

The Illinoian till is blue gray where unweathered. It is less calcareous and carbonaceous than the Kansan till, although perhaps only locally. It is not certain to what extent the valleys, which were excavated in Yarmouth time, were filled with Illinoian till. It appears that the larger valleys were only partly filled with till, because the depth and width of valleys in which Sangamon deposits accumulated seem too large to be the result of Sangamon erosion.

Sangamon Interglacial Stage.

Following the recession of the Illinoian glacier a gumbotil was formed from the Illinoian till on flat or poorly drained upland surfaces, which is similar to the gumbotil on the Kansan till. Above the Illinoian gumbotil there is usually a layer of loess or loess-like silt which, in the Alexis quadrangle, is not known to exceed three feet in thickness. It is noncalcareous, and in many places contains small carbonized traces of plant material. It is probably a late Sangamon deposit, equivalent in age to the Sangamon loess described by Leighton.[4] It is not thick enough in the Alexis quadrangle to show a calcareous zone. A black soil in many places overlies the Sangamon loess-like silt or the Illinoian gumbotil.

The amount of erosion which was accomplished during Sangamon time was sufficient to strip all Illinoian till from the surface in some places. In a gully exposure near the northwest cor. SE. ¼ NE. ¼ sec. 12, T. 12 N., R. 3 W., the late Sangamon loess-like silt rests on the Illinoian till, and a few feet away on the Yarmouth reddish sands. In a cut bank along the edge of a low terrace along the south side of Pope Creek the section described on page 258 is exposed:

No. 1 of this section is believed to be Sangamon, overlaid by Peorian loess. The position of this old soil at the present water level shows that no actual deepening of the valley of this stream has taken place since Sangamon

Leighton, M. M., The Farm Creek exposure near Peoria, Illinois—a type Pleistocene section: Illinois State Acad. Sci. Trans., vol. 18, pp. 402-404, 1925.

time. Other terrace remnants of similar form are common along the larger streams, and the loess has been found to form the terrace material in one other place. This shows that the levels of the larger streams of the area in late Sangamon time were generally as low as they are at present.

Pleistocene section of a cut bank on the south side of Pope Creek in the NW. ¼ sec. 4, T. 13 N., R. 3 W.

	Thickness		Depth	
	Ft.	In.	Ft.	In.
6. Loess or loess-like silt, yellowish, soft	2	0	2	0
5. Loess or clay, yellowish brown, non-calcareous	3	0	5	0
4. Clay, slightly sandy, becoming more sandy toward base	3	6	8	6
3. Sand, brownish at top, yellowish at base, well stratified	3	6	12	0
2. Loess, blue gray, highly calcareous (Peorian)	4	0	16	0
1. Soil, black, with no pebbles, to level of Pope Creek (Sangamon)	3	0	19	0

Iowan Glacial and Peorian Interglacial Stages.

No deposits of Iowan age are known in this region unless the main loess deposition started here in late Iowan time. If the thin Sangamon loess was calcareous when deposited, it seems to have been completely leached before the deposition of the overlying calcareous Peorian loess. If the Sangamon loess formerly covered the entire surface it was eroded from many of the slopes before the Peorian loess was deposited.

Loess of late Iowan or Peorian age covered the uplands, slopes, and valley plains of the main streams and their larger tributaries. It rests on the Sangamon loess, on the eroded surface of the Illinoian till, on Yarmouth sands, and on the Pennsylvanian and Mississippian strata which form the bed rock of this area. The loess varies from 6 feet or less to 20 feet in thickness. Where it is thicker than 8 feet there is an upper, buff colored, noncalcareous zone and a lower gray calcareous zone. Fossils of air-breathing gastropods were collected in the calcareous zone of the loess at three localities. The section of a terrace along Pope Creek described above shows stratified sands and clays 7 feet in thickness between calcareous loess below and noncalcareous loess or loess-like silt above. This suggests that the valley was flooded during the time of loess deposition and an alternation of fluviatile and eolian deposits resulted.

Wisconsin Glacial Stage and Recent Time.

No deposits which can be definitely ascribed to the Wisconsin glacial stage are present in this area. As loess deposits are found on the Bloomington moraine of the Wisconsin glacier in the vicinity of Peoria and elsewhere, a part of the loess of the Alexis area may be post-Wisconsin in age.

The larger streams meander in a series of small curves which are mainly restricted to the valley plain. Actively eroded cut banks are few along the larger streams. The valley plains show a series of large meander curves not related to the present meandering of the streams. This is believed to represent a period of active valley widening on the part of these streams before the Peorian loess deposition overloaded the valleys with debris. The fact that considerable remnants of these loess-covered terraces are still preserved along four of the five large streams of the area shows that these streams have not renewed active valley widening since the deposition of the Peorian loess.

The smaller streams in areas of cleared forest or cultivated slopes have trenched below their alluvial plains, which are preserved as terraces. The greatest amount of trenching is seen in those streams which have cut into the soft Yarmouth sands. This renewed erosion is probably the result of deforestation by man and cultivation of some of the steeper slopes.

Summary.

The Pleistocene and recent events in the Alexis region may be summarized as follows:

1. Kansan. Deposition of black, carbonaceous, very calcareous, bouldery till, probably from the Keewatin center.

2. Yarmouth. A very long interglacial epoch; development of a gray gumbotil from the till on poorly drained upland surfaces; formation of a black humus soil; deposition and oxidation of sands and silts; erosion of present main valleys nearly to their present size and depth.

3. Illinoian. Deposition of calcareous sands and silts in advance of the Illinoian glacier; deposition of blue cal-

careous stony till from the Labrador center, the direction of ice movement locally being from the east or southeast; partial filling of Yarmouth valleys with till.

4. Sangamon. Formation of brownish gray gumbotil and black soil on poorly drained surfaces; deepening of valleys of major streams at least to present depth; deposition of loess or loess-like silt in late Sangamon; beginning of leaching of this loess.

5. Iowan. Minor amount of leaching and some erosion on steeper slopes.

6. Peorian. Deposition of loess on uplands, slopes, and valley plains.

7. Wisconsin and recent. Leaching of part of Peorian loess; erosion of loess from smaller valleys and partial erosion from larger valleys, the remnants of Peorian valley plains forming terraces; recent renewal of erosion in smaller valleys, resulting from deforestation and cultivation of steeper slopes.

KARST TOPOGRAPHY AND SANITARY ENGINEERING AT ALTON, ILL.*

J. E. Lamar, Illinois State Geological Survey

In 1926, the City of Alton had a rapidly growing subdivision so located topographically that it was impossible to connect it with any of the existing city sewers without the expenditure of a considerable sum of money for the construction of a pumping station, tunnel or siphon. Therefore, inasmuch as the subdivision is located on the margin of an area of Karst or sink hole topography, it was proposed to dispose of the sewage by running it into a conveniently located sink which was at the time carrying off the surface drainage of the area. The Division of Sanitary Engineering of the State Department of Public Health raised the question whether or not the sewage discharged into this sink would enter Mississippi River above the city water supply intake, located about one-half mile south of the sink (Figure 1). The Illinois Geological Survey was called into consultation by the Division of Sanitary Engineering and this paper describes how the probable point of discharge was determined and the factors involved in the determination.

Factors Influencing Sub-surface Drainage Character of Rock Formations.

The rock formation involved in the region under consideration are the basal Ste. Genevieve and the Upper St. Louis limestones. The Ste. Genevieve is for the most part a pure limestone, locally oolitic. The St. Louis consists of thin, medium and thick beds of limestone some of which are very pure, others very argillaceous. In particular, a bed about 12 inches thick lying beneath a brown layer about 18 inches thick which in turn underlies the conglomeratic beds of the upper St. Louis, is highly argillaceous and in the bluffs about a mile and a half above the business district of Alton is responsible for numerous springs and seeps, as well as a rather extensive development of underground aque-

*Courtesy of the Chief, Illinois State Geological Survey.

ducts which descend to the general level of this bed irrespective of its elevation above the River.

Dip of the Rock Strata.

The dip of the limestone exposed in the river bluff has a great variation due to extremely local warpings, but in general is thought to be from 1 to 2 degrees, approximately S. 20° E.

Jointing.

In the area under consideration there are two principal and rather pronounced sets of joints, one trending about N. 60° E., the other N. 45° W. Of these the former is the most important in influencing sub-surface drainage, for by far the greater number of observable underground water channels trend approximately in the direction of this set of joints.

The Sinks.

The sinks vary in size from relatively large depressions about 300 feet in diameter at the rim and 60 to 80 feet in depth, to small ones of a few tens of feet in diameter and of proportionately shallow depth. Many of the sinks show limestone in their funnels and a few are the termini of small surface drains.

Conclusions Concerning Underground Drainage.

From a study of field evidence the following conclusions are thought warranted, and thought to apply to the sinks of the region:

(1) That the water draining into the limestone sinks descends through enlarged crevices and joints in the rock, moving principally downward until it reaches a layer of limestone which, because of its argillaceous or siliceous character, is less previous, and less soluble than the rock generally.

(2) That joints in these argillaceous beds tend to become clogged by materials, residual from the solution of the calcium carbonate from the rock and by settlings from the descending water whose movement may be partly or wholly impeded by the argillaceous beds.

(3) That the water moves laterally along these less soluble beds until it encounters crevices or joints which have not been closed and permit further downward descent.

(4) That the water entering sinks other than those immediate to the river bluff, flows in rather well-developed, mature sub-surface drainage systems.

(5) That the sinks immediate to the river bluff probably drain toward the bluff and such water as they collect issues through the caverns in the bluff.

(6) That the age of a given sink relative to others in the same region and rock formation is generally indicated by its size, and that the larger and deeper sinks are the older.

(7) That the alignment of the older sinks indicates the route of the oldest underground water channels and that these are probably the course of the major sub-surface drainage.

Determination of Underground Drainage.

With the foregoing points in mind the elevations of the bottom of the largest sinks throughout the area were contoured.[1] The resulting map (fig. 1) shows an alignment of older sinks which suggest that water entering the proposed disposal sink probably takes a southeasterly course, as indicated by the arrows in Figure 1, for about 700 feet. This course is possibly induced by the N. 45° W. joint system. Then, the underground drainage turns almost due south to the sink with an elevation of 120 feet. From this point the direction of flow is problematical because of the lack of elevations on sink bottoms. Either the N. 45° W. set of joints was most effective in influencing the course of the drainage and it went southeast to the Grand Avenue Creek system, itself an enlarged and united series of sinks, or else the effect of the major system of joints, the N. 60° E. set, with offsets in the course of the drainage due to the N. 45° W. joints, should result in the discharge of the water from the spring at A.

With these two potential points of discharge in mind, fluorescein was introduced into the stream of water entering the disposal sink. The dye was introduced at 3:30 P. M.

[1]The elevations of the bottoms of the sinks were taken from a topographic map kindly lent the author by Mr. J. E. Schwaab, City Engineer of the City of Alton.

and had not appeared in either of the potential discharges by 6:00 P. M. The following morning, however, spring A was flowing green water. The color persisted for about 200 feet out into Mississippi River. Examination of other springs along the river bluff in the suspected discharge area failed to reveal the discharge of dye-colored water from any other springs or seeps.

Conclusions.

The phenomena described suggest that at least in some regions of limestone sinks, it is possible to determine the general direction of the flow of underground water from contours drawn on the bottoms of the major sinks of the region, coupled with data on the jointing of the area and its effect on sub-surface drainage.

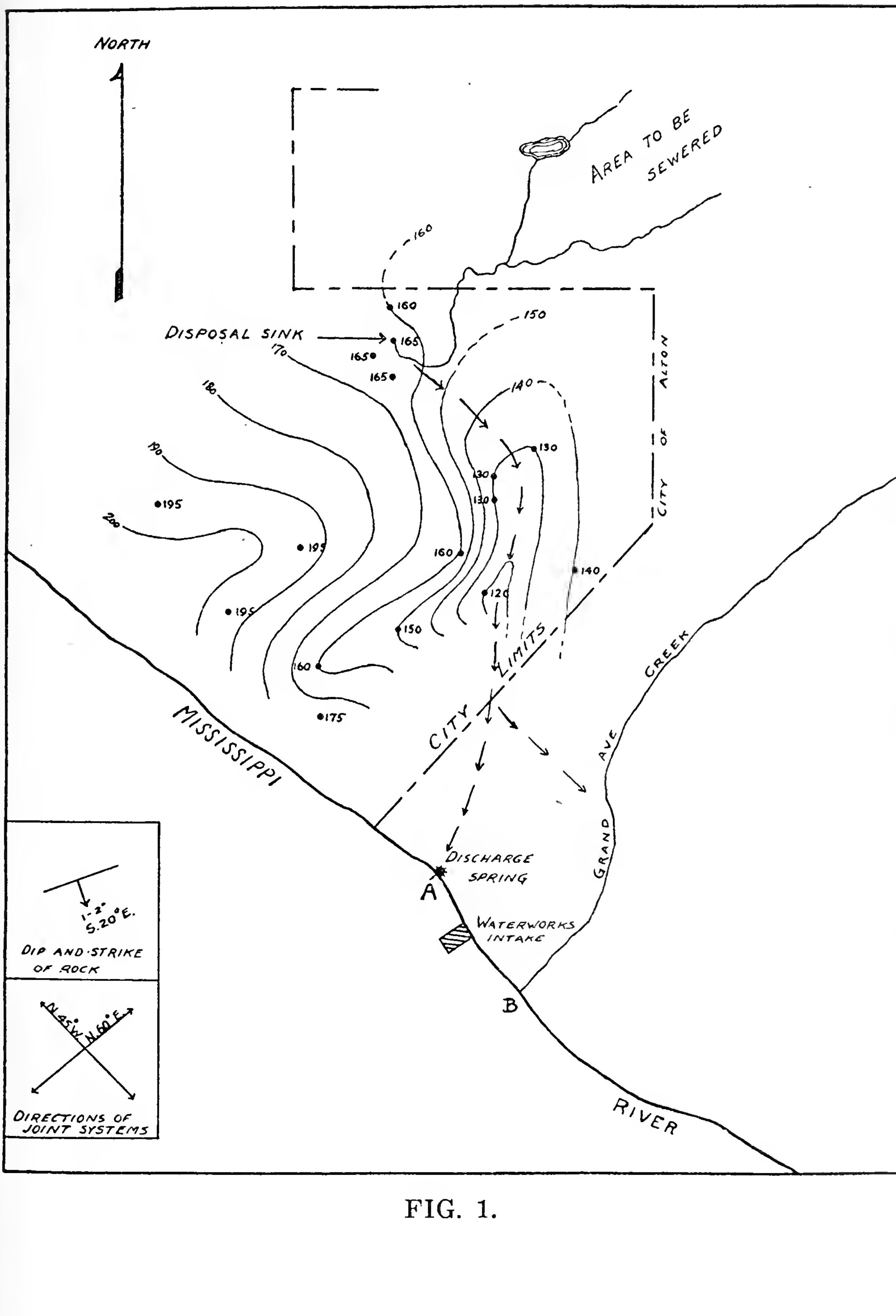
NORTH
AREA TO BE SEWERED
DISPOSAL SINK
CITY OF ALTON
CITY LIMITS
MISSISSIPPI
RIVER
GRAND AVE CREEK
DISCHARGE SPRING
A
B
WATERWORKS INTAKE
DIP AND STRIKE OF ROCK
DIRECTIONS OF JOINT SYSTEMS

FIG. 1.

PRE-PENNSYLVANIAN SURFACE WEST OF THE DUQUOIN ANTICLINE.*

L. G. HENBEST, ILLINOIS STATE GEOLOGICAL SURVEY.

Introduction.

During some stratigraphic studies on the Pennsylvanian, the results of which are to be included in a general report on the coal of the State, several interesting features of the pre-Pennsylvanian surface west of the Duquoin anticline were discovered. Several profiles, based on well records, were drawn across this region from west to east (one is reproduced in fig. 1). They showed that the contour of the Mississippian-Pennsylvanian unconformity, the depositional structure of the Pottsville and Carbondale formations, and the geographical, lithologic changes within the Pottsville correspond. This correspondence is so significant that the paleogeography of the region in Pottsville and Carbondale times can be determined.

Selection of a Datum Plane.

To eliminate the post-Pennsylvanian deformations, it was necessary to find a datum plane which represents an original, level surface. No. 6 coal was chosen because it is the most easily followed horizon in the Pennsylvanian, it is wide spread, its formation was conditioned by a state of quietude in geologic processes that is unique for the "Coal Measures" of Illinois, and its deposition marked the climax of those geologic processes during the Pottsville and Carbondale which worked toward an extension of the seas and the filling of the basins.

Mississippian-Pennsylvanian Contact.

The contour of the pre-Pennsylvanian surface was delineated by measurements from the datum plane, or No. 6 coal, to the Mississippian-Pennsylvanian contact. Figure 1 is a profile, based on well logs, extending from Millstadt to the Duquoin anticline at Centralia which represents some of these measurements. The vertical scale is 100 feet to the

*Courtesy of the Chief, State Geological Survey.

inch and the horizontal scale is 4 miles to the inch. The straight line at the top is the horizon of No. 6 coal and the bent line at the bottom represents the unconformable contact between the Mississippian and the Pennsylvanian.

The records above the Carbondale and below the Pottsville are omitted.

In figures 1 and 2 the divergence of the lines representing the datum plane and the pre-Pennsylvanian surface is conspicuous. In the vicinity of Millstadt, in St. Clair County, the interval between the top of No. 6 coal and the top of the Mississippian is from 10 feet to about 50 feet. Eastward, to the Clinton County line, the interval increases to about 150 feet, but between this county line and Trenton (Clinton County) the interval increases much more rapidly than elsewhere, i. e. from 150 feet to more than 350 feet. From Trenton eastward to the Duquoin anticline the interval increases less rapidly. Other profiles and well records not exhibited here show that this same general profile of the pre-Pennsylvanian surface is continuous from Madison County south to Coulterville, Randolph County. It is especially interesting that the escarpment near Trenton (figs. 1 and 2) extends almost due south toward Coulterville. It is called the Trenton-Coulterville escarpment in this paper.

Depositional Structure of the Pottsville and Carbondale Formations.

The correspondence between the topography of the pre-Pennsylvanian surface and the depositional structure of the Pottsville and Carbondale formations is significant.

A basin extends eastward from the brink of the Trenton-Coulterville escarpment. Its lowermost portion is filled with Pottsville sediments. The Carbondale formation overlaps the Pottsville and extends westward toward St. Louis; thus filling the rest of the basin below No. 6 coal.

Insofar as specific horizons in the Pottsville can be followed, they appear to thin out westward and to be overlapped by the strata above. If this is true, the thinning out is due more to conditions of deposition than to stages of widespread erosion after deposition, although intraformational unconformities probably are common in the Pottsville. The most that can be said at this time about the changing thickness of the Carbondale formation is that horizons far apart vertically in the basin converge toward the west. The critical point in determining the causes of this convergence is the correlation of the coal below No. 6 which occurs along the margin of the Carbondale basin at Millstadt and at other places farther north. The correlation of this coal is uncertain, but it is No. 5 coal apparently. In general, then, the thinning of the Pottsville and Carbondale formations westward is due to a series of overlaps which indicates that marine invasions progressed toward the St. Louis region. The greatest overlap is that of the Carbondale over the Pottsville.

Lithologic Differences Within the Pottsville.

The lithology of the Pottsville has considerable bearing in determining the character of the pre-Pennsylvanian surface. Figure 3 is a diagrammatic representation of lithologic changes in the Pottsville formation. In Saline County, quartz pebble conglomerates are restricted to the lower Pottsville, but in western Williamson County and in Jackson County larger quartz pebbles have been found and they are not restricted to the lower Pottsville. The upper Pottsville in Saline County contains at least four marine limestones, and one of these limestones—the Curlew—is rather pure except for the presence of chert, and contains a fauna of large branchiopods, corals, and numerous Fusulinella and other Foraminifera, thus indicating a relatively quiet sea during its formation. In Jackson County, one lenticular limestone is reported from the upper Pottsville; whereas surveys northwest of this place, indicate that no limestones exist in the Pottsville at the outcrops. So the Pottsville takes on a distinct shoreward facies toward the northwest as would be expected from the contour of the pre-Pennsylvanian basin and the consequent depositional structure of the middle and lower Pennsylvanian.

Conclusions.

It appears from the evidence brought out that the pre-Pennsylvanian surface originally consisted of an upland area in the west half and a basin in the east half of this region and that the Trenton-Coulterville escarpment represents the western margin of the basin. After the filling of this basin by Pottsville sediments the strand line moved westward as a result of a general lowering and extension of the basin, and the Carbondale formation was deposited in the broader basin.

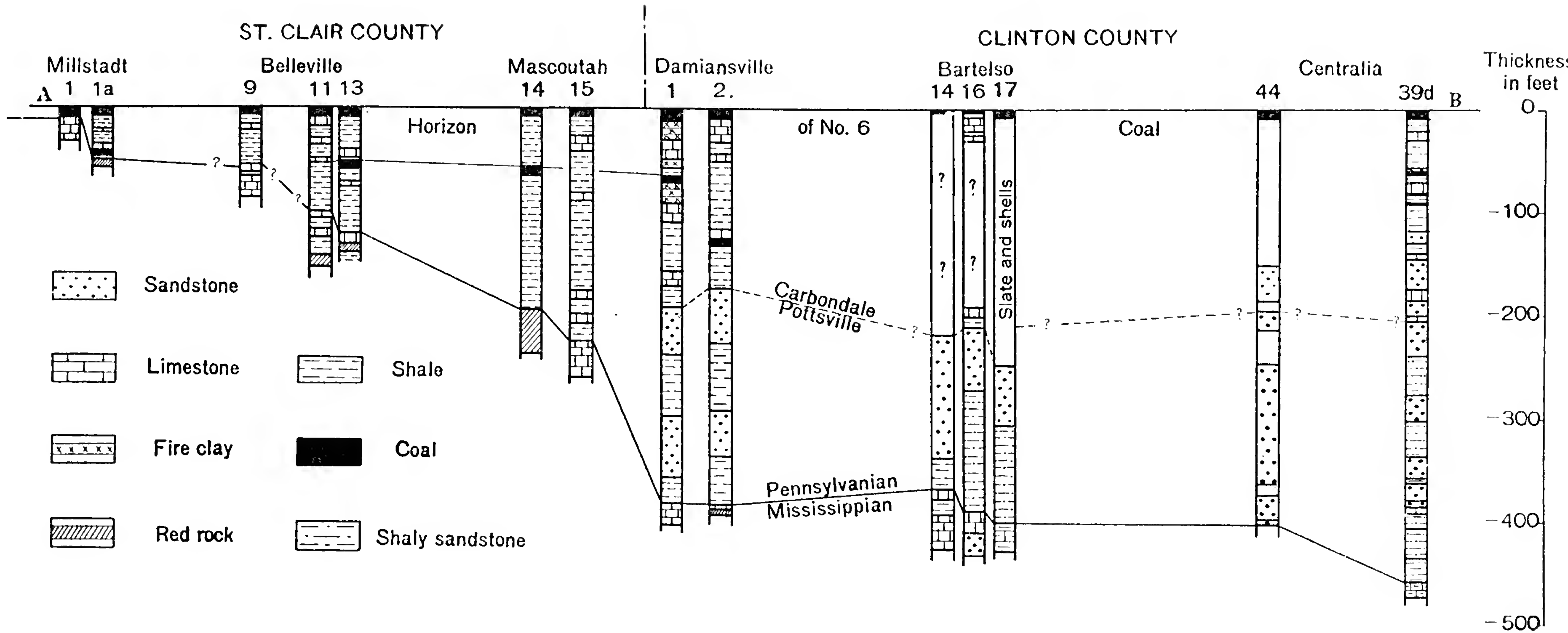

Fig. 1.—Profile showing the thickening of the Carbondale and Pottsville formations eastward. (The numbers at the top of the logs correspond to locations on the isopachous map, Fig. 2).

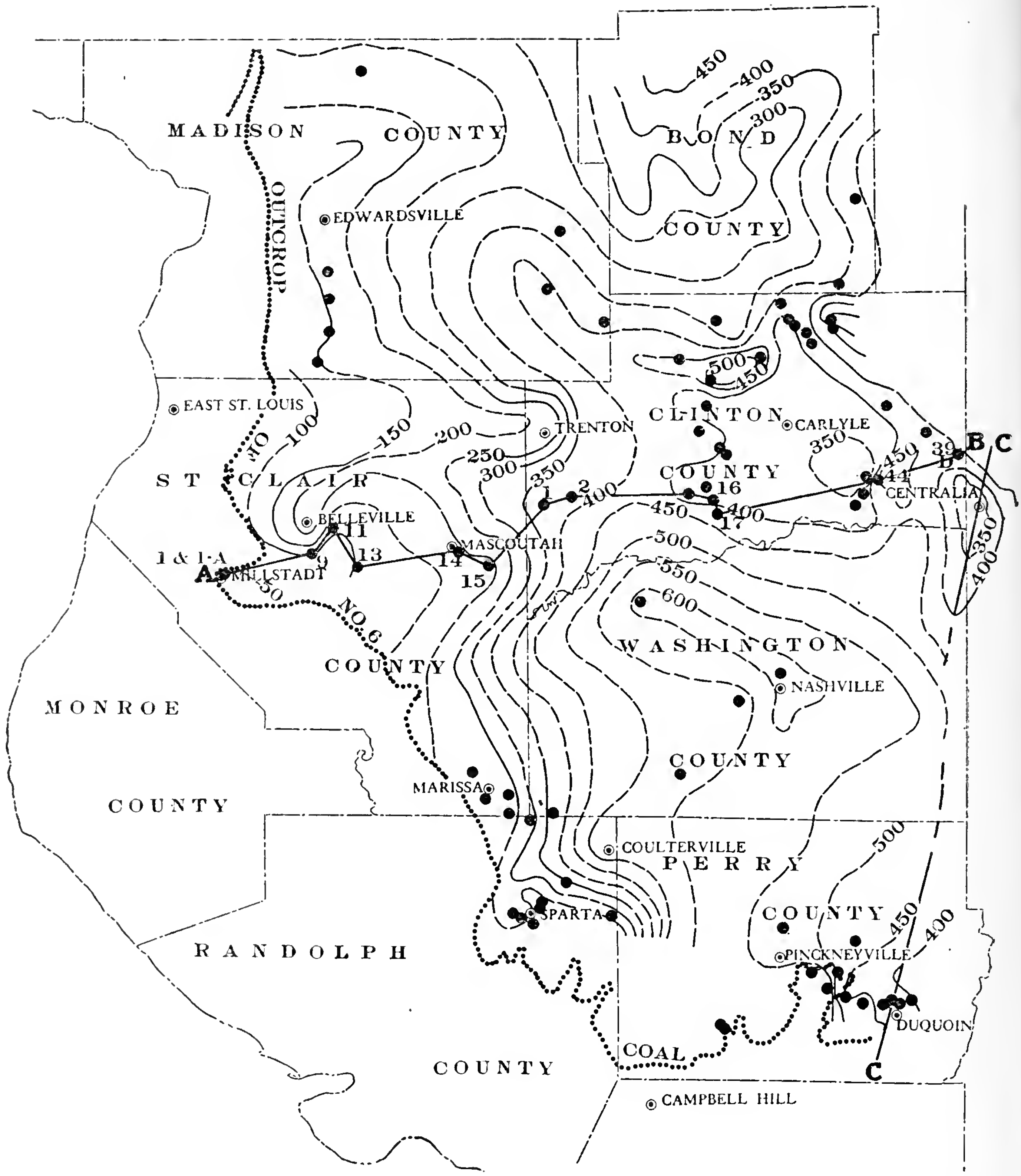

Fig. 2.—Isopachous Contour Map. The figures on the contours refer to the distance in feet from the horizon of No. 6 coal to the pre-Pennsylvanian surface. The line A-B gives the location of the profile in Fig. 1; and C-C the axis of the Duquoin anticline.

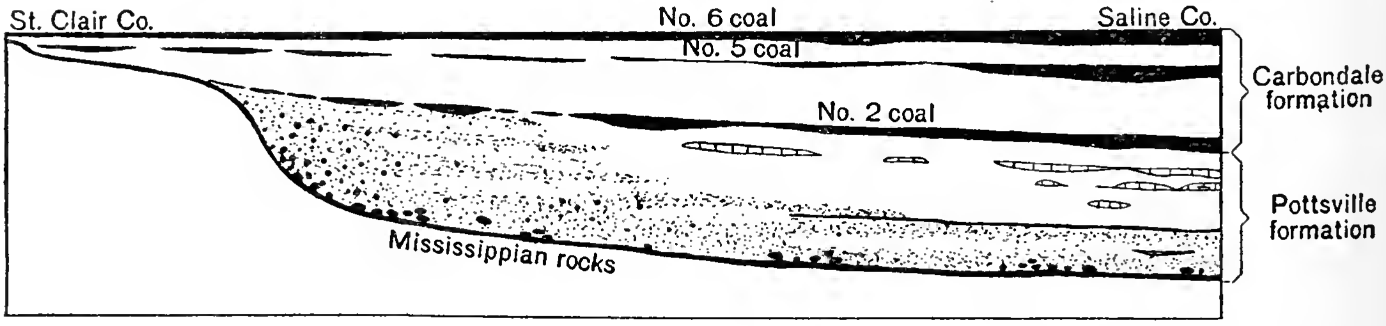

Fig. 3.—Diagram to represent horizontal lithologic changes in the Pottsville.

MOLLUSCAN LIFE OF THE LOESS DEPOSITS OF ILLINOIS.*

FRANK COLLINS BAKER, CURATOR, MUSEUM OF NATURAL HISTORY, UNIVERSITY OF ILLINOIS.

Introduction.

Since the work of Dr. B. Shimek on the mollusks of the Iowa loess deposits, little attention has been paid to the life of these very interesting strata. During the interval between Dr. Shimek's studies and the present time, the classification of mollusks has become much more refined and the limits of species and varieties have been more closely drawn, more weight being given to small variations than formerly. This so-called splitting of the species has become more and more necessary in the study of geological horizons for the purpose of recognition of different faunas of subordinate strata, and it is not strange that the more recent life of the Pleistocene should receive similar treatment, the result of which has been to recognize a number of apparently stable variations characteristic of some of the loess faunae, and which are different from the related forms living today. It has been stated that the land snail fauna of the loess deposits, and, indeed, of the whole Pleistocene, is practically like that living in the same area today. This statement has been found to need qualification, however, as the fauna of the Pleistocene is considerably different from that of the present time, especially as regards the State of Illinois. The writer has believed that a careful comparison of the Pleistocene with the recent fauna would show many species which differ more or less from their relatives living today, and the studies of the past ten years have shown that this supposition is correct, not only as regards the land fauna, but also of the fauna of the streams and lakes. That this should be so is not strange, for the covering of so large an area with a huge sheet of ice must necessarily have changed both climate and environment, and the fact that not all species responded to these changes again indicates that not all species have the same

*Contribution from the Museum of Natural History, Univ. of Ill., No. 47.

degree of plasticity in responding to changes of such a drastic character.

During the past six years the Illinois State Geological Survey, under the direction of Dr. M. M. Leighton, Chief, has been conducting surveys in various parts of the state, during which the superficial deposits have been carefully examined and their stratigraphy accurately worked out. This accuracy in the examination of field relations is of the utmost importance, for the value of deductions from fossil faunae rest absolutely on the accuracy of the work of the field geologists. The Survey has been fortunate in having available for its field studies such men as Dr. Paul MacClintock, Dr. Geo. Ekblaw, Dr. Benj. Cox, and Dr. H. R. Wanless, to all of whom as well as to Dr. Leighton, the writer's thanks are due. The present essay is of a cooperative character, between the Illinois Geological Survey and the Museum of Natural History of the University. The material described in two previous papers, collected by the Illinois Survey, should be consulted in connection with this paper and certain changes made in the species listed. This data is incorporated in the present paper (see Journ. Geol., XXX, pp. 43-62, 1922; The Nautilus, XXXIV, pp. 61-68, 1920). See also Baker, Life of the Pleistocene, Bull. Univ. Ill., XVII, No. 41, 1920. The material studied is in the research collection of the museum of natural history. For descriptions of new varieties see Nautilus, XL, p. 114, 1927.

Ecological and Climatic Considerations.

Of the 49 species and varieties listed in the table, 43 are strictly land mollusks, three live under moist conditions, bordering streams *(Carychium)* and three are amphibious, living in small, shallow streams, or, more frequently, on wet mud flats above water mark *(Galba, Pomatiopsis)*. As these genera now live in association with true land mollusks, which have migrated to the wet surface, it is not strange that they should be incorporated together in some loess deposits. In many cases the loess was probably deposited after the shallow wet area had become dry and the land mollusks wandered into this area seeking moisture. Only in a few cases are these aquatic forms associated with loess mollusks, the majority of land species living in open woodlands or shrub-covered areas far above streams. This has been called upland loess, and the strata containing acquatic forms lowland loess, by the Iowa geologists and the distinction is well taken.

The land snail fauna found in loess deposits of the interglacial intervals indicates strongly that the animals were under climatic and environmental conditions which were different from those obtaining in Illinois at the present time. Of the 49 species and varieties listed in this paper 32 now live in Illinois, 10 are extinct, and 7 are now living in areas far removed from the state. Only 65 per cent now live in the same areas. Taking the fauna as a whole, it contains many species which now live in a drier and relatively more severe climate—Wisconsin, Michigan, Colorado, Nebraska, Utah, Arizona, etc. In the table the present location of the fossil species is indicated and it will be seen that they are, in some cases, far removed from Illinois. The near relatives of the extinct species also live far from the state area.

It has been affirmed that the fauna of the loess does not differ materially from that of today in the same area and that the climate must have been similar. But this could not have been so, judging by the nature of the fossils, as well as of the deposits, aeolian or wind-blown, fine dust. The present habitat of *Oreohelix cooperi* (relative of *Oreohelix iowensis*), *Gonyodiscus cockerelli* (relative of *Gonyodiscus shimekii*), *Sphyradium alticolum, Vertigo modesta,* and *Vallonia gracilicosta* conculsively prove that the conditions in Illinois when these species lived must have been similar to those under which these species live today—drier and relatively cooler. The associated species, for the most part, now live with these species, in the western areas and their association together in Illinois loess deposits is not strange.

Several varieties of common local species, now abundant in Illinois, differ more or less markedly in size or form from the typical form as known today, as *Polygyra profunda pleistocenica, P. multilineata altonensis, P. hirsuta yarmouthensis, P. monodon peoriensis, Succinea ovalis pleistocenica, S. grosvenori gelida,* and *Pomatiopsis scalaris,* thus stamping the fauna as under more rigorous conditions than at the present time, these variations being, for the most part, smaller than the typical form living today. This local variation will become more apparent, even in other species, when more material from more widely-spread localities is critically examined.

Of the four typical loesses represented, the Peorian at present contains the greatest number of species, 34 or 76 per cent, followed by the Early Wisconsin with 25, or 51 per cent. The Yarmouth and Sangamon will show a larger percentage of species when more deposits are discovered in Illinois. In Iowa the number recorded is greater than in Illinois. It is of more than passing interest to note that most of the Peorian loesses are regarded as Early Peorian, and some of them were probably laid down very soon after the retreat of the ice, indicating dry conditions at a very early stage of the interval. In the case of the loess overlying the Bloomington moraine in Bureau County near Weyenet, there is an absence of weathering between the till and the overlying loess, indicating that the loess was deposited soon after the recession of the ice. The climate thus would be somewhat colder than that of today and, apparently, was somewhat drier, perhaps like that of portions of Nebraska and the Dakotas at the present time, or even Idaho and Montana, where wind-blown sand in the form of dunes is now being deposited.

The present paper is to be regarded as a report of progress on a restudy of loess fossils from a modern viewpoint of taxonomy, as well as a more careful discrimination of stratigraphy than has been made previously. Greater quantities of many species are needed for comparison than have been available so that range of variation may be more clearly known. In the present contribution no attention has been paid to previous records of loess mollusks, only that material coming directly under the writer's attention being considered available. Some of these older records need confirmation.

Stratigraphic Data for Deposits in Which Terrestrial Life Occurs.

These deposits include silts, old soils, loess, and sands. The material has been collected by members of the Geological Survey during the past four or five years. The species included in each deposit are listed and an interpretation is made of the geologic horizon of the stratum in which the life occurs.

Locality: Clark Co., three miles southwest of Marshall, NW, NE. sec. 16, T. 10 N., R. 12 W. Section as below noted:

1. Silts (like loess) but containing abundant glacial stones scattered through the mass, with fossils throughout the whole section, calcareous throughout........ 40 ft.
2. Leached and weathered pre-Illinoian drift........ 10 ft.
3. Pre-Illinoian till and gravel, calcareous........ 10 ft.

Stratigraphic Horizon: Probably Yarmouth, but might be Aftonian.

Dr. MacClintock believes that the best explanation of this deposit (1) is that it is an overridden pre-Illinoian deposit picked up by the ice and transported some distance. While this hypothesis appears doubtful from some standpoints, it seems the best at present available. The mixing of land, fresh water, and amphibious life suggests such a condition.

Molluscan Life: From number 1 silts.

Polygyra monodon peoriensis	*Carychium exiguum*
Polygyra hirsuta yarmouthensis	*Galba parva*
Helicodiscus paralellus	*Pomatiopsis scalaris*
Strobilops virgo	*Hendersonia occulta*
Succinea ovalis pleistocenica	*Pisidium species*

Locality: Clark Co., Big Creek exposure, near locality above.

Material: Taken from the top of the pre-Illinoian interglacial soil and from the lower few feet of the overlying Illinoian till, evidently picked up from the interglacial material and incorporated in the basal portion of the till, which is also very silty (MacClintock).

Stratigraphic Horizon: The pre-Illinoian till appears from its distribution to have had a Labradorian source and so may well be of Nebraskan age. The interglacial deposit, therefore, may be either of Yarmouth or Aftonian age, or possibly both, if the Kansan drift is absent (MacClintock). The mixing of land and fresh water species may indicate transportation from original locality.

Mulluscan Life:

Polygyra monodon peoriensis	*Hendersonia occulta*
Helicodiscus paralellus	*Carychium exile*
Vertigo ventricosa	*Carychium exile canadense*
Cochlicopa lubrica	*Galba parva*
Succinea ovalis pleistocenica	*Gyraulus altissimus*

Locality: Bureau Co., sec. 35, SW ¼ NE ¼, T. 16 N., R. 10 E., near Depue (Dr. Leighton).

Material: A section from a spur near Depue Zinc Co., shows:

1.	Wash from slopes above	5 ft.
2.	Stratified sand, few pebbles and few shells, layers perceptibly inclined to the east	10 ft.
3.	Coarse gravel	1–2 ft.
4.	Glacial till, probably Illinoian	10+ ft.
5.	Fossiliferous silt with color bands gray and rusty; few scattered pebbles, changes above to glacial till. To the east, the slope becomes gray, stratified, and softer	5+ ft.
6.	Sand with few scattered pebbles and fossils, pinkish yellow, some thin layers of pink silt, gives pink coating when washed down over sand. Few thin cemented fragments of sand about 1 in. thick in gully	20 ft.

Stratigraphic Horizon: The fossiliferous silts are believed to be of Yarmouth age, the stratified sand of Sangamon age.

Molluscan Life:

Polygyra hirsuta yarmouthensis	*Succinea grosvenori gelida*
Polygyra monodon peoriensis	*Hendersonia occulta*
Helicodiscus paralellus	*Galba parva*
Succinea ovalis pleistocenica	

Locality: Jackson Co., Campbell Hill Quandrangle; Sec. 36, T. 7 S., R. 6 W., SW. ¼ NE. ¼. (Dr. MacClintock).

Material: Exposure along road cut up side of hill. Valley here shows terraces at 460 ft. AT and loess and till show in terrace deposits.

1.	Leached loess	20–25 ft.
2.	Leached pebbly drift, many striated stones	3–4 ft.
4.	Leached loess	2 ft.
5.	Loess, calcareous, irregular "kindchen," iran mottling and aspect of old loess, very dense, fossiliferous	10 ft.

Stratigraphic Horizon: No. 5 is believed to be pre-Illinoian loess, probably Yarmouth. Fossils rare.

Molluscan Life:

Hendersonia occulta	*Strobilops virgo.*

Locality: Mercer Co., Sec. 9, T. 14 N., R. 3 W., Mercer Township. From hard road cut (Dr. H. R. Wanless).

Material: Loess.

Stratigraphic Horizon: Early Peorian.

Molluscan Life:

Succinea grosvenori gelida
Succinea ovalis pleistocenica
Heicodiscus parelellus
Gonyodiscus shimekii
Sphyradium alticolum
Vertigo modesta
Hendersonia occulta
Galba parva

Locality: Mercer Co., Sec. 4, T. 14 N., R. 1 W. (Dr. Wanless).

Material: Loess.

Stratigraphic Horizon: Early Peorian.

Molluscan Life:

Polygyra thyroides
Succinea ovalis pleistocenica
Succinea grosvenori gelida
Gonyodiscus shimekii
Vitrea hammonis
Vertigo ventricosa
Vertigo modesta
Hendersonia occulta
Cochlicopa lubrica, var.

Locality: Warren Co., Sec. 12, T. 12 N., R. 3 W. From gully (Dr. Wanless).

Material: Loess.

Stratigraphic Horizon: Probably Peorian.

Molluscan Life:

Succinea ovalis pleistocenica
Succinea grosvenori gelida
Gonyodiscus shimekii
Sphyradium alticolum
Vertigo modesta
Hendersonia occulta

Locality: Rock Island Co., Sec. 22, SE ¼ of NW ¼, T. 18 N., R. 1 E. (Dr. Leighton).

Material: Loess over soil and gumbo till, 35 feet from top of hill.

Stratigraphic Horizon: Early Peorian Loess.

Molluscan Life:

Succinea ovalis pleistocenica
Succinea grosvenori gelida
Gastrocopta tappaniana
Sphyradium alticolum
Helicodiscus paralellus

Locality: As above.

Material: Loess over gumbo till, 15 feet from top of hill.

Stratigraphic Horizon: Early Peorian.

Molluscan Life:

Vertigo modesta	*Succinea grosvenori gelida*

Locality: Whiteside Co., NE 1/4 NE 1/4 sec. 32, T. 22 N., R. 5 E.

Material: Yellow loess, road cut across and over spur 11 feet maximum depth, shows: 9½ feet yellow loess over 1½ feet gray loess, both fossiliferous and calcareous; yellow loess effervesces more violently than gray loess; no sharp line demarcates the two, for they are gradational within 1-12 inches. (Dr. M. M. Leighton).

Stratigraphic Horizon: Early Peorian.

Molluscan Life:

Vertigo modesta	*Succinea grosvenori gelida*

Locality: Whiteside Co., sec. 23, T. 20 N., R. 3 E, near center (Dr. Leighton).

Material: Loess.

Stratigraphic Horizon: Early Peorian.

Molluscan Life:

Succinea grosvenori gelida	*Pisidium species*
Galba parva	

This deposit appears to be laid down near water, because the Galba is common while the *Succinea* is represented only by several immature individuals. The Pisidium also indicates nearness to water.

Locality: Bureau Co., NW 1/4 sec. 1, T. 15 N., R. 6 E. New highway cutoff through three ridges going upgrade (Dr. Leighton).

Material: In lowest ridge is exposed 15-18 feet of pebbly sand, yellow; in next ridge, red sand beneath gumbotill gray and sandy, leached, passing through fossiliferous loess; in highest ridge fossiliferous loess. Between gumbotill and overlying fossiliferous loess is about 10 feet of chocolate brown, loess-like silt with band of gray color, calcareous mostly in spots. Fossils from fossiliferous yellow loess.

Stratigraphic Horizon: Peorian.

Molluscan Life:

Succinea ovalis pleistocenica	*Gonyodiscus shimekii*
Succinea grosvenori gelida	

Locality: Lawrence Co., 2 3/4 miles N-NW of St. Francisville, SE 1/4 SE 1/4 sec. 6, T. 4 N., R. 11 E. (Dr. MacClintock).

Material: Road cut in NW corner of group of hills rising above Wabash River flats and entirely surrounded by flood plain deposits. Top of cut is 8-10 feet below the highest elevation of the rather flat-topped hills. Road cut shows; from top to bottom:

1. Loess, leached, reddish buff .... 3–4 ft.
2. Loess, calcareous, light yellowish buff .... 4 ft.
3. Sand, calcareous .... 1 ft.
4. Loess, calcareous, fossiliferous, containing abundant 'kindchen', gray drab, iron-mottled and concentrically stained .... 4 ft.
5. Loess, leached, reddish buff more compact than that above.... 4 ft.
6. Till, weathered, leached and oxidized .... 3½ ft.
7. Bed rock.

Stratigraphic Horizon: Dr. MacClintock suggests that No. 6 is Illinoian till, No. 5 Peorian loess, and No. 4 early Wisconsin loess. He also states that No. 5 might be Sangamon loess and No. 4 Peorian loess. The fossils do not include certain species which should be in Peorian loess and from this viewpoint the first interpretation would seem best.

Molluscan Life:

Polygyra hirsuta yarmouthensis
Strobilops virgo
Euconulus fulvus
Zonitoides minusculus
Hendersonia occulta

Locality: Madison Co., Collinsville bluffs (Dr. Leighton).

Material: Loess.

Stratigraphic Horizon: Early Peorian.

Molluscan Life:

Hendersonia occulta
Pyramidula alternata
Gonyodiscus shimekii
Pupoides marginatus
Gastrocopta armifera
Polygyra appressa
Succinea retusa peoriensis
Succinea grosvenori gelida

Locality: Adams Co., Quincy, Vine and Second St. (Leighton and Cox coll.).

Material: Fossiliferous loess overlying till.

Stratigraphic Horizon: Early Peorian.

Molluscan Life:

Gonyodiscus shimekii
Vertigo modesta
Hendersonia occulta

Locality: Adams Co., Municipal Quarry, NW 1/4 NW 1/4 sec. 26, T. 1 S., R. 9 W. (Leighton & Cox).

Material: Loess.

Stratigraphic Horizon: Early Peorian.

Molluscan Life:

Hendersonia occulta
Polygyra monodon peoriensis
Polygyra appressa
Gonyodiscus shimekii
Sphyradium alticolum
Vertigo ventricosa
Vertigo modesta
Succinea ovalis pleistocenica
Succinea grosvenori gelida
Vallonia gracilicosta

Locality: Adams Co., Quincy, quarry near (south of) Curtis Creek, near bluff road on east side SE 1/4 SW sec. 11, T. 2 S., R. 9 W. (Leighton & Cox).

Material: Loess from 15 feet above bed rock.

Stratigraphic Horizon: Early Peorian.

Molluscan Life:

Hendersonia occulta
Polygyra monodon peoriensis
Polygyra fraterna
Helicodiscus paralellus
Gonyodiscus shimekii
Vertigo modesta
Succinea ovalis pleistocenica

Locality: Union Co., Alto Pass south of Textile Hollow (Dr. Ekblaw).

Material: Loess.

Stratigraphic Horizon: Probably Early Peorian.

Molluscan Life:

Polygyra profunda
Polygyra profunda near *pleistocenica*
Polygyra appressa
Polygyra tridentata
Polygyra fraterna
Succinea ovalis pleistocenica
Circinaria concava
Pyramidula solitaria
Pyramidula alternata
Gastrocopta armifera
Hendersonia occulta

The absence of such typical Peorian species as *Gonyodiscus shimekii, Sphyradium alticolum, Vallonia gracilicosta,* and *Succinea grosvenori gelida* suggests that this deposit may be younger than Peorian. These smaller fossils may have been overlooked, however, and the age may be true Peorian. The presence of a form of *Polygyra profunda,* described from Alton, gives a Peorian aspect to the deposit. All other species are present in the recent fauna.

Locality: Bureau Co., Buda Country Club, east bank Coal Creek. (Dr. MacClintock).

Material: Section of bank shows following strata:

1.	Soil and subsoil	2 ft.
2.	Pink till	7 ft.
3.	Laminated pink clays, calcareous	2 ft.
4.	Light buff-gray loess, fossiliferous	5 ft.
5.	Laminated (slightly fatty) gray clays	3⅔ ft.
6.	Dark gray loess, slightly calcareous, fossiliferous	4½ ft.
7.	Silt, dark gray, with small pebbles, slightly calcareous	1 ft.
8.	Clay, fatty, greenish to yellowish, leached and weathered	3½ ft.
9.	Silt, leached, with peat bands	2 ft.
10.	Alluvial coal (from underlying coal bed)	1 ft.
11.	Clay, no pebbles, leached	1½ ft.
12.	Till, calcareous, yellow to golden buff	2 ft.

Stratigraphic Horizon:

Dr. MacClintock interprets the section as 1, 2, Bloomington; 3, early Bloomington lake; 4-7, Peorian; 8-12 Iowan and Peorian. An alternative interpretation is that the lower may be Illinoian with Sangamon over it, and calcareous Peorian loess on the weathered Sangamon. Whichever one is correct makes the fossils Peorian in age.

Molluscan Life: The same species occur in both upper (4) and lower (6) loess.

Gonyodiscus shimekii
Polygyra monodon peoriensis
Succinea grosvenori gelida
Hendersonia occulta

Locality: Gallatin Co., Shawneetown hill, SW SW ¼ sec. 17, T. 9 S., R. 10 E. (Dr. MacClintock).

Material: Road cut on south side of hills exposes 20 feet of loess quite typical. Upper 3-5 feet leached, lower 15 feet calcareous and fossiliferous. This same loess covers the whole hill and no drift or rock was seen.

Stratigraphic Horizon: Dr. MacClintock does not venture an opinion concerning the age of the lower calcareous loess, but the life suggests Early Wisconsin, as it does not include typical Peorian fossils.

Molluscan Life:

Polygyra hirsuta yarmouthensis
Polygyra fraterna
Polygyra appressa
Pyramidula alternata
Gonyodiscus cronkhitei catskillensis
Hendersonia occulta
Vitrea hammonis
Helicodiscus paralellus
Strobilops labyrinthica
Vertigo gouldii
Gastrocopta armifera similis
Succinea grosvenori gelida

Locality: Gallatin Co., NE NW sec. 9, T. 9 S., R. 3 W., six miles west of Shawneetown (Dr. MacClintock).

Material: Loess.

Stratigraphic Horizon: Probably Early Wisconsin.

Molluscan Life:

Polygyra profunda
Polygyra appressa
Polygyra hirsuta yarmouthensis
Pyramidula alternata
Pyramidula solitaria
Hendersonia occulta
Galba parva

Locality: Bureau Co., Buda Quadrangle. (Dr. Mac Clintock)

Material: Railway cut exposing 15-20 feet of loess leached to depth of 6 feet. Gastropod fossils in a two-foot horizon about 9 feet from top of cut. Loess buff-drab in color and fairly dense in texture.

Stratigraphic Horizon: Post-Bloomington or Early Wisconsin.

Molluscan Life:

Vertigo modesta
Succinea grosvenori gelida
Vallonia gracilicosta

Locality: Bureau Co., Buda Quadrangle (Dr. Mac Clintock).

Material: Cut through gravelly phase of the Bloomington terminal moraine. Ten foot bank of Post-Bloomington loess, fossiliferous (MacClintock).

Stratigraphic Horizon: Early Wisconsin.

Molluscan Life:

Pupilla cf hebes
Vertigo modesta
Sphyradium alticolum
Succinea grosvenori gelida

Locality: Bureau Co., road cut east of Wyanet, east bank of West Bureau Creek, NE NW ¼ sec. 22, T. 16 N., R. 8 E. (Dr. MacClintock).

Material: Cut through Bloomington moraine shows:

1. Dark gray soil .... ½–1 ft.
2. Bleached loess, yellow buff, with some gray mottling, limonite streak 1–2 in. thick near base .... 7–8 ft.
3. Calcareous loess, yellow clay, with some ochre coloring in upper 2½ ft., mostly gray below with ferruginous pipes and stains up to 1 in. in diameter. Upper part of clay highly fossiliferous, lower part more compact .... 6–7 ft.
4. Below loess calcareous till, pinkish yellow when dry, strong pink when wet, pebbly clay till with small sand lenses at top, limestone pebbles to top, some gray to dark shale.
   Till is dark gray at depth of 6–8 ft. below base of loess. On opposite side of valley the loess is underlain by 3–5 ft. sand and gravel.

Stratigraphic Horizon: Immediately post early Wisconsin.

Molluscan Life:

Polygyra pennsylvanica	*Sphyradium alticolum*
Succinea grosvenori gelida	*Vallonia gracilicosta*
Vertiga modesta	*Cochlicopa lubrica*
Pupilla cf hebes	*Hendersonia occulta*

Locality: Tazewell Co., SW NE 1/4 sec. 27, T. 26 N., R. 4 W. (Dr. Leighton).

Material: Loess over Wisconsin till. Road cut near top of slope shows:

1. Gray soil .... ½–1 ft.
2. Maximum leached buff loess .... 3½ ft.
3. Maximum calcareous yellow fossiliferous loess .... 4½ ft.
4. Gravel with limestone pebbles, maximum .... 1 ft.
5. Banded silts for horrizontal distances of 20 ft., pinkish wavy .... 1 ft.
6. Pink calcareous till .... 6–7 ft.
7. Gray calcareous till, jointed, pinkish cast on surface .... 6+ ft.

Stratigraphic Horizon: Immediately post Early Wisconsin.

Molluscan Life:

Succinea grosvenori gelida	*Vertigo modesta*
Gonyodiscus cronkheitii anthonyi	*Sphyradium alticolum*

Locality: Henry Co., NW NE 1/4 sec. 16, T. 17 N., R. 2 E. (Dr. Leighton).

Material: Gully exposure south side road shows:

Three feet fine sand with thin wavy bedding, yellow, overlain by ¾ ft. of very fine sand or silt mottled with limonite stains, overlain by ½ to ⅔ ft. of greenish gray fossiliferous silt, overlain by thin bedded pink gritless clay alternating with gray silt, overlain by ¾ ft. of grayish yellow fine sand, all calcareous.

Stratigraphic Horizon: Probably late Wisconsin.

Molluscan Life:

Gonyodiscus cronkhitei anthonyi	*Succinea avara vermeta*

Locality: Bureau Co., 3 1/4 miles south of Wyanet (Dr. MacClintock).

Material: Post Bloomington loess, a section showing:

Leached loess .... 3 ft.
Calcareous fossiliferous loess .... 8–9 ft.
Medium gravel .... ½ ft.
Pink calcareous till (Bloomington) .... 5–10 ft.

Stratigraphic Horizon: Contacts are all distinct with no weathering showing that loess was deposited soon after recession of the ice, i. e., Early post-Bloomington or very Early Wisconsin. At southeast side of cut the gravel is missing and the loess lies on the till. (MacClintock).

Molluscan Life:

Succinea grosvenori gelida	*Pupilla cf hebes*
Vertigo modesta	

Systematic Discussion of Species.

Family HELICIDAE

Polygyra tridentata (Say)

Alto Pass, Union Co. Early Peorian. This is the small form of Indiana and Illinois, but rather more depressed than recent specimens.

Polygyra profunda (Say)

Alto Pass, Union Co. (Early Peorian); near Shawneetown (Early Wisconsin). The large, flattened form typical of the recent fauna. Among the Shawneetown lot there are several specimens resembling *pleistocenica*.

Polygyra profunda pleistocenica F. C. Baker

Near Alton (see Baker, 1920, p. 63). Occurs in loess of Sangamon age and in a concretionary basal horizon believed to be of Yarmouth age. This small form appears quite constant in the Pleistocene deposits examined.

Polygyra multilineata altonensis F. C. Baker

Near Alton, in loess of Sangamon age. This large variety of *multilineata* is at present known only from this locality and horizon.

Polygyra appressa (Say)

Near Alton (Sangamon); Alto Pass, Union Co., Adams Co., Quincy, and Collinsville bluffs, Madison Co. (Early Peorian); near Shawneetown, Gallatin Co. (Early Wisconsn). Specimens show some variation; the Alto Pass material is like that living today; Gallatin Co. specimens are rather larger (23 mm.) than recent forms from Illinois, and one specimen is without a parietal denticle and with a strong basal callus on lower lip; another specimen has a heavy parietal denticle almost like *palliata*. Specimens from Shawneetown Hill loess and from Collinsville have a distinct denticle on the upper part of the outer lip.

Polygyra pennsylvanica (Green)

Bureau Co., immediately Early Wisconsin loess. A single specimen is small and has a very low spire. Somewhat similar specimens occur living in Washington Co., Ill. Height 10; diameter 14 mm.

Polygyra thyroides (Say)

Mercer Co., Early Peorian loess. A single broken specimen apparently typical.

Polygyra hirsuta yarmouthensis F. C. Baker

Clark and Bureau counties (Yarmouth); near Alton Ill., and New Harmony, Ind. (Sangamon); Lawrence Co., St. Francisville (Peorian); Gallatin Co., Shawneetown (Early Wisconsin). The Pleistocene *hirsuta* are uniformly smaller and have a differently formed parietal tooth or lamina than the form now living in Illinois and Indiana.

Polygyra monodon peoriensis F. C. Baker

Clark and Bureau counties (Yarmouth); Adams and bureau counties (Peorian). The *monodon* vary greatly in the loess. The Adams County forms are uniformly smaller than the *monodon* of the recent fauna. All fossil forms differ sufficiently from recent forms for varietal distinction.

Polygyra fraterna (Say)

Union Co. and Adams Co. (Peorian); Shawneetown Hill loess (Early Wisconsin). The Pleistocene *fraterna* are about the same in size as the recent form of the species. A single specimen from Alto Pass has a very high spire as compared with recent forms. H. 6. 2; D. 9 mm. Not enough matarial is at hand to satisfactorily compare Pleistocene with recent forms of this species.

Oreohelix iowensis (Pilsbry)

This species is known from the loess of Iowa, in the Yarmouth, Sangamon, and Peorian intervals. It has been cited from Cass Co. (Sangamon), Whiteside Co. (Peorian), and Peoria (Peorian). It is apparently not abundant in Illinois (See Baker, 1922, p. 58).

Family CIRCINARIIDAE

Polita hammonis (Ström.)

Near Alton (Sangamon); Union Co., Alto Pass (Peorian). The fossil material is smaller, with a more depressed spire and a wider umbilicus than living specimens from Illinois. It is apparently not common as a fossil.

Family ZONITIDAE

Polita hammonis (Ström.)

Mercer Co. (Peorian); Shawneetown Hill (Early Wisconsin). It has also been reported from all intervals from

Aftonian to pre-recent (see Baker, Pleistocene, p. 389). The few specimens examined are similar to the recent forms. The record of *Vitrea wheatleyi* from Carroll Co. peat deposits (Baker, 1922, p. 58) is erroneous, the specimen being a form of *hammonis*.

Zonitoides arborea (Say)

Near Alton (Sangamon). Also reported from all intervals from Aftonian to recent (Baker, Pleistocene, p. 289). The Sangamon specimens are somewhat smaller than shells of the recent fauna. Not enough material is at hand for a satisfactory comparison of the fossil with the recent forms.

Euconulus fulvus (Müller)

Whiteside Co. (Peorian); St. Francisville, Lawrence Co. (Early Wisconsin). Reported from all intervals. The fossil specimens appear similar to the recent form.

Family ENDODONTIDAE

Anguispira alternata (Say)

Near Alton (Sangamon); Collinsville and Alto Pass (Peorian); Gallatin Co. (Early Wisconsin). The *alternata* from the Sangamon interval near Alton are uniformly smaller than shells from the recent fauna, as are also shells from the Peorian at Collinsville. The Alto Pass and Gallatin Co. specimens are larger and more like the recent form. Measurements of maximum diameter of the different forms are: Alton (Sangamon) 17 mm.; Collinsville (Peorian) 16 mm.; Alto Pass (Peorian) 20 mm.; Gallatin Co. (Early Wisconsin) 22 mm.; recent fauna from Illinois, 23-25 mm. It will be observed that the early forms from Sangamon and Peorian time are usually smaller than those from later time. More material is needed to establish this geological variation more definitely.

Anguispira solitaria (Say)

Alto Pass, Union Co. (Peorian); Gallatin Co. (Early Wisconsin). The specimens from Gallatin Co. average considerably larger than the usual size of the species as found in Illinois and Indiana, diameter 29 mm. Largest Illinois and Indiana specimen, 25 mm.

Gonyodiscus shimekii (Pilsbry)

Near Alton; Adams Co.; Collinsville bluffs; Whiteside, Mercer, Bureau, Warren counties, all Peorian interval.

This very striking species appears to be characteristic of the Peorian interval, scarcely a deposit of loess occurring that does not include this species. It has been reported from the Yarmouth interval in Iowa (see Baker, Pleistocene, pp. 254-256), but late studies by Alden and Leighton indicate that some of these may be referable to Peorian time (An. Rep., Iowa Geol. Surv., XXVI, 1917). In Illinois *shimekii* is not at present known in strata earlier than Peorian, nor is it found in later deposits. It appears to be a horizon marker for this interval. It is abundant in loess deposits of Iowa.

Gonyodiscus cronkitei anthonyi (Pilsbry)

Tazewell Co. (Early Wisconsin); Henry Co. (Late Wisconsin). The few specimens examined do not differ from the recent form. This species has been recorded from all of the interglacial intervals, but no material from Illinois earlier than Early Wisconsin has been seen (see Baker, Pleistocene, p. 389). Some of these records may have been based on the var. *catskillensis.*

Gonyodiscus cronkhitei catskillensis (Pilsbry)

Shawneetown Hill loess, probably Early Wisconsin. One specimen with high spire and angulated periphery appears referable to this form.

Helicodiscus paralellus (Say)

Clark and Bureau Co. (Yarmouth); near Alton (Sangamon); Adams, Rock Island, Mercer Co. (Peorian); Shawneetown Hill (Early Wisconsin). This almost monotypic species varies but little throughout the Pleistocene. The Yarmouth and Sangamon specimens are a trifle smaller and have a wider umbilicus than in the recent form, though the last feature varies much among the living representatives.

Sphyradium alticolum (Ingersoll)

Adams, Rock Island, Mercer, Warren Co. (Peorian); Bureau Co. (Early Wisconsin); Tazewell Co. (Late Wisconsin). In Iowa, this species has been recorded from Aftonian, Yarmouth, and Sangamon intervals. Most of the Pleistocene *Sphyradium* are probably referable to *alticolum,* which appears to be a species approaching extinction. It does not occur living in Illinois and is found only in the higher regions of the west (Utah, Colorado, Wyoming). *Sphyradium edentulum* is the species now living in Illinois. The *alticolum* from Post Wisconsin deposits is more like the living form in having the last whorl somewhat enlarged, causing a peculiar constriction behind this whorl. The shell is also somewhat narrower than the shell of the species as it occurs in the Peorian deposits (see Hanna, Proc. U. S. Nat. Mus., XLI, p. 373, 1911, for figures of all American species).

Family SUCCINEIDAE

Succinea ovalis pleistocenica (F. C. Baker)

Clark, Bureau Co. (Yarmouth); near Alton (Sangamon); near Alton, Madison Co., Mercer, Warren, Rock Island, Bureau, Adams, Peoria, Union Co. (Peorian). Also in Peorian loess at Freeport, Iowa. The Pleistocene form of this common recent species differs from the living form in having a longer spire and a rounder aperture. It appears most abundant in the Peorian interval and has not been seen from later deposits.

Succinea grosvenori gelida (F. C. Baker)

Bureau Co. (Yarmouth); Boone Co. (Sangamon); Mercer, Warren, Whiteside, Bureau, Boone, Rock Island, Adams, Carroll, Ogle, Stephenson, Madison Co. (Peorian); Bureau, Tazewell, Gallatin Co. (Early Wisconsin). This small *Succoinea* has been variously reported, many years ago as *verrilli,* and later as *grosvenori, vermeta,* and *avara.* It is apparently a variety of *grosvenori* peculiar to Pleistocene time. It is smaller and much more elongated than *grosvenori.* Baker's references (Journ. Geol., XXX, p. 43, et seq.) are all based upon this form. It extends throughout the series of intervals from Yarmouth to Early Wisconsin.

Succinea avara (Say)

Stephenson Co., in loess-like clay (Post-Wisconsin). A few specimens in this deposit are referred to *avara,* resembling the small forms living in the Mackenzie River district of Canada. The largest specimen measures 5.5 mm. in length. Specimens from Henry Co. (Late Wisconsin) are probably referable to variety *vermeta* (Say)

Succinea retusa (Lea)

Whiteside Co. (Post-Wisconsin). A single, rather small specimen.

Succinea retusa decampi (Tryon?)

Bureau Co. (Yarmouth soil). The specimens referred to this variety are rather small, with strikingly flat-sided whorls and long spire. Two specimens measure, length 9.5 and 8 mm., diameter 5 and 4 mm.

Succinea retusa peoriensis (Wolf)

Madison Co., Collinsville bluffs (Peorian). Several specimens of a *Succinea* with wide shell is referred to this variety. Additional material is needed for a more satisfactory determination.

Family PUPILLIDAE

Strobilops virgo (Pilsbry)

Clark Co., Jackson Co. (Yarmouth). Lawrence Co. (Early Wisconsin). Typical but apparently rare. It has been reported from the Aftonian and Peorian intervals, but none has been personally examined (Baker, Pleistocene, p. 388).

Strobilops labyrinthica (Say)

Gallatin Co., Shawneetown Hill loess (Early Wisconsin). Typical form with one large, heavy parietal lamella emerging from aperture. This species has been reported from all intervals, but many of the records were probably founded on some one of the allied species. It probably occurs in other strata.

Pupoides marginatus (Say)

Madison Co., Collinsville (Peorian). The fossil form is slightly wider and has half a whorl less than the recent form of the species. Not enough material is at hand for confirming this variation as a stable geological form.

Gastrocopta armifera (Say)

Whiteside Co., Union Co., Madison Co. (Peorian). Typical for the most part, the Alto Pass (Union Co.) specimens being slightly narrower.

Gastrocopta armifera similis (Sterki)

Near Alton (Sangamon); Gallatin Co. (Early Wisconsin). The *armifera* from these deposits are noticeably narrower than the typical form, the columellar lamella is more pointed, there are but two palatal lamellae, and the parietal lamella is smaller than usual. This form is quite noticeably different from the wide typical form and appears to be the same as the recent *similis*.

Gastrocopta tapaniana (C. B. Adams)

Rock Island Co. (Peorian). One broken specimen is referred to this species.

Gastrocopta contracta (Say)

McHenry Co. (Late Wisconsin). Common and typical.

Pupilla cf hebes (Ancey)

Bureau Co. (Early Wisconsin); Whiteside Co. (Peorian). The *Pupilla* from the Illinois loess deposits is not *muscorum* but apparently *hebes*. They are of the same size (larger than *muscorum*), the aperture is completely edentate, and the lip lacks the heavy deposit of the recent species. There are seven whorls. A specimen from Whiteside Co., has the outer lip slightly thickened, but the Bureau Co. specimens are exactly like *hebes* from Arizona identified by Pilsbry. Measurements of two specimens are: L. 3.4 and 3.6 mm., diameter 1.7 and 1.9 mm. Arizona specimen L. 3. 6, D. 1. 8 mm. The aperture is shaped like *hebes*, *not* like *muscorum*. Additional material is needed to satisfactorily determine the range of variation of this pleistocene form. Dr. Pilsbry suggests that it may be local form of *muscorum*.

Vertigo ventricosa (Morse)

Clark Co. (Yarmouth); Adams Co., Mercer Co. (Peorian). The few specimens are apparently typical. Variety *elatior* sterki is reported from loess deposits at New Harmony, Indiana (probably Sangamon).

Vertigo gouldii (Binney)

Gallatin Co., Shawneetown Hill loess (Early Wisconsin). A specimen is referable to this species, but is rather more elongated than in living examples.

Vertigo modesta (Say)

Whiteside, Mercer, Warren, Rock Island, Adams Co. (Peorian); Bureau, Tazewell Co. (Early Wisconsin). This small land shell is very common in the loess of Iowa and Illinois and exhibits great variation in size and number of denticles in the aperture. In the Tazewell deposit the single specimen has only a small parietal tooth; specimens from Mercer Co. are the same. From Mercer and Whiteside counties specimens occur without a parietal tooth and these are similar to the form *parietalis* (Ancey) now living in the Rocky Mountain Region. The majority have four teeth as in the typical form. The size runs from 1.9 to 2.6 mm. in length. It has been recorded from the Yarmouth and Sangamon intervals, but specimens have been seen only from Peorian and later deposits. Some of the early records may have been based upon deposits now considered of later age. The record by Hershey (Amer. Journ. Sci., II, p. 324, 1896) appears to be referable to the Yarmouth interval, the clays underlying Illinoian till. It is recorded as *Pupilla blandi* (not of Morse), under which name *modesta* has been listed by Iowan geologists.

Family COCHLICOPIDAE

Cochlicopa lubrica (Müller)

Mercer Co. (Peorian); Bureau Co. (Early Wisconsin). The few specimens seen from these deposits are like the typical form now living.

Cochlicopa lubrica (Müller) Variety

Clark Co. (Yarmouth). A specimen from the Yarmouth soil differs from the living form in the size of the shell and in the small size of the aperture. It is also more slender. Length 5, diameter 2 mm.; aperture length 1.5, diameter 1.1 mm. The aperture is about 30 per cent of the length while in typical *lubrica* it is 35 to 40 per cent. Additional material is needed to determine the nature of the variation.

Family VALLONIIDAE

Vallonia gracilicosta (Reinhard)

Whiteside and Adams Co. (Peorian); Bureau Co. (Early Wisconsin). This is the common *Vallonia* of the loess. Fossil specimens are a trifle larger than specimens from Colorado, with less thickened reflected lip, and with very fine striae.

Family AURICULIDAE

Carychium exiguum (Say)

Clark Co., loessal silt (Yarmouth). Typical.

Carychium exile (H. C. Lea)

Clark Co., (Yarmouth soil). Typical.

Carychium exile canadense (Clapp)

Clark Co., (Yarmouth soil). Typical. The presence of the three forms of this genus, common at the present time in northern United States, is interesting, indicating that the deposit was formed in low, damp or wet ground. The specimens examined are typical of the forms living today. They have been recorded from all the intervals from Aftonian to Late Wisconsin.

Family LYMNAEIDAE

Galba parva (Lea)

Clark, Bureau Co. (Yarmouth soil and loessal silt); Carroll Co., blue silt (Peorian). Mercer Co., Whiteside Co. (Peorian loess). The fossil material shows some variation, especially in the length of the spire and the flatness of the inner lip. Some specimens resemble variety *sterkii* Baker. The recent form also varies greatly.

Family PLANORBIDAE

Gyraulus altissimus (F. C. Baker)

Clark Co. (Yarmouth soil). A single, immature specimen is referred to this species.

Family HELICINIDAE

Hendersonia occulta (Say)

Clark Co. (Yarmouth soil), Jackson Co., Bureau Co. (Yarmouth loess); Mercer, Warren, Adams, Madison, Union, Bureau Co. (Peorian loess); Bureau, Gallatin, Lawrence Co. (Early Wisconsin); Near Alton (Sangamon loess). This small species is one of the most abundant mollusks in loess deposits and must have been widely and continuously distributed during the different interglacial intervals. Its modern descendant is widely distributed, but it is extremely local and the distribution markedly discontinuous. Specimens from several places in the Peorian and Early Wisconsin intervals are notably smaller than those from other places, indicating a size variation during Pleistocene time. It may be possible to establish a maximum and minimum size when more material has been examined. Yarmouth specimens are rather large, and measure 6 to 6.5 mm. in diameter; Sangamon specimens, 6-6.2 mm.; Peorian, 5.1 to 7 mm.; Early Wisconsin, 5.5 to 6.8 mm. The smallest specimens are from near Quincy, Adams Co., and these measure 5.1 to 5.6 mm. Another set from Gallatin Co., measure 5.5 to 6.1 mm. Not enough material is at hand to determine the variation among the recent examples of the species.

Family POMATIOPSIDAE

Pomatiopsis scalaris (F. C. Baker)

Clark Co. (Yarmouth, loessal silt). This newly described species has been found in Illinois only in this interval. In Indiana, the type locality, New Harmony, Posey Co., the loess is of considerable extent and thickness but its stratigraphic horizon has not been determined accurately. It has been considered Sangamon by Shimek (Baker, Peistocene, p. 306) but may equally well be Peorian. In Illinois, loess deposits in Lawrence Co. (St. Francisville) and Gallatin Co. (Shawneetown) are regarded as of Early Wisconsin age.

Pomatiopsis lapidaria (Say)

Stephenson Co., near Ridott (Late Wisconsin). These specimens are like the recent species. See Baker, Journ. Geol., XXX, p. 45.

True Freshwater Mollusca

Pisidium species

Clark Co. (loessal silt). A single valve of a large Pisidium occurred with land species. As *Galba*, *Pomatiopsis*, and *Carychium*, species which habitually live in or near small streams or on mud flats, also occurred, it is highly probable that the single valve was washed onto a mud flat bordering a stream, as occurs frequently at the present time.

TABLE OF DISTRIBUTION OF LOESS LAND MOLLUSCA*

Species	Y	S	P	EW	LW	E	I	Ex	Present location.
Polygyra tridentata			x				x		
Polygyra profunda			x	x			x		
Polygyra p. pleistocenica	x	x	x			x			
Polygyra m. altonensis		x				x			
Polygyra appressa		x	x	x			x		
Polygyra pennsylvanica				x			x		
Polygyra thyroides			x				x		
Polygyra h. yarmouthensis	x	x	x	x		x			
Polygyra m. peoriensis	x	x	x			x			
Polygyra fraterna			x	x			x		
Oreohelix iowensis	x	x	x			x			
Circinaria concava		x	x				x		
Polita hammonis			x	x	x		x		
Euconulus fulvus			x	x			x		
Anguispira alternata			x	x	x		x		
Anguispira alternata, var		x	x					?	Minn., Wis.
Anguispira solitaria			x	x			x		
Gonyodiscus shimekii		?	x			x			
Gonyodiscus c. anthonyi				x	x		x		
Gonyodiscus c. catskillensis				x				x	Mich., Wis., Minn.
Helicodiscus paralellus	x	x	x	x	x		x		
Sphyradium alticolum			x	x	x			x	Utah, Col., Wyo.
Succinea pleistocenica	x	x	x			x			
Succinea g. gelida	x	x	x	x		x			
Succinea avara					x		x		
Succinea retusa					x		x		
Succinea r. decampi	x							x	Mich.
Succinea r. peoriensis			x				x		
Strobilops labyrinthica				x			x		
Strobilops virgo	x			x			x		
Pupoides marginatus			x				x		
Gastrodonta armifera			x				x		
Gastrodonta a. similis		x		x			x		
Gastrodonta contracta					x		x		
Gastrodonta tappaniana			x				x		
Pupilla cf hebes			x	x				x	N. Mex., Ariz., Nev., Utah, Col.
Vertigo ventricosa	x		x				x		
Vertigo modesta	x	x	x	x				x	Locally in Me., Vt., Ct., Rocky Mts.
Vertigo gouldii				x			x		
Cochlicopa lubrica			x	x	x		x		
Cochlicopa lubrica, var	x					x			
Vallonia gracilicosta		x	x	x				x	Mont., Col., Dakotas
Carychium exiguum	x	x	x	x	x		x		
Carychium exile	x	x	x	x	x		x		
Carychium e. canadense	x						x		
Galba parva	x		x		x		x		
Hendersonia occulta	x	x	x	x			x		
Pomatiopsis scalaris	x	x	x			x			
Pomatiopsis lapidaria					x		x		
Total distribution	18	19	34	25	13	10	32	7	

*Symbols in table: Y, Yarmouth; S, Sangamon; P, Peorian; Ew, Early Wisconsin; Lw, Late Wisconsin; E, extinct; I, living in Illinois today; Ex, exotic or living north or west of Illinois today.

OIL PROSPECTING IN WESTERN ILLINOIS ON THE BASIS OF THE STRUCTURE OF COAL BEDS.

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Introduction.

The most efficient and economical development of oil resources depends in part upon an understanding of the mode of origin and accumulation of oil pools. Oil is found in the interstices of porous strata, mainly sandstones and limestones; most sedimentary strata are not porous enough to contain oil that can be profitably extracted. Moreover, many sufficiently porous strata contain salt water or gas instead of oil. Two of the fundamental questions of petroleum geology are, first, when and where have the porous beds been formed; and, second, what conditions govern the filling of some with salt water and some with oil or gas?

The Anticlinal Theory.

One of the earliest generalizations concerning the occurrence of petroleum is known as the anticlinal theory. According to it, oil is found at the crests of anticlines, or up-bowings of the strata, and gas, oil and water have a definite succession in the porous stratum according to their respective specific gravities. The warpings of the strata may be shown on a map by contours which represent lines of equal elevation of some stratum called the "key horizon" which passes over the fold.

Relation of Oil and Gas Fields to Structure in Southwestern Illinois.

The known occurrences of oil and gas in southwestern Illinois accord with the anticlinal theory. Figure 1[1] shows the location of oil and gas producing areas in southwestern Illinois (except the Waterloo field in Monroe County). Practically without exception they are situated upon, or are closely related to, well-defined anticlinal structures. Most of these anticlinal structures are features both of the shal-

[1]Bell, A. H., The Sorento dome: Illinois State Geol. Survey, Press Bulletin Series, Illinois Petroleum No. 6, Fig. 1, p. 2, Dec. 4, 1926.

lower and of the deeper strata, but are usually more accentuated in the latter.

Choice of a Key Horizon.

The requisites of an ideal key horizon are first, that it shall be an easily recognizable stratum or contact, and, second, that it shall have a stratigraphic position near the prospective oil-bearing stratum. Wide separation of the key horizon from the oil-bearing bed is undesirable because of the chance of unconformity between them.

Structure Mapping in Southwestern Illinois.

In most of the area of figure 1 the presence of an overlying mantle of glacial and fluvial deposits of Pleistocene age prevents the determination of structure by means of surface outcrops. As there is no traceable outcropping key horizon sub-surface structure is determined almost entirely by the use of the data supplied by well borings and mines. Because of the economic importance of Herrin (No. 6) coal in southwestern Illinois more datum points are known for it than for any other bed either above or below, and it is therefore usually chosen as the key horizon for structure maps in this area. It possesses physical characteristics that render its identification easy where it is present in its normal thickness and even in places where it is thin or absent, its stratigraphic position may usually be recognized in carefully kept logs by a correlation of other beds.

Because the vertical section supplied by the diamond drill core shows the strata in their proper order, and because the lithologic character and fossil content of the core may be studied in detail, the geological information obtained from core drilling is, in general, superior to that obtained from churn drilling. The accuracy of maps prepared from sub-surface data varies according to the closeness of spacing of the datum points.

The use of Herrin (No. 6) coal as a reference bed in structure contour maps has the disadvantage commonly attending wide separation of the key horizon and the oil-bearing sand. The most productive oil sands in the general region are of Chester age and are separated from the key horizon by the inter-systemic unconformity at the top of the Chester. The problem of the relation of Pennsylvanian to pre-Pennsylvanian structure in Illinois is important for its economic as well as its geologic interest.

The use of diamond drill logs not previously employed made possible the revision of the earlier structure map of parts of Bond, Madison, and Montgomery counties.[2] For example, the construction of such new maps as those showing the structures of the Ayers and Sorento domes by 10-foot instead of 50-foot contours has been made possible by the use of data derived from diamond drill records. As a result of this more detailed mapping, structures appear which were not previously delineated (fig. 2[3]).

It might be of interest to know that shortly after the publication in December, 1926, of Illinois Petroleum No. 6, describing the Sorento dome, the acreage on the top of the New Douglas dome was leased and so far, one well, located 40 feet down from the crest of the dome on the southwest flank, has been completed to a depth of 841 feet. Although considerable sand was found both in the Pennsylvanian and in the Chester, it was filled with salt water and there was no showing of oil. A second test is to be drilled higher on the structure.

The continual acquisition of new data by the Survey makes possible from time to time the revision of earlier maps and the delineation of structure in greater detail. A continuation of this type of work constitutes one of the activities of the petroleum section of the Survey. The purpose of this work is to present the most accurate information possible in regard to structures thereby encouraging prospecting for oil in a systematic manner and preventing as far as possible useless expenditure on wild cat drilling in localities that are geologically unfavorable. The generalized character of some of the earlier maps accounts for occasional failures even when the wells were drilled on indicated structures. Moreover, favorable structures even though accurately mapped are not always productive of oil; other favorable conditions besides structure are necessary for the accumulation of oil in commercial quantities. For these reasons many of the oil operators are not fully convinced of

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[2]Blatchley, R. S., Oil and gas in Bond, Macoupin and Montgomery Counties, Illinois: Illinois State Geol. Survey Bull. 28, pl. II, 1914.

[3]Bell, A. H., The Sorento dome: Illinois State Geol. Survey Press Bulletin Series, Illinois Petroleum No. 6, Fig. 2, p. 7, Dec. 4, 1926.

the value of geological studies in the development of oil production.

In order that the relationship between geological structure and oil production may be more fully realized, it is clear that the structures should be indicated with the greatest possible accuracy. In demonstrating the usefulness of geological information the Survey has an educational function. Eventually, perhaps, the oil operators of Illinois will employ geologists of their own to a greater extent than at present. The Survey will still have an important function of acting as a clearing house for geological information and of carrying forward the study and interpretation of the ever-increasing mass of geological data from the State as a whole. Thus, by a study of so-called "pure" science, the economic interests of both present and future generations are served.

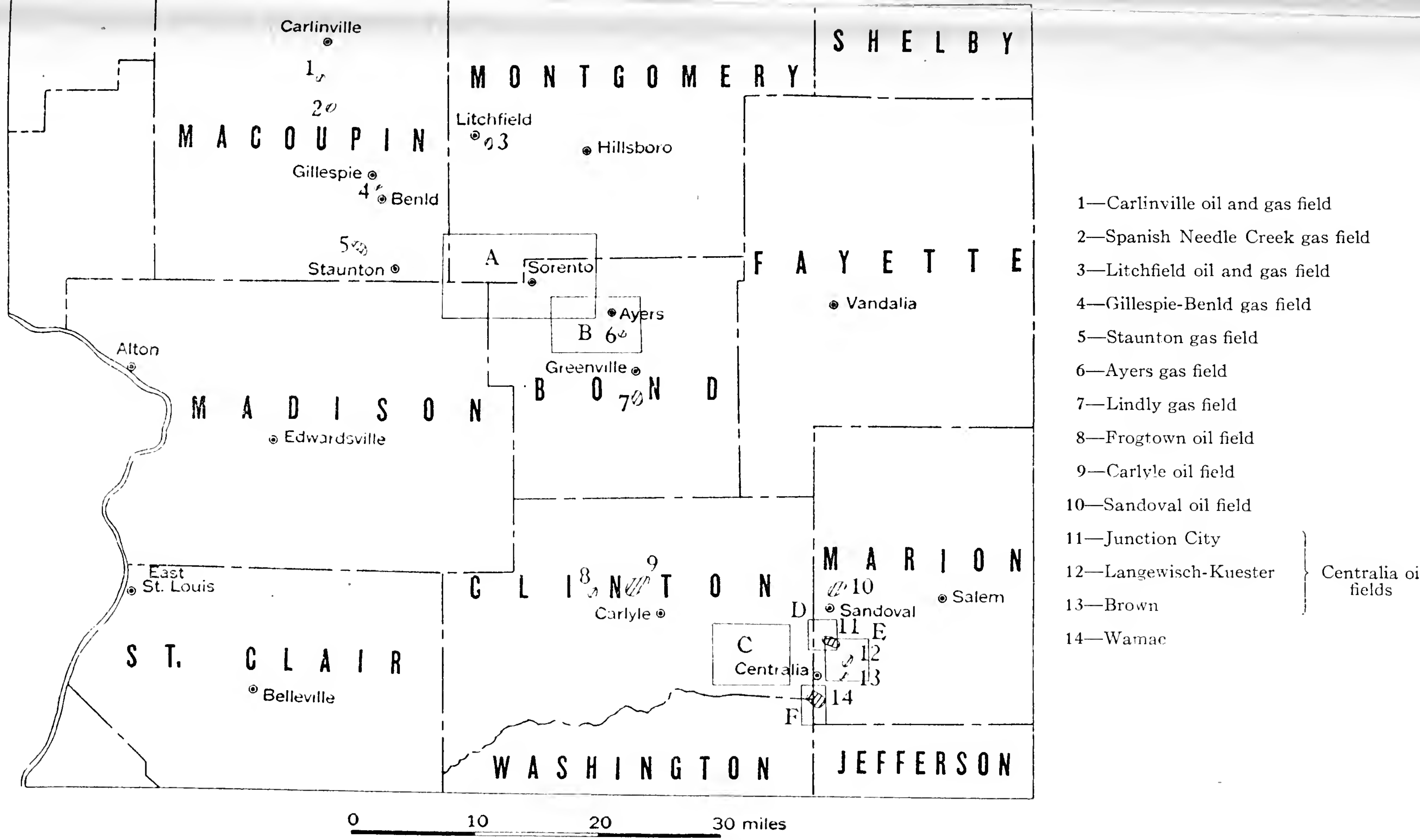

Fig. 1.—Index map showing locations of oil and gas fields in part of southwestern Illinois. Structure of area A is shown in figure 2. (By A. H. Bell, State Geological Survey.)

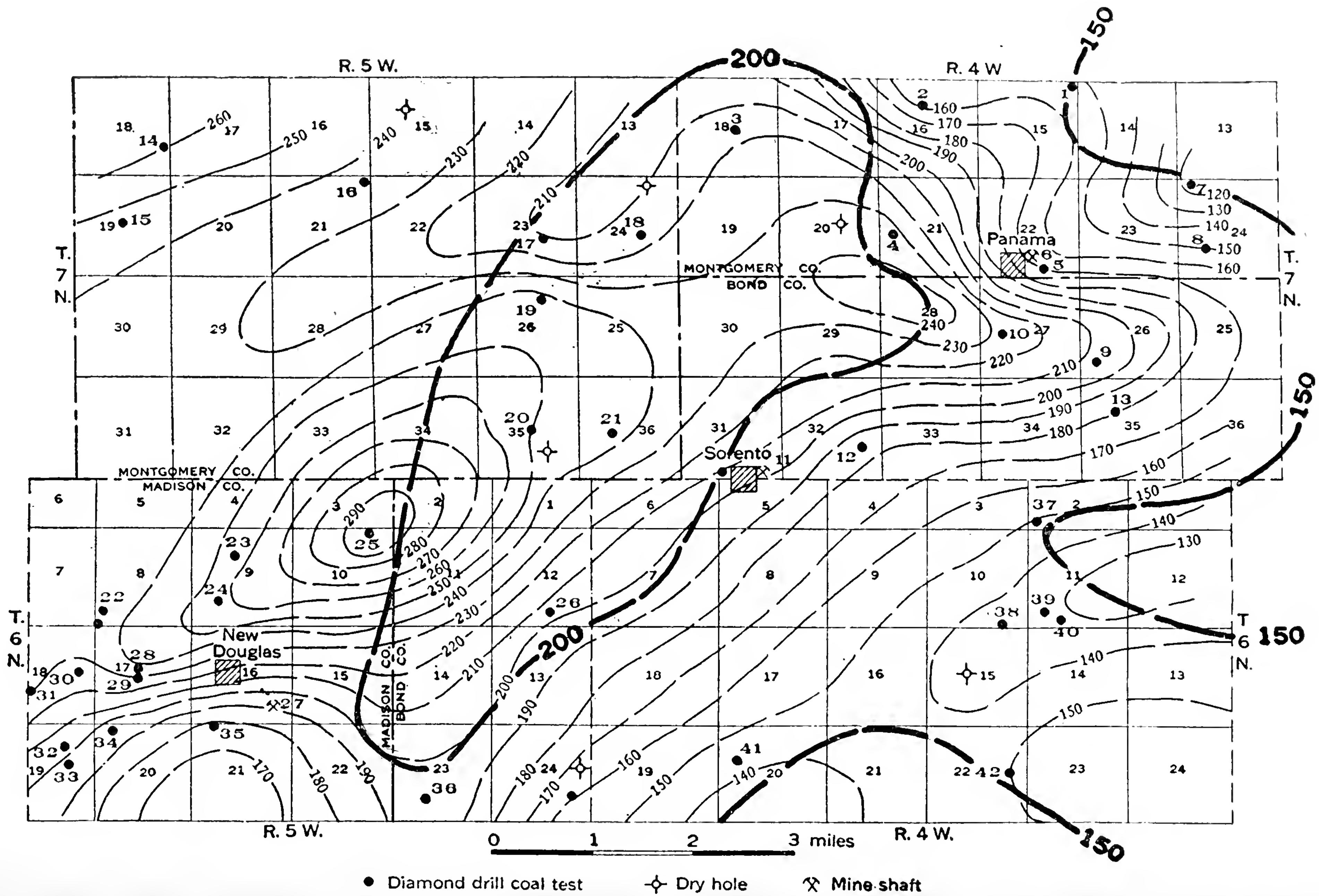

Fig. 2.—Structure of Area A. See Fig. 1.

MUTIPLE-LEVEL CIRQUES.

MARGARET BRADLEY FULLER, NORTHWESTERN UNIVERSITY.

Introduction.

Field studies in the higher ranges of Colorado and Montana show that many cirques at the heads of extensively glaciated valleys are marked by terraces or multiple-levels. Within the cirque proper the walls are shelved and pocketed at all levels from the rock floor to the crested rim of the over steepened walls. At the down-valley end of the cirque "step and riser" topography marks the descent to the main U-shaped valley.

It is also notable in most ranges south of the International Boundary that the existing glaciers are of the small cliff type perched within or along the walls of the cirques made by great Pleistocene glaciers. Locally, as radiating from the summits of Mt. Shasta, Mt. Ranier and other conical peaks of considerable altitude, true valley glaciers exist.

The small, locally active cliff glaciers are responsible for the detailed topography within the giant cirques, and, in the course of their existence, develop a second cycle of glacial erosion and impose marked detail on the larger features of the earlier and more extensive glaciation.

Topography of Multiple-level Cirques.

Lewis and Livingston Ranges, Montana.

Many types of cirques abound in Glacier National Park, Montana. The simplest are nearly vertical walled, flat-floored, tarn-enclosing basins of craterlike simplicity. More commonly the cirques are complex with multiple-levels[1] and subsidiary pockets. Profiles of the cirque walls show distinct, variously elevated levels harboring glacierettes and drifts of nevé from an acre to two or more square miles in extent. Many giant cirques have small living glaciers on the floors at their heads and others perched along the upper walls. Other cirques, although possessed of hanging glacier-

[1]The term "terrace" might well be used to describe the topography of cirque walls as carved by the secondary recent glaciers. Since "terrace" has been used so widely to describe the topography of stream erosion it is not advisable to apply the term to topography described herein. The term "multiple-level" is proposed here to define both topography and mode of origin.

ettes, have no glacier at the foot of the enclosing walls. Fig. 1.

The principles of glaciation and nivation responsible for the recent development of the multiple-level detail within the vast cirques were set forth by Matthes in his studies of the Big Horn Mountains.[2] It will be shown that additional factors in certain regions cooperate to produce the type profile indicated.

Excellent examples of multiple-level cirques appear on the eastern flank of the Lewis Range and the western flank of the Livingston Range. The relationships of the drainage lines and U-shaped valleys to the bed rock have certain noteworthy features:

1. At the east in the Lewis Range and the west in the Livingston Range the great Pleistocene valley glaciers moved down the valleys but up the dip of the strata. This favored unequal gradients along the down-valley portions and permitted the development of "step and riser" profiles. It also favored the scouring and plucking of linked basins along the course of the glaciated valley. At the head of each valley a vast cirque was excavated, where the bergschrund operated down the dip of strata inclined from ten to twenty degrees. The cirque basin evacuated by the glacier was, in many cases, not at the uppermost limits of the preglacial valley.

2. The Grinnell argillites and interbedded quartzite, overlain by the Siyeh limestone of both massive and thin beds, mark the heads of most of the valleys in both ranges. Both formations are easily quarried and plucked by ice and sapped by snow. Differential plucking and scour along alternating weak and resistant beds favored incipient terracing of the cirque walls and the development of secondary bergschrunds. As the ice retreated the main glacier became separated into different lobes at different levels, and each lobe operated as an individual glacier, dug, deepened and scoured its nest and piled up a moraine around it.

3. Snowfields, icefields and glaciers seldom occur now in the bottoms of valleys, but are mostly hung along the upper walls of cliffs, or in pockets close to the summits of divides, due not so much to favorable locations for snow

[2]F. E. Matthes, "Glacial Sculpture of the Bighorn Mountains, Wyoming." U. S. G. S. 21st Ann. Rept. Pt. 2, 1899, pp. 173-190.

drift and accumulation as to places less exposed to sun and wind. The snow line is well above the valley floors, one thousand feet to fifteen hundred feet, and lies close to the summits of divides.

Sperry-Avalanche Region.

At the Sperry-Avalanche region a multiple-level cirque is in the making. Avalanche Basin is a huge "crater" cirque harboring a lake. Fig. A. At the head, the enclosing walls rise over 2500 feet sheer to Sperry Glacier. Sperry Glacier itself rests in a shallow cirque and shelf above Avalanche Basin and covers about a square mile.

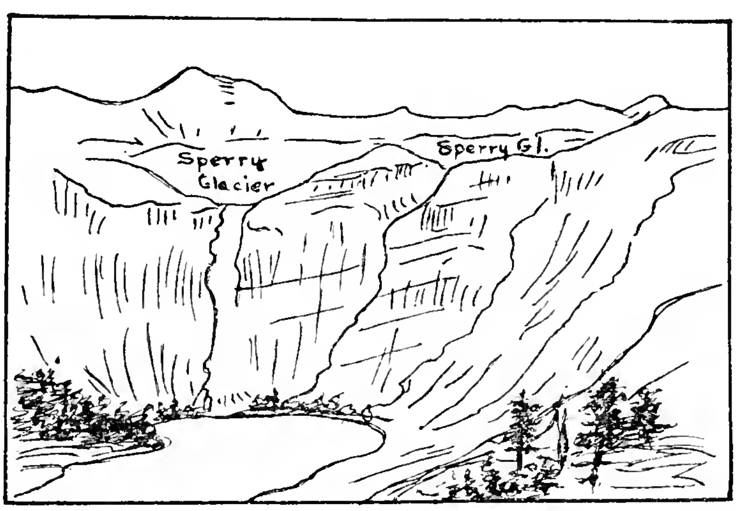

Fig. A. The main cirque of Avalanche Basin with Sperry Glacier hung above and to the rear on a wide shelf. The site occupied by Sperry Glacier appears to have been the upper head of the valley occupied by nevé only and not glaciated at the time the main cirque was excavated.

Recently Sperry Glacier has waned and separated into several lobes, each of which acts as an independent glacier. Each has a well defined bergschrund, is sapping, plucking and nesting into the surrounding walls, each lobe on a rock bench of different level so that the whole area is being cut into multiple-levels, in terrace fashion. Fig. 2.

The crest of Avalanche cirque and the floor of Sperry Glacier is approximately at the top of the Grinnell quartzite. The base upon which many other recent glaciers of cliff type rest is somewhat predetermined by the contact between weaker and more resistant formations. The well defined levels of secondary cirques within and along the walls of the primary amphitheaters lie, in many places, at the top of the Grinnell formation and at the base of the Siyeh.

Matthes[1] noted that the cirques in the Bighorn Mountains are not everywhere at the heads of the valleys but that "the upper ends of the preglacial valleys remain unglaciated above the present sites of the amphitheaters." The upper end of the valley is, in most cases, an open, much nivated bench above the site of the glacier which cut the amphitheater. Within Glacier Park, in both Lewis and Livingston Ranges, such benches are the most favorable sites of existing glaciers. Thus Sperry Glacier lies nearly 2500 feet above the cirque of Avalanche Basin, Harrison Glacier nearly 2000 feet above Harrison valley and cirque and Grinnell Glacier over 1500 feet above Grinnell cirque and lake.

As a rule recent glaciers lie upon flats and in shallow cirques newly created and above the main amphitheater

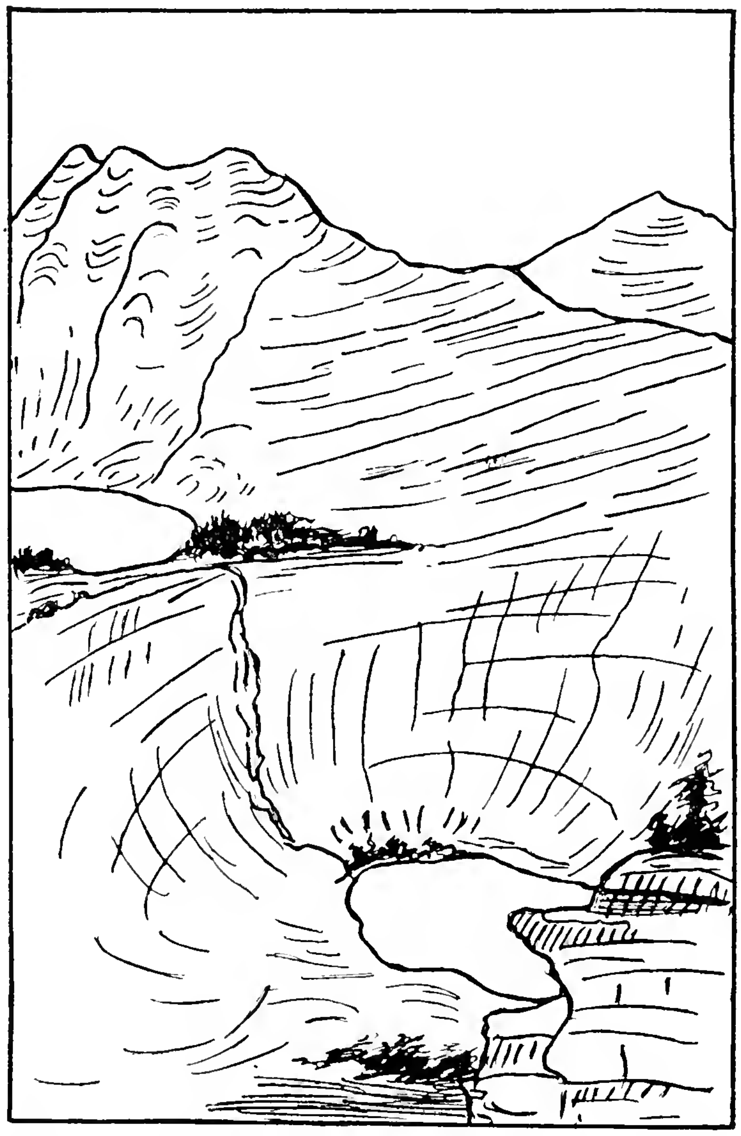

Fig. B. Cirque of Little St. Mary's Lake and the upper cirque of Lake Ellen Wilson above it. The third level is to the left above and out of the view.

made during Pleistocene cycles. It is believed that the present glaciers are not in many cases the survivors of the formerly extensive and thick valley glaciers which shaped the

[1]F. E. Matthes, *op cit.* pp. 178-179.

great cirques and U-shaped valleys, but are recently accumulated masses, in many places occupying sites unaffected by the early cycle and above the cirques made during the earlier cycle of glaciation. The present snow line ranges from an altitude of 6000 feet near the International Boundary to 6500 feet thirty miles south and is well above the rim of the giant cirques.

Along Little St. Mary's valley there are two great cirques. One encloses Lake Ellen Wilson and heads at Gunsight Pass. The other is farther down the valley, a sheer drop of 1500 feet, and is occupied in part by Little St. Mary's Lake. Fig. B. No remnant of either the earlier glacier responsible for Little St. Mary's cirque or the latter glacier which carved the amphitheater of Lake Ellen Wilson remains now. The action of successive cliff glaciers at successively higher levels towards the heads of valleys along the west slope of the Livingston Range has cut marked areas into multiple-level cirques, all linked in series.

Swiftcurrent Region.

Swiftcurrent valley exhibits a later step in the development of a multiple-level cirque. Along the Garden Wall Swiftcurrent Glacier and Grinnell Glacier with Gem Glacier above are active in cutting new levels within the giant cirques. Grinnell Glacier has more than half obliterated the wall of its ancestor. The results of nivation as carried on by snow and nevé banks are evident in small "cirques" all along the Garden Wall.

Two Medicine Region.

The Two Medicine region is nearly twenty miles southeast of the Swiftcurrent area and at a slightly lower altitude. Active glaciers are lacking and snow and nevé banks alone are responsible for the recent sculpturing detail in the great Pleistocene glacier cirques. Along the bases of cirque walls on shelves up to the rims the nevé banks have sunk pockets into the sheer walls, and are continually spilling talus and the "talus moraine" which normally encircles the snow bank rim, over the edge of the shelf to talus cones below. Fig. 3.

The cirques at the heads of valleys draining the Two Medicine region exhibit the last stage in the secondary glaciation cycle. The small active glaciers and glacierettes have melted and only ice and snow banks continue on a small scale to pocket the walls by nivation and impose upon the major earlier amphitheaters, developed by the Pleistocene valley glaciers, a wealth of small detail and local relief.

In the final stage the snow and ice banks have disappeared entirely and the minor cirques, multiple-level terraces and pockets have filled with talus and lost the amphitheater outline through exfoliation and frost action. Such conditions are evident south of the Park.

Front Range in Northern Colorado.

Multiple-level cirques in the Ranges of Colorado are less well developed than those in Glacier Park. It appears that the massive granite and gneiss of the region is less favorable for the ready cutting of shelves and pockets by nivation and plucking. Hence the erosion by recent glaciers is poorly defined and not readily recognized.

Along both east and west slopes of the Continental Divide the Pleistocene valley glaciers carved marked amphitheater cirques in granite and gneiss. Present glaciers are of the cliff type and situated high on the walls of the cirques. Such glaciers are shaping the major cirques into multiple-levels. Nivation by snow and ice is a minor feature. The multiple-levels of Glacier Gorge to the west of Longs Peak are marked by small lakes and but little moraine. Other great cirques exhibit similar detail.

Steps in the Development of Multiple-level Cirques.

1. A valley glacier at its maximum stage, by sapping, developed a steep-walled cliff enclosing the head of the glacier. The amphitheater created was, in some cases, not at the head of the pre-glacial valley. Avalanches brought down loose rock from above and the scaled-off talus glissaded over the snow and ice to join the moraines.

2. The valley glacier receded so as to abandon the major part of its valley. Remnants of ice were left nested in the bottom of the cirque or perched high on cirque walls. Such small glacierettes, by plucking and nivation, dug in and deepened the rock floors so as to pocket the walls. The products of such erosion, together with talus from cliffs

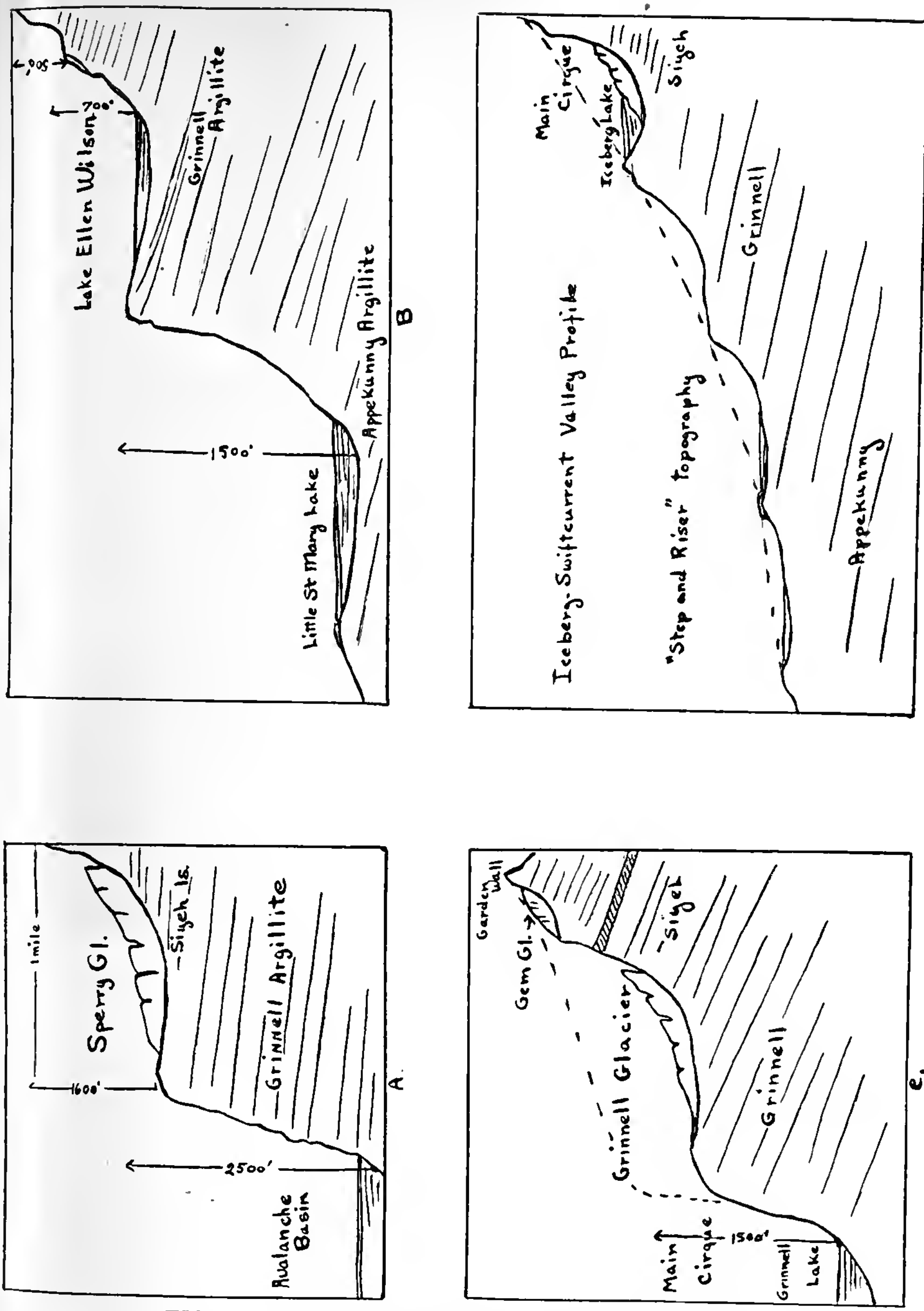

FIG. 1. PROFILES OF MULTIPLE-LEVEL CIRQUES.

(a) Shows the main cirque of Avalanche Basin and cirque wall up to Sperry Glacier which is perched in a secondary and somewhat shallower cirque above the main cirque.

(b) In the Little St. Mary's valley the glaciers of both upper and lower cirques have vanished, leaving three levels well established.

(c) Profiles of Grinnele cirque, Grinnele and Gem Glaciers, show three multiple-levels in the making.

(d) In the Iceberg Lake-Swiftcurrent valley only one level of cirque is evident. Note that the down-valley end is marked by "step and riser" topography.

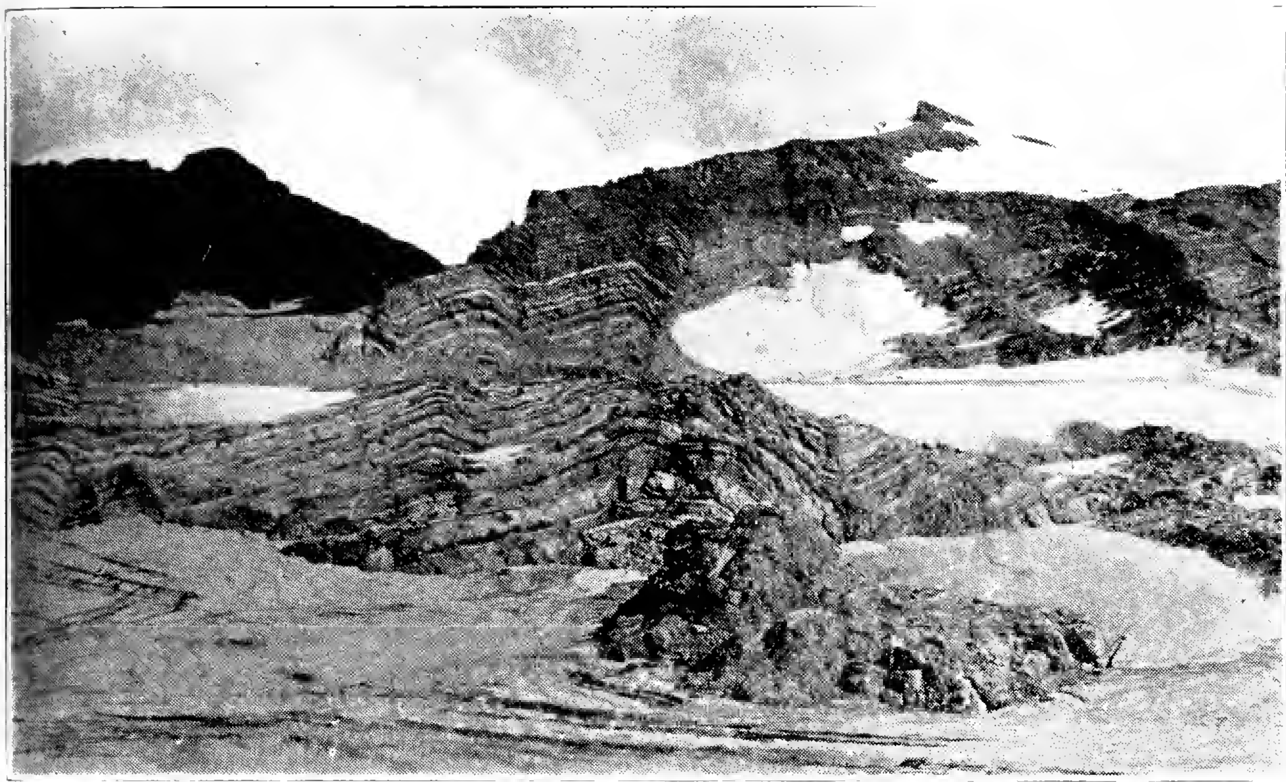

Fig. 2. View of Sperry Glacier in 1926 (August) showing its separation into different lobes at different levels, each lobe operating to nest itself into a separate cirque. Vertical distance in the view is about 1500 feet and the horizontal distance about three-fourths of a mile.

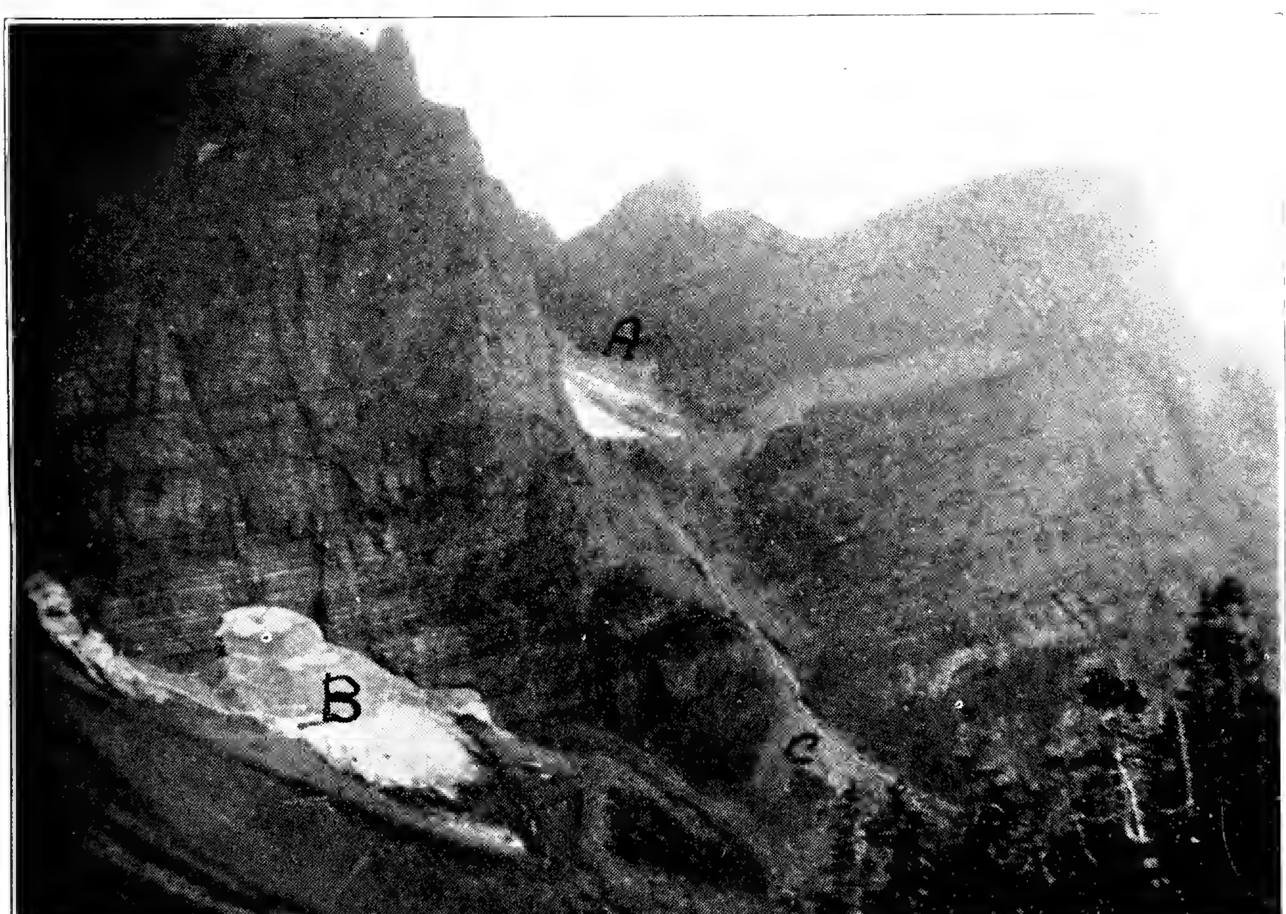

Fig. 3. Detail of main cirque wall showing small subsidiary glaciers (a) hanging glacier carving a secondary cirque and spilling moraine and talus to a cone below (c); (b) small glacier at foot of a cirque wall with typical horseshoe moraine.

above, accumulated in a horseshoe moraine or was spilled over the narrow shelf to the floor below. In some cases recent glaciers are not survivors, but are newly gathered and occupy sites hitherto unglaciated, such as the shallow benches marking the heads of preglacial valleys, situated above the present highly elevated snow line. The small glaciers which survived from the earlier and more extensive epoch, as well as those which are obviously of recent gathering, are maintained because of strategic position for snow accumulation and along shaded cliffs.

3. The small cliff glaciers continue to excavate basins commensurate with their size and carve the walls of the giant cirques into multiple-levels as long as they survive. It is believed that the majority of such glaciers are relatively short lived.

4. With the exception of cirques and shelves developed by glaciers the size of Sperry and Grinnell, the small cirques abandoned by the ice and the pockets developed by nivation, once empty, soon fill with talus and harbor less and less of drift each year. In this way the record of such small moraine-rimmed pockets or moraineless shelves is soon obliterated.

Summary.

It appears that small cliff glaciers operating within and along the walls of the earlier developed amphitheaters, as well as those perched above the rims of giant cirques, mark the recent cycle of glaciation. Such cliff glaciers impose distinct but small scale detail upon the older topography. They develop multiple-level cirques within and about the giant amphitheaters created by the Pleistocene valley glaciers.

THE PHOSPHATE ROCK INDUSTRY OF MOROCCO.

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Phosphatic material, such as animal refuse, bones, fish, and guano have been used for fertilizer for such a long time that it is nearly impossible to state when its application as such was first discovered. However, it was not until the discovery of the mineral phosphates that the artificial fertilizer industry rose to such magnitude that today abundant supplies of this mineral have become indispensable. Fortunately the beneficence of nature insures us vast deposits of mineral phosphates.

One of the richest phosphate fields, probably only surpassed by that of the United States, is the Moroccan. It is found in three fairly large areas, all on the Tertiary and Quaternary tableland nearly 100 miles broad, bordering the Atlantic Ocean.[1] Of these regions the northernmost one, about 80 miles southeast of Casablanca and including Oued-Zem, El Boroudj, Guisser, and Kasba Tadla on the north,

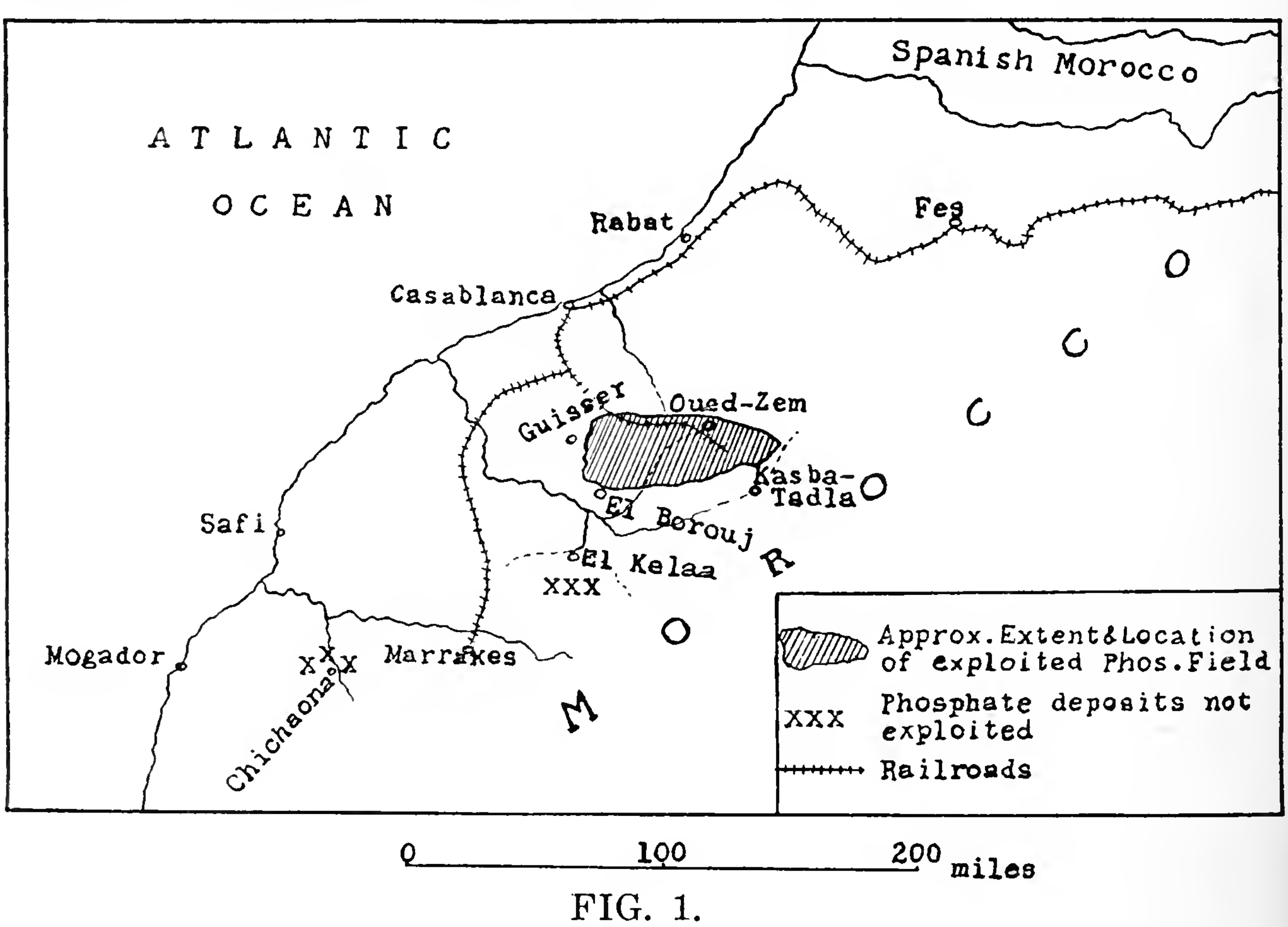

FIG. 1.

south, east, and west sides respectively, is the only one that has been explored in any detail, and at present the only one

[1]Stone, R. W. *Phosphate Rock*, U.S.G.S. Min. Res. of the U. S. 1919, Pt. II, p. 222.

mined.[2] (Fig. 1). This field covers an area some 75 kilometers in length and from 5-35 kilometers in breadth. The phosphate found here is in the form of fine grayish sand, friable, and with a high percentage of phosphate of lime (73-78%). As regards its quantity the estimates vary from "many millions" to "hundreds of millions" of tons. G. R. Mansfield of the United States Geological Survey places the reserves for this northern area at 1,000,000,000 metric tons.[3]

The phosphate beds, separated by calcareous beds, clay, and a low percentage of phosphatic marls, consist of horizontal layers varying in thickness from a maximum of 65 feet in the north at Oued-Zem to 98 feet at the south in El Boroudj.[4] From a topographical point of view they present the appearance of a plateau rising gradually from the north to the south, and since this plateau is criss-crossed by a number of intermittent streams the erosion caused thereby has made prospecting for the phosphate a comparatively simple matter. It has likewise made both surface mining and horizontal tunneling possible. The deposits, however, are not continuous throughout the district above described, and their value fluctuates with the variation in the grade. In many places the grade is too poor to be commercially recovered, and unfortunately this is often true of the thickest beds.

At El Boroudj cliff, which is the southern boundary of this exploited field, erosion has caused the phosphate to disappear, but it reappears further south in the region of El Kelaa. About 60 miles to the southwest of this field another layer of phosphate makes its appearance, which is known as the Chichaona-Imintannt field. Both of these beds, said to be as much as 200-275 feet thick in places, form parts of the same sedimentary series that is present in the Algerian and Tunisian deposits. However, no attempt at exploitation in these regions has as yet taken place.

Production.

The development of the phosphate rock deposits of Morocco has proceeded with almost unprecedented vigor.

[2]Mansfield, G. R. *Phosphate Reserves Ample for 2000 Years*, Engineering and Mining Journal, vol. 122, No. 21, p. 812.

[3]Mansfield, G. R. *Phosphate Reserves Ample for 2000 Years*, Engineering and Mining Journal, vol. 122, No. 21, p. 812.

[4]Loyd, S. L. *Moroccan Phosphate Deposits*, Engineering and Mining Journal, vol. 113, April 8, 1922, p. 565.

From an output of 6,981 tons in 1921, the production has increased to 720,680 tons in 1925[5] (Fig. 2). When the Protectorate (the French) realized that the phosphate deposits were of such enormous extent and value they made the entire exploitation a matter of State monopoly, which greatly facilitated the construction of railroads, port equipment, and mines. To this can be attributed largely the phenomenal increase in production. However, the scarcity of labor limits the output. It has been said that in order to bring the production up to 1,000,000 tons per annum 20,000 miners will have to be employed, which is more than the total population of the region under development.[6] Furthermore, the labor supply, being largely recruited from the country-side, is curtailed during the ploughing and harvesting seasons. As yet wages are not high enough to induce foreign labor to come to Morocco. The extent of the deposits being practically unlimited, it would seem that production is entirely dependent on the demand and the availability of labor.

Exportation.

There are no statistics concerning the domestic consumption of phosphate fertilizer, but it is understood that prior to 1925 the amount was negligible. Consequently, practically the entire output is exported. It appears, however, that the producers are either not attempting or have been unable to place their products extensively in other markets than those of Europe. The only exceptions are small amounts that are sent to the Union of South Africa and to Australia (Fig. 3). The European market is canvassed thoroughly, a policy which apparently seeks to establish a well-rounded demand that will give greater stability to the industry. The expansion of the European buying market will admit the ready disposal of increased output. Morocco exports only the high grade phosphate, which since the war has been especially demanded by the trade. It is the high-grade Moroccan rock that competes so strenuously with the high-grade Florida phosphate, for in 1925 Europe consumed 721,227 tons of Moroccan phosphate as compared with 614,571 tons of high-grade Florida phosphate (Fig. 2).

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[5]Waggaman, W. H. *Phosphate Rock*, The Mineral Industry, vol. 34, p. 552.
[6]*Ibid.*, p. 553.

Although no figures as to the cost of extraction and carriage of the phosphate to the port of Casablanca has been announced, the price of phosphate at English and French ports amounted in 1924 to only $5.25 per ton.[7] This amount appears exceedingly low, when it is considered that the mineral must be extracted, sorted, crushed, loaded on cars and carried 80 miles to Casablanca, loaded on ships and transported to the various foreign markets. No doubt, in order to permit a greater profit, the producers are endeavoring to reduce transportation and handling costs by manufacturing super-phosphate (which is the concentrated form of phosphate fertilizer) in Morocco. This high-grade product can more readily than the raw product support the freight rates. The preparation of super-phosphates has already been started in a small way at Casablanca.

Morocco's Future in Phosphate Production.

Although active propaganda to increase the sales of Moroccan phosphate is being carried on by the French, several economical and geographical conditions greatly facilitate the exploitation of this field. These are:

1. Moroccan ports are exceedingly well-placed geographically to secure favorable freight rates to the European markets.
2. Phosphate deposits can be mined more cheaply than any other known deposits because of (a) horizontal beds, (b) high percentage of phosphate of lime, (c) proximity to the coast, (d) soft texture of the rock which is highly desired in the manufacture of super-phosphates.
3. Morocco can furnish, if necessary, all the standard grades of phosphate from high to low.
4. Facilities for railroad construction from the coast to the mines are excellent.
5. Low wages and assistance from the French Government stimulate sales.

The Moroccan enterprise has been in existence only since the war, but already it is third in world production. As time goes on it is highly probable that Europe will secure the bulk of its supply from the North African phosphate fields (the high grades from Morocco and the lower grades

[7]Mansfield, G. R. *Phosphate Rock in 1924*, U.S.G.S. Min. Res. of the U. S. 1924, Pt. II, p. 102.

from Algeria and Tunisia). The physical characteristics of the phosphate, its accessibility from the mining standpoint, and its transportation facilities are the chief factors governing price, which in turn determines sales. Since Morocco is especially favored in these respects, she should be able to maintain a commanding hold upon the European market.

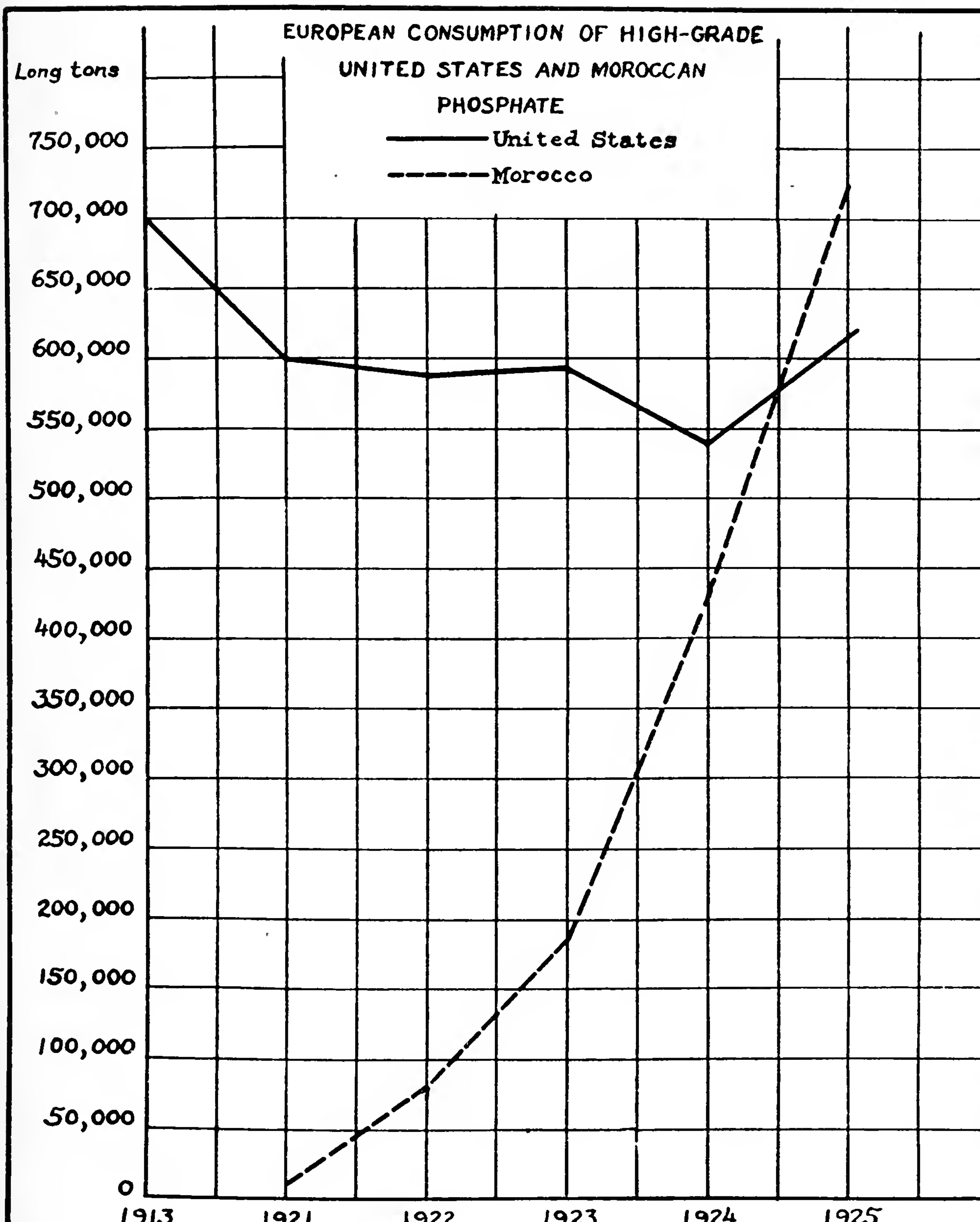

Fig. 2

The exports of Moroccan Phosphate rock to Europe approximately equals the total production since domestic sales and the deliver--ies to other countries than Europe are almost negligible.

Note:- Data for U.S. from Min. Res. of U.S. Pt. II, 1925, p. 161, for Morocco from letter to writer from A.D. Cameron, U.S. Consul, Paris, France, Mar. 1927.

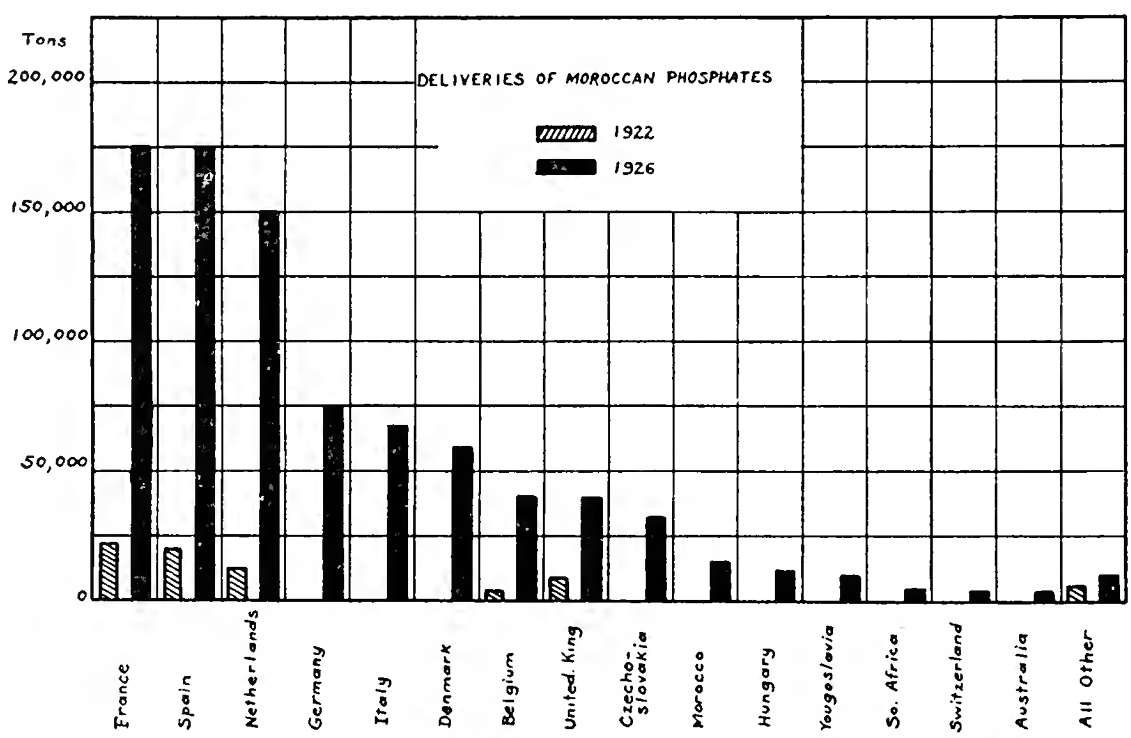

Fig. 3

Data from letter to writer from U.S. Vice-Consul A.D. Cameron Paris

PAPERS IN MEDICINE AND PUBLIC HEALTH SECTION, JOLIET.

RABIES IN ILLINOIS.

THOMAS G. HULL, PH.D. CHIEF BACTERIOLOGIST, ILLINOIS DEPARTMENT OF PUBLIC HEALTH.

When the old Greeks looked up into the heavens, they imagined that they saw all sorts of curious figures and animals outlined by the stars. Thus the stars were grouped into constellations and named after the animals and gods they represented. Modern astronomers continue to use those names for star groups. If on a clear winter night you face south and look up you will see in front of you "The Great Dog" dominated by a particularly bright star "Sirius," or the "Dog Star". In July and August this star rises with the sun and to it the ancients attributed the great heat of the season as well as the cause of dogs going "mad".

"Mad dogs" have been known as far back as history goes. The Greek philosphers Aristotle and Plutarch wrote about the disease under the name "hydrophobia" (fear of water). From Rome we hear of it through the writings of Vergil and Ovid who called it "rabies" (from the Latin rabere, to rave).

The notion of the ancients, and which still prevails, that rabies is a hot weather disease, is erroneous. It is true that the disease may be prevalent during the summer, because dogs are out of doors to a greater extent and hence come into contact with each other more. This seems to be the case in Illinois as evidenced by the number of heads of rabid animals received both at the laboratory of the State Department of Public Health in Springfield and of the Chicago Health Department. In other communities, however. notably New Jersey, Kansas and Washington, D. C. March is the month of greatest prevalence, with August the lowest month of the year.

History does not reveal when rabies first appeared in Illinois, but we can be quite certain that it was not long after the white man settled here and established communication with the outside world.

Rabies is on the distinct increase in the State at the present time. For many years the disease was very prevalent in Chicago but it has fallen off markedly due to compulsory muzzling and leashing of dogs and catching of stray animals. More than 10,000 strays yearly are picked up in that city. On the other hand very few animal heads were formerly received for examination in laboratories downstate, but since 1923 the number has been increasing rapidly at the laboratories of the State Department of Public Health at Springfield and Carbondale, and the Department of Animal Pathology at Urbana.

The spread of rabies over the state has been in the form of a wave northward. In 1924 the State Laboratory at Springfield found the unprecedented number of 39 positive examinations, all from the southern counties; the next year number jumped to 60, with the disease advanced farther north, while in 1926 there were 140, reaching up as far as Will County.

Laboratory examinations for rabies are made by various institutions throughout the state—State Department of Public Health, University of Illinois, Chicago Health Department, Chicago Pasteur Institute and others. Not only are dogs' heads examined but other animals, for all warm blooded animals are susceptible to the disease,—horses, cows, cats, squirrels, even skunks have been received by us. The examination is the same in each instance. The skin over the skull is laid back, the skull cap removed, the brain exposed, a small section pressed out between glass and stained after a certain manner. If the animal was rabid usually typical Negri bodies are easily seen in the brain cells. It is not known for certain whether these are protozoa that cause the disease, or are degeneration products of the brain tissue. They are always found in the brain of well advanced cases of the disease however.

Human deaths from rabies have been increasing both in Illinois as well as over the country as a whole. In the United States for the last three years there was an average of 84 human deaths yearly. In this State there were 4 last year.

Anti-rabic vaccine, if taken promptly, is a sure preventative of the disease. If too much time elapses after the bite, sometimes the patient dies in spite of the vaccine. None of the four persons who died in Illinois last year had received vaccine. Even when an animal is rabid, only one in six of the persons it bites will contract the disease even when no vaccine is taken. The other five escape through various causes—probably because the dog's teeth are wiped free of saliva by the clothing of the victim.

By the use of anti-rabic vaccine the Pasteur Institute in Paris was able to save 165 to every one that died, this one dying because of delayed treatment or other causes beyond their control.

The Chicago Pasteur Institute increased this figure to more than 750 saved to one death using the original Pasteur method. Since 1910, among the thousands of persons treated this institution with improved methods has not lost a single patient.

This is the experience of many institutions. In Illinois the State Department of Public Health distributes anti-rabic vaccine free of charge to those unable to pay for it.

The credit for the discovery of anti-rabic vaccine goes to Louis Pasteur. In past days some of the most horrible outrages imaginable were perpetrated against persons who had been bitten by rabid dogs,—strangling, suffocating or bleeding to death of the poor victims. On July 6, 1885, after numerous experiments on dogs, Pasteur administered the material to the first human being. This story of Pasteur and Joseph Meister is one of the most gripping and touching ever written. But the little boy, horribly torn and mangled by the mad dog as he was, lived, as thousands have done since.

The control of rabies in a community depends principally on the control of dogs. A suspected animal should not be killed but *chained* securely in a safe place with regular care and attention. If after a week or ten days it has shown no symptoms, it can be released and any persons bitten need take no anti-rabic treatment. If, on the other hand, it develops symptoms of rabies, the animal may be killed and the head sent to the laboratory for examination. If sent in before any symptoms have occurred, the laboratory examination may be unsatisfactory, and leave the patient in more doubt than before.

Any community may rid itself of rabies by requiring the leashing, muzzling or impounding of all dogs, or as a substitute the vaccination. Of course, stray and ownerless dogs should be destroyed.

Positive Laboratory Examinations for Rabies

	Chicago	Springfield	Urbana	Carbondale
1911	119	3	...	...
1912	116	0		
1913	83	0		
1914	122	0		
1915	119	0		
1916	40	0		
1917	11	0	—*	
1918	26	0	—	
1919	19	2	—	
1920	30	0	—	
1921	44	2	1	
1922	56	1	2	
1923	57	2	5	
1924	59	39	25	
1925	21	60	23	4**
1926	17	140	69	12

*Laboratory of Animal Pathology established 1917.
**Carbondale Laboratory established in 1925.

THE IMPORTANCE OF REST IN THE TREATMENT OF PULMONARY TUBERCULOSIS.

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In the modern treatment of pulmonary tuberculosis three important factors are recognized; namely, food, fresh air and rest and we are realizing more and more that the greatest of these is REST. In fact as Doctor Stewart of Manitoba has said, "REST IS THE CURE."

When we realize that the average healthy individual spends about $\frac{1}{3}$ of his life in sleep and several hours more in freedom from work to repair the ordinary wear and tear incident to life's activities, how much more rest should be required when tissues are injured by disease and when at this time extra demands are thrown upon them? During sleep, which more nearly approaches complete rest, all cellular activity is lessened, mental exertion ceases, muscular activity is lessened, metabolic changes decrease, temperature lowers, circulation becomes slower, blood pressure is reduced and respiration becomes slower and much shallower. When the lungs are the seat of disease, it is necessary that the body cells have the minimum demands upon them.

The ordinary case of tuberculosis requires rest and care for a long time—years rather than weeks or months—and even after all activity has ceased in order that the reparative process may go on.

The longer I work with tuberculous patients the more firmly convinced I am of the necessity of a more absolute rest, carried out for longer periods of time even after there are no signs of activity.

ULTRAVIOLET RADIATION AND LIVING PROCESSES.

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Various physical and chemical agents have been shown to be capable of influencing life processes in either of two directions, stimulating or inhibiting them, depending on the dosage used, and the degree of susceptibility of the tissue concerned. Ultraviolet radiation and visible light (plus the action of a sensitizing dye) are no exception. Radiation studies covering a five-year period, beginning at the Nela Research Laboratory in Cleveland, and continuing at the University of Chicago and at Woods Hole, Mass., have included the following types of experimental study: activation of eggs of star-fish and sea urchins by means of ultraviolet radiation[1,2] and visible radiation plus the action of a sensitizing dye;[3] stimulation of frog muscle and nerve by means of radiation in the same two spectral regions;[4] differential disintegration in Protozoa,[5] the lower Metazoa,[5] and early embryos[6];[7] modification of development in Arbacia[6,8] Fundulus,[9] and the chick;[7] inhibition of the fertilizing capacity of Arbacia sperm;[10] inhibition of the fertilization reaction in Arbacia;[11] and the modification of the division rate in Paramecium.[12]

In the three first-named studies, there has obviously been stimulation of a passive system to an active one. In the case of egg-activation, ripe unfertilized echinoderm eggs were stimulated to develop without the addition of sperm, simply by the action of radiation upon the surface of the egg. Radiation, then, may be added to the long list of parthenogenetic agents, though its efficiency is relatively low when measured in terms of the numbers of free-swimming larvae produced. Activation is often incomplete, resulting only in membrane formation.

Radiation in either of the two above-mentioned spectral regions, when allowed to impinge directly upon the surface of an excised gastrocnemius muscle of a curarized frog will augment the twitching induced by the salt solutions in which the muscle is suspended, and will finally produce contractions. Under properly regulated conditions, these contractions may, within a short period of especial reactivity of the muscle, coincide fairly well with the time of flashing on of the light. In another series of experiments, radiation, impinging directly on the sciatic nerve of a nerve-muscle preparation stimulated the nerve. The impulse was carried by the nerve to the muscle and the latter contracted.

Obviously, the ripe unfertilized egg and the sensitized muscle are biological systems in dynamic equilibrium with their environment, yet are easily activable. Stimulating doses of radiation as used in the above experiments, rarely exceeded a period of duration of a few seconds in the ultra-violet experiments, and a few minutes when visible radiation was used in the presence of a sensitizing dye. When longer exposures are made, inhibition of normal life processes occurs, often resulting in death and disintegration.

Such a series of experiments were made with Stentor, Hydra, Planaria, Arbacia larvae, and chick embryos. The results may be summed up as follows: Those regions of the body which at the time of exposure, have the highest rates of physiological activity, are the first to die and disintegrate. The rate of disintegration is a function of the relative rates of physiological activity of the various body regions, and consequently there appear in the radiated organism, gradients of death and disintegration coincident, in general, with the metabolic gradients present. In other words, in lower animals and in early embryos, the disintegration gradient is a simple anteroposterior one, while in higher animals and later developmental stages, such simple gradients are obscured by the appearance of local regions of high physiological activity.

With sub-lethal doses of radiation, (i. e., doses which are not immediately lethal) it is possible to modify embryonic development. Such studies have been made with eggs of Arbacia (where exposures were made before and after fertilization, and in another series, where eggs were fertilized by radiated sperm) ; with eggs of Fundulus (radiated at various intervals after fertilization) ; and with hen's eggs, (where exposures were made for varying periods before incubation, and at different intervals after incubation.)

While the embryos appear characteristically modified according to species, the results agree in their main features, namely, the regions of the embryo, which at the time of exposure had the highest rates of physiological activity, are most readily modified in their development, and the liability to modification of specific region depends on the relative rate of this region as compared with that of the rest of the body. Embryonic development may be either accelerated or inhibited, depending upon the dosage of radiation employed. In either case, the regions of highest activity are the first to be modified. With accelerating doses, the resulting embryos exhibit the characteristics of differentially accelerated forms in which the most active regions have attained a relatively more rapid rate of growth than normally. With slight doses, differential recovery appears, while with longer doses, differentially inhibited forms result. The proportion of specific types of abnormalities produced varies with the period of development at which exposures are made, e. g., in Fundulus and in the chick, modification of development of the circulatory system, and of the sense organs and brain parts appears in the largest proportion when exposures are made early in development. Inhibitions of the developing tail region appears when exposures are made much later in development. The most favorable period for the production of modifications in the development of a particular organ appears to be just previous to the time when the organ makes its morphological appearance, that is to say, when the preprimordial stage is reached, such a region has a relatively high rate of physiological activity, and in consequence, is most intimately dependent on its environment for its subsistence, and most readily registers the results of any environmental change which produces a deleterious action on life processes.

Two other methods of studying the inhibitory action of ultraviolet radiation were made as follows: Arbacia sperm were radiated, and were found to lose their capacity for fertilizing normal eggs, as well as their agglutinability by normal egg-water; also, Arbacia egg-water loses its power of agglutinating normal sperm. The rate of loss of both these activities is a function of the dosage of radiation employed.

A series of experiments, now in progress, demonstrates the effect of ultraviolet radiation on the division rate of Paramecium caudatum. Here again, small doses, i. e., less than 5 seconds at a distance of 12 inches from the arc, stimulate the rate of division, while longer doses depress the rate. Inhibiting doses applied early in the division cycle may inhibit division to such an extent that the two daughter cells are unable to separate. There results therefore, a considerable proportion of "permanent" pairs. A second exposure, (and occasionally a third, where both members of the pair do not divide simultaneously,) will further inhibit the division of each of the components of a "permanent" pair, and may, in a small percentage of cases, produce "permanent" 3- and 4-celled Paramecia. Further study is being made of the optimum conditions for the production of 4-celled forms and of their behavior and viability.

In conclusion it may be stated that, (1) living organisms are differentially susceptible to radiation, and (2) that dosage is an important factor in determining whether such effects shall be stimulative or inhibitory in nature.

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X-RAY AS A REMEDY IN BENIGN DISEASES OF WOMEN: A REVIEW OF 455 CASES—COVERING 10½ YEARS.

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To report in a few minutes 455 cases covering ten and a half years' work is impossible. However, a statement of the practical aspect of x-ray may be undertaken with the hope that this brief survey may result in a better appreciation of x-ray as a benignly efficient agent in the nonsurgical treatment of women's diseases. I am convinced that certain pathologies in the generative organs of a woman belong to the x-ray therapist and that, exclusive of cancer, these diseases are better treated with the low voltage and fractional doses. This technique being more deliberate, gives, as Nature does, abundant time for readjustment. It is also the safest, most conservative method, and may be so applied that it is free from undesirable results. There is no injury to tissues adjacent to the pathology under treatment and no "x-ray sickness." The patient can immediately and continuously go about her business. There are no detrimental blood changes, no secondary sex manifestations such as obesity, loss of normal sex impulse, etc., because the endocrine balance is not disturbed. When the menopause does follow it is not so precipitate and stormy, as after radical operation.

Another important reason for preferring low voltage, and small doses gradually applied is that in younger women the x-ray effect may be limited in most cases so that the pathology is reduced without profoundly influencing ovarian functions and the menses. Until recently I have not accepted the younger women for x-ray so I have only nine cases in which the menses were resumed in from four months to three years. One conceived and bore a normal child at full term. Of the possibility of pregnancy I cannot judge, however, because five were unmarried. I have recently been strongly upheld in this effort with younger women by reports from Newcomet (1) of Presbyterian Hospital of Philadelphia and Knox of St. Luke's, New York (2), the latter stating that even in women of twenty-five years of age the menstrual function may be impaired only temporarily. I have had 40 cases under 40 years of age. Twenty were less than 35 and the youngest 26.

What is the effect of small doses of x-ray on the tissues? A brief answer to this question follows:

1. X-ray inhibits ovarian stimulation. The ripened follicles and the ripening follicles are usually destroyed but the primordial follicles, if x-ray is discreetly applied, will later develop (3).

2. The internal secretion is apparently not influenced by the conservative application of x-ray (4).

3. The blood vessels are reduced in size by the effect on the endothelial lining of the capillaries, thus limiting the too abundant blood supply (5).

4. The glandular tissues both in the body of the uterus and in the cervix are directly influenced. They become less in size and function, thus adding to the increasingly normal picture.

5. The fibroid tumor cells gradually disintegrate in a regular order, and in favorable cases are finally carried away by the leucocytes.[6]

In the average case all these changes are necessary to recovery, and if the x-ray operator has the judgment to stop when his work is done, nature at her best is imitated and no harm results.

The pathology most frequently presented for x-ray treatment is fibroid tumor of the uterus, of which we have treated 286 cases. For practical purposes these fall into three groups. First, those unfavorable to x-ray that should not be accepted because of serious complications or because of symptoms suggesting necrosis, cystic degeneration or cancer; second, those less favorable, who for sufficient reasons should be accepted. This group includes women who are not good surgical risks at the time of treatment but who may later become so because of improved general health. In some cases, however, surgery will probably never be possible and the x-ray therapist can here offer a definite relief. This group may include those who cannot turn aside from compelling responsibilities at home or in business, and also those who refuse to submit to surgery.

From this group, however, we have had some surprising successes, and from this group also may come an occasional disappointment, as will be seen later. The third group and the best, are those of the intramural type of tumor that are hemorrhagic. These are most favorable to x-ray and yield 100 per cent in satisfaction. The great majority of these tumors disappear, and fortunately this favorable type occurs in 75 per cent of all cases. They are ideal cases when the fibroid is situated below the umbilicus, is not seriously complicated and occurs in a woman of 38 years or more.

Apropos of the above question of selection, I find that as my experience grows and my judgment in diagnosis, prognosis, technique and management becomes more reliable, I am accepting cases that I would have once refused. This is possible because I find that a much larger percentage respond to treatment and return to health than I at first thought possible.

Here, in fairness to the subject, I must include a paragraph of my failures that came to operation. As I look back I see that they have come mainly through errors in diagnosis.

The first was a myxomyoma. That is rare, almost never diagnosed until after operation. Next came a fibrocystic tumor of the ovary in median position. Then a cancer of the fundus uteri was accepted after a negative hospital report. The next was a fibroid tumor closely associated with a dermoid tumor. The fibroid disappeared, the dermoid remained. The next case gave me great anxiety and regret. She was a very poor surgical risk and also was unsuited to x-ray. The tumor was large, multiple and hemorrhagic to an unusual degree. The complication was one of the worst cases of exophthalmic goitre I ever saw. X-ray shrank the tumor, reduced the hemorrhage and so improved general health that the goitre gradually subsided. But the hemorrhage would recur. Radium was finally applied the third time before hemorrhage disappeared. Five years of good health followed. Then a papillomatous cyst of the ovary required operation. The small fibroid remaining seemed so innocuous that it was not removed, because of the risk of too long an operation. Again she became well and resumed her work. But a year later, seven years after treatment began, she died of a malignant growth the nature of which was not determined. This case is reported more in detail because it is my only case of cancer which developed after a thorough irradiation.

Submucous fibroids are a complication that may defeat the ideal result and they often escape early diagnosis. These are said to occur in about 10 per cent of the cases. Eight per cent usually recover with the fibroid. Two per cent either prolong the hemorrhage, which finally ceases, or they may require curettage to complete the cure, or as in one of my cases, by developing a suspicion of malignancy may lead to operation. Not one of my group, however, has been malignant. Béclère reports seven of these failures out of 700 cases (7). This corresponds to my own experience. One case in which the large tumor had disappeared was curetted and cured—one was operated upon. This was a very complicated case, at first a poor surgical risk which became under x-ray a good risk. The tumor and adhesions were much reduced but bleeding occasionally recurred. The health, however, was greatly improved and the patient was then operated upon successfully. Another case was so improved under x-ray that a dangerous and radical operation was changed to a simple non-mutillating one.

Beside fibroid tumors x-ray remedies the following:

The menopause often plays the part of a bad citizen or an outlaw. We deal with these cases when hemorrhage is the principal offense, or when, with a multiplicity of smaller offenses, the patient becomes a nervous wreck, her general health suffers and her whole family becomes discordant. The hemorrhage may become a serious matter even though gross pathology may not be demonstrable. There is, however, as Samuel Geist has well established, a histologic picture in the endometrium that is pretty constant. He finds hypertrophy of the mucosa, edema of the stroma and enlarged glands which may be cystic (8). Though these changes are comparatively small and not palpable, I contend they are pathologic and should be dealt with. My 20 cases have all responded to x-ray after a few weeks and good order again reigns in the small community.

The ovaries, when they present the small follicular cysts, should not be patched or removed. These cysts may grow to the size of a lemon, but under x-ray they recover promptly with the fibroid tumor. I have a list of 63 cases that are well.

The large ovarian tumors are always surgical. They are not caused, nor prevented, nor cured by x-ray.

The cervix uteri, where cancer prefers to attack, should be cured long before that tragedy. In cases of cystic degeneration of cervical glands, with erosions that are sometimes extensive and threatening, and the resulting leucorrhea, the x-ray is a dependable remedy, and the response to treatment is prompt and satisfactory. To date no case of cervicitis has developed cancer, though we have had several that required follow-up treatment. We have treated 68 cases.

Dysmenorrhea, the type that resists all measures, that incapacitates the sufferer, that makes of her a haunted invalid throughout the month, should be ended with x-ray. These cases, 18 in number, have come so promptly into good health that they have given great satisfaction.

Adhesions generally yield with the rest as do also indurated and inelastic tissues. After a free reparative circulation is established, the tumor usually becomes freely movable and later the uterus, which was held down by tumor weight and adhesions, may resume a normal position, to which it naturally inclines (9). This has occurred often enough so that we now entertain a reasonable hope for that result. The reduction of adhesions was one of the earliest observations made by the earliest x-ray therapists.

General management includes attention to the individual needs and a flexible régime for the woman who does not conform to the general rule. In order to estimate what the rule may be, we have a large card printed with regard to convenience and precision of detail on which we record so exactly the technique of each treatment that today we can repeat in every respect a treatment given ten years ago today. On this card is also noted the results of the check-up examinations. If there is less improvement than there should be a search is immediately made to find why the stasis.

Improvement is very soon apparent in a well selected case, and errors in diagnosis are promptly discovered. After treatments are finished it is our practice to urge the patient to report periodically to her physician or to myself for the follow-up estimation of her condition. In this way only can we draw reliable conclusions and attain accuracy as to results. Because the above named details are so important, I object to a technician, untrained in diagnosis and in the requirements of these cases. He should not be put in full charge even though he is under the so-called "direction" of a physician who is himself often untrained in exact gynecologic estimation and in x-ray possibilities. We should remember that x-ray is at once the most dangerous and the most benign of all the therapeutic agents. Because of these discrepancies in management, x-ray as a remedy in women's diseases has not come into full recognition. It has been in this special field more neglected, more misunderstood and more trifled with than has any other scientific measure.

Doubtless questions have arisen in your minds in the course of this paper. Some of those commonly asked I shall now endeavor to answer.

Q. Why are not normal tissues injured while pathologic tissues are remedied? Ans. They should not be if x-ray is not given too long and too strong. They are not changed during a brief application and with the low voltage technique because the pathologies we have discussed are all influenced by smaller doses than are muscle, nerve and other tissues (10).

Q. Is there not danger of x-ray burns? Ans. There is, always. But if in ten and one half years we have managed to avoid burns and other accidents, it follows that it can be done. It is, however, the one thing that makes x-ray therapy a most exacting business. In each of the ten cases of x-ray burns that I have known about in outside laboratories there was either ignorance or carelessness or a gambler's disposition to take chances.

Q. Does x-ray affect a woman sexually? Ans. It does not, under moderate application, if treatments are ended when the work is done. My women are, in a large majority, unchanged in this respect, except for the better. This is the result of improved health and freedom from pain and discomfort during coition. The results are better under moderate x-ray than from radical surgery. Bride, of London, reports that 39 per cent of his operated cases are disturbed as to sex relations (11). Fear and psychic instability here enter into the problem, and these are favorably influenced if a woman knows that her generative organs are intact, as after x-ray.

Q. Is the danger of cancer greater if the pathology is not removed surgically? Ans. No. This fallacy should have been exploded long ago. During my ten and a half years only one died of cancer and that was seven years after treatment. Throughout the world of x-ray therapy there is the belief that x-ray helps to prevent cancer by relieving the precancer pathology and by the return of normal circulation. Franque, the famous x-ray therapist of Paris, reported 200 cases of fibroid with one cancer following (12). According to accepted statistics, he was entitled to six. The same is true of my own series.

Q. Why do you prefer x-ray to radium or surgery? Ans. I do, in selected cases only. When I get a case suitable to x-ray I prefer it for the following reasons:

1. There is no danger to life. Both radium (13) and surgery have an admitted mortality.

2. X-ray requires no loss of time, no hospitalization, and is therefore less expensive.

3. X-ray covers a wider field, includes more possible outlying pathology, stimulates more actively circulation of lymph and blood.

4. X-ray more easily reduces the large tumor than can radium.

In closing I wish to urge that Time and Nature are two almost invincible allies; that x-ray in remedial doses, not destructive doses, reduces the pathology and the adhesions, establishes a free circulation—after which more treatment is not often required; that health is conserved by methods free from shock and prostration and by leaving a woman's pelvis intact and functioning if possible; that the universal acceptance of x-ray depends upon an accurate estimation of the case before, during and after treatment, careful records, a cautious disposition and a less amount of x-ray rather than more.

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DISEASE IN PLANTS—A COMPARISON WITH HUMAN DISEASE.

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Although Phytopathology as a separate branch of study in our universities is a comparatively recent acquisition, the history of the study of plant diseases takes us back through the days of superstitious and religious beliefs to the very beginning of man's civilization. With his very earliest attempts at growing plants for his own use, man must have observed the appearance of disturbances in their growth and productivity for the very earliest writings mention the visitation of various plagues. These were considered to be sent by the gods and early offerings were made to the gods to propitiate them and get them to protect the crops.

The Bible makes mention of such maladies as blightings, rusts, mildews, and blastings and considers that they were laid down, like the boils of Job, as an expression of the wrath or disfavor of the Deity.

Among the greatest of ancient botanists was Theophrastus (372-287? B. C.) of Greece, a pupil of Aristotle. He accurately observed in his *Historia Plantarum* that cultivated plants were more subject to disease than wild ones. "As to diseases," says he, "they say that wild trees are not liable to diseases which destroy them. Cultivated kinds, however, are subject to various diseases, some of which are, one may say, common to all or to most, while others are special to many kinds. General diseases are those of being worm-eaten, of being sun-scorched, and rot.

"The olive in addition to having worms (which destroy the fig, too, by breeding in it) produces also a knot (which some call a fungus and others a bark blister) and it resembles the effect of sun scorch. The fig is also liable to scab. Moreover, there are certain affections due to season or situation which are likely to destroy the plant, but which one would not call diseases; I mean such affections as freezing and what some call 'scorching.' As to diseases of seeds —some are common to all, as rust, some are peculiar to certain kinds." Theophrastus seems to have made rather a careful study of the epiphytotics of rust as they occurred in Greece.

The true etiology of disease in plants in these ancient days was, for the most part, buried deep in the mystery and superstition from which it was a long time in being extricated. Legends were evolved to explain the maladies and diseases were dedicated to special gods, such as the Roman rust gods, Rubigus and Rubigo, in whose honor annual festivals of propitiation were held.

From 476 A. D. to the beginning of the seventeenth century, which includes the "Dark Ages," was a dark age for Phytopathology too, but interest was revived in the seventeenth century, this time among the farmers and agriculturists, whereas previously it was the philosopher who speculated on the cause of disease while the superstitious farmer offered up libations to the gods. (We still have some farmers who plant certain crops by the dark of the moon.) It was during this century that the first law, so far as record shows, was enacted for the express purpose of controlling a plant disease. In Rouen, France, in 1660, a decree was passed directing the digging up and destroying of all barberry plants. The barberry was thought to bear some mysterious relation to the wheat-rust epiphytotics. It is a striking thing how often the observations and, one might almost say, "hunches," of these early observers came very near hitting the truth, as was the case in this first "barberry eradication campaign."

The eighteenth century was a period devoted to taxonomy-attempts to name and classify the diseases on a symptomologic basis. The names were fashioned after or copied from those used for supposedly similar human diseases. Thus we have plant cancers, tumors, fevers and so forth. Johann B. Zallinger in his book on plant diseases, 1773, divided plant diseases into (1) Phlegmasiae or inflammatory diseases, (2) Paralysis or debility, (3) Discharges or draining, (4) Cachexia or bad constitution, and (5) Chief defects of different organs.

It must be remembered that all during this time any fungi found associated with disease lesions were considered not as causes of the disease but as abnormal structures resulting from the disease—that is, morbid plant tissues. Although more emphasis was now laid on the causal nature of such environmental factors as droughts and freezing, the etiology of plant diseases was still largely assigned to supernatural forces. There was an occasional leaning toward the autogenetic theory of disease, the plant being considered to have within it a disposition to disease. Unger (1833), a strong advocate of the autogenetic theory, believed that fungi originated from the diseased host tissues but still he recognized them as distinct organisms worthy of names and classification. He believed diseases were brought about through internal disorganization of the nutrition processes, having their origin in a lack of certain chemical constituents of the sap. The fungi, or entophytes as he called them, were the transformed sap of these diseased tissues, the morbid sap being exuded into the intercellular spaces and there converted under the influence of the still living cells of the host into fungus structures.

During the latter part of the eighteenth century and the early part of the nineteenth, further studies on the part of the growing school of mycologists resulted in the recognition of the independent nature of the entophytic fungi which were found to propagate their kind by means of the spore-like structures or reproductive bodies. It then followed that the organisms must be the causes of the diseased conditions with which they were associated rather than the result. The theory was upheld by such men as De Candolle, Link and Tulasne, but there was up to this time no carefully checked infection experiments to prove it. The first positive proof of the causal relation of an organism to a plant disease was brought out by a young German botanist, Anton de Bary, who was trained in medicine but after practicing two years gave up medicine for research in Botany.

In 1853, just seven years before Louis Pasteur presented to the Academy of Science his first work upsetting the spontaneous generation theory, De Bary published his classical work, "Die Brand Pilze," establishing unquestionably the causal nature of the fungi found associated with rust and smut diseases. Previous to this time, 1844-45, the eyes of everyone were turned upon the economic importance of plant diseases through the widespread and disastrous epiphytotic of the Phytophthora late blight which devastated the potato fields of Europe resulting in famine in some regions. De Bary worked out and published in 1861, the nature of the late blight and the causal relation of Phytophthora infestans.

Just previous to this, in 1858, the farmer scientist, Julius Kuhn, published his famous phytopathologic text—the first to appear based on the remarkable discoveries and researches of De Bary, Pasteur and the others of that school.

It is an interesting little side line, that an appendix in the book was entitled, "The Microscope as a household utensil for the farmer."

Perhaps the last great stage in the development of phytopathology as an independent field of work was ushered in by the discovery of Bordeaux mixture in 1883, and the subsequent emphasis placed upon the economic features of plant pathology. Like Dr. Arno B. Luckhardt's discovery of the anaesthetic property of ethylene gas, and many other discoveries far reaching in their effects, the fungicidal properties of Bordeaux mixture were learned quite by accident. Millardet, a young Frenchman was another physician who abandoned medicine for the pursuit of botany. While attempting to devise control measures with which to combat the devastating spread among the wine grapes of an introduced American fungus causing mildew, he accidentally observed the prophylactic effects of a mixture of copper sulfate and lime which had been sprinkled on grapevines near the road to prevent stealing of the fruit. He at once undertook the investigation of copper as a fungicide and developed the Bordeaux mixture which has been so efficiently and universally used since.

The most important event in the rise and development of phytopathology in this country was the establishment in 1885 of a section of Mycology of the Botanical Division of the United States Department of Agriculture. F. Lamson Scribner was appointed as mycologist and the following year Erwin F. Smith, later so well known for his work on Plant Cancer, was called to be his assistant. Since their work had mostly to do with diseases in plants the name of this section was changed in 1887, to that of Vegetable

Pathology. From a union of this section with four other divisions arose the present Bureau of Plant Industry.

Such has been the history of Plant Pathology, slower in its earlier development than the history of medicine, but rather quickly springing to maturity after the world became convinced of its practical nature in meeting the needs of plant-eating, wearing, and sheltered man.

And of practical value it surely is, for there is not a cultivated plant which is not subject to several diseases, nor does one find that the wild plants are immune to all the rusts, smuts, leaf spots, and pests in general that prey upon plant tissues. Just what is a plant disease and do they have diseases just like humans? is a question a plant pathologist is often called upon to answer. Perhaps the hardest part of the answer comes in the question "what is disease?" for the line between disease and health is sometimes a very narrow one, especially when nothing more is involved than some slight change in function.

It is evident that the concept, "disease," cannot mean just the same to the medical doctor as it does to a phytopathologist for the very reason that man sets himself up as a judge of what health in plants shall consist of. When the medical doctor visits the bedside of another human who claims to be sick, the patient considers that he is himself the best judge of whether or not he is in good health. Unfortunately, for its own complete life functions sometimes, the plant is not able to state its views on the matter. We do not consider that the lovely white bordered coleus leaves are diseased, yet further loss of the same green pigment has reduced some plants to parasitism, and when such light areas show up in mosaicked potato-plants we are immediately alarmed. In both cases the nutritional processes of the plant have been diminished. The farmer has learned to know how beneficial to him is the presence on the roots of his clover and alfalfa of the little tubercles inhabited by nitrogen-fixing bacteria and would probably laugh to scorn any suggestion that the roots were diseased. Yet a hand as warty as the alfalfa roots is certainly considered pathological.

The cauliflower developed under cultivation has its normal flower shoots compacted and aborted and so enlarged that they form a fleshy edible mass whose normal function of producing seed is completely interfered with. A quite different looking plant, this horticultural variety, from its ancestral plant Brassica oleraceae, variety sylvestris, still growing wild on the seashores of western and southern England and Europe. The ancestor at beholding the cauliflower or those other wayward brothers,—the Brussels sprouts with its multiple heads, and the kohlrabe with his goiterous neck—would probably (were it given the power of expression) throw up its branches and exclaim in holy horror, "Look what the association with these wicked men in cities has done for my poor children! Why didn't they stay at home on the seashores of the old country as any self respecting Brassica plant should do?" One might well regard the changes which have taken place in the cauliflower under cultivation as pathological. Certainly from the plant's point of view they are. However, any tendency in the cauliflower to revert back to its ancestral type and function correctly would be viewed with concern and considered pathological from the view-point of man. A plant disease is usually considered, then, as any marked deviation from the normal functions or structure of the plant as it *now* exists, whether wild or greatly modified by cultivation—any deviation which involves death or impairs the life or economic value of the plant.

Various factors are responsible for a difference in the nature of disease in plants and animals. A closed circulatory system and an intricate nervous system in animals results in more systemic diseases. The nearest approach to the circulatory system in plants is the vascular system which is not a connected system of veins offering free circulation to all parts of the plant body as in the case of the human circulatory system. There is no demonstrable nervous system, the most nearly comparable thing being the very fine cytoplasmic strands passing from one cell to another. Hence diseases in plants are more apt to be local as in Nailhead spot of tomatoes, than systemic as in loose smut of grains. In loose smut of grains the organism (Ustilago) gains entry to the young seed and penetrating the ovary wall lies dormant in the embryo. When the seed germinates the resulting dwarfed plant harbors the parasite which keeps pace with the growing point till time for flowering and is therefore in the new seed which becomes a mass of loose smut spores scattering to new plants.

Plants are more at the mercy of the environment than humans are, which again affects the nature of disease in the two. Man being a warm blooded animal is not submitted to the vast temperature range to which plants are exposed. A circulating blood stream, respiratory activities with the giving off of heat in warmed air, involuntary muscular reactions such as shivering, and the giving off of sweat from the body surface all combine with the radiation from the skin itself to keep uniform the bodily temperature of man, even were he not able to move to new environment or to put on or remove clothing at will. Plants on the other hand are fixed in their environment, and are able only by transpiration and radiation to cut down the temperature in summer and by a slow chemico-physical process to harden themselves to extreme temperatures in winter. With a weather as fluctuating as that in Chicago where there can be a daily range of over 40° between maximum and minimum, it is not surprising that the plants are often caught with a lowered resistance. Non-parasitic diseases due to hot winds, freezing temperatures, or excessively high temperatures, unfavorable light relations, and unfavorable soil and atmospheric water relations are very common in the plant world as may be evidenced by the common appearance of sun scalds, sun burns, blastings, waterloggings and like symptoms, as contrasted with the occasional sun stroke, heat-exhaustion and frosted ear occurring among humans.

Plants also lack the elaborate defense mechanism against the invasion of organisms. The lacunae of the tonsils are veritable culture basins for numerous streptococci and other bacteria, but these are kept at bay not only by the epithelium but by an army of bacteria-destroying-leucocytes which constantly stream out from the lymphoid tissue. A plant has no such army for self protection. If the skin of the leg or arm is broken through accident and the injured area becomes infected with streptococcus or staphylococcus, a protective mechanism is at once activated to keep it local. An acute inflammation occurs with dilatation of the blood vessels, increased blood flow, exudation of serum and leucocytes and increased local heat. A wall of leucocytes about the inflamed area limits the spread of the infection. If, on the other hand, the plant loses its protecting cutinized layer by trauma and the parasite gains entrance there is no resultant releasing of a host of little bacteria-digesters, no production of a hostile temperature.

If the plant does not succeed in laying down a corky protective layer and forming wound tissue, and if its protoplasm does not contain a substance toxic to the invading organism, it has no further recourse. Cells may die over a large enough local area to check further advance by starving out the invader.

This leads us rather nicely to a comparison of immunity in plants and animals. Humans may possess a natural immunity, as is true of the most of us in the case of tuberculosis, or an acquired immunity as in the case of those people who have once had scarlet fever and are therefore free from its infection. Plants have natural immunity only. There are some few reported cases of acquired immunity in plants, but none of them have held up under tests. Immunity in plants is mostly a matter of genera, one genus being free from a disease while another is susceptible. Much use of this fact has been made in the breeding of disease resistant strains. Resistant strains are the only hope to the farmer in the case of such diseases as cotton and melon wilt which are caused by species of Fusarium, an almost ubiquitous soil parasite. Pioneer work in the breeding of disease resistant strains was done by W. A. Orton of the Bureau of Plant Industry and great steps are being made along these lines at the present time.

Some of the essential differences in principle between diseases of plants and those of man have been brought out, but in many essentials diseases in the two are very similar.

The response of plant cells to a pathological stimulus is in many ways like that of the cells of the human body. There may be a qualitative change in the cell or the response may be of a quantitative nature such as decreased photosynthetic activity or increased mitotic activity. The response of the cells may be one of hypoplasia, as in nanism, the cells becoming smaller or failing to reach their normal number. Such a response is exhibited by pot bound plants and is made use of economically by florists in producing small evergreens for decorative purposes.

Or the cells may be stimulated to excessive division resulting in hyperplasia. This may or may not be accompanied by hypertrophy, or the enlargement of cells already present. Both symptoms are exhibited in peach leaf curl which is one of the most serious diseases affecting fruits in cooler climates. The physiological pathology involves hypertrophy and hyperplasia, chlorosis, necrosis and dropping of the leaves with subsequent loss of vitality due to defoliation and development of new leaves.

Metaplasia such as is exhibited in the bronchi of the human lungs when the high columnar epithelium cells are changed to stratified squamous cells, is seldom if at all exhibited in plants. The nearest phenomenon is the stimulation of the cambium to form cortical tissue instead of phloëm as in club root of cabbage. Finally, the stimulus may result directly in morphological, physical or chemical disorganization with local or total necrosis. Most of the leaf spot and fruit spot disease are examples of local necrosis.

The effect of the parasite on the host is accomplished by toxins as in some Fusarium wilts, enzymes as in slimy soft rot of vegetables, or less frequently by mechanical trauma, as in Albugo which causes excessive contortion of its host as well as loss of food. The parasite may interfere directly with the food supply of the plant much as the tapeworm does in man, or it may fill the vessels as in Fusarium wilt and thus cut off the transfer of water and soil solutes.

As in animals, so in plants physiological predisposition seems to play a certain part in the development of disease. Just as in tuberculosis, race is an important influence, the disease seeming to be particularly fatal to negroes, so there is a racial predisposition in plants. Black rot, caused by Pseudomonas campestre, is confined entirely to plants of the mustard family. Age is also an important factor, onion smut occurring only in young tissues. There are some fungi which are known definitely as seedling blights.

Sex influence is demonstrated in the limiting of ergot of rye to the ovary. In man certain diseases may be confined to one system or even to a part of one system, as in the confinement of Tabes dorsalis at onset to the sensory tract of the nervous system. Similarly diseases in plants may be confined to one system or to one organ. Potato wart attacks only the tuber of the potato.

As to the *causes* of plant disease—one might divide plant diseases much as Osler does in his text book, into (1) specific infectious diseases, (2) diseases due to physical agents, (3) intoxications, (4) deficiency diseases, (5) diseases of metabolism.

In the case of plants most emphasis would be laid on the first of these, a great deal more emphasis laid on the second than in the case of animals, and least emphasis put on intoxications. Apple scald may be considered as an intoxication. It occurs on apples in storage and seems due to the accumulation in the air surrounding the apples of the odorous substances given off by the apples in their respiration (amyl esters of formic, acetic and caproic acids). It is prevented by wrapping in oiled papers which absorb these odorous substances.

More specific infectious diseases of plants are caused by fungi than by any other group of parasites. Practically every taxonomic group is represented among the disease formers. Some fungi are strictly parasitic as in the case of the wheat-rust, some are either parasitic or saprophytic which is true of that widely known soil fungus and decay producer—Fusarium. Some of the fungous diseases have reached national importance, for instance, the chestnut blight and the white pine blister rust which have spread rapidly with serious effects.

There are many cases of plant injury due to metazoan parasites. Common among these are the nematode disease of roots of various plants (root-knot caused by Heterodera radicicola), and bulb and stem infections due to species of Tylenchus. The oriental fruit moth causes injury in peaches and apples and the codling moth is responsible for an injury to apples. The striped cucumber beetle and his little friend of the polka dotted uniform, Diabrotica duodecipunctata, feed upon the leaves and young stems and cause much damage to the cucumber vine. Plants like humans are subject to lice, though lice are a little more prevalent among the plant aristocrats such as the Rose family than is true of man.

There is no proven case of protozoan infection in a plant though the connection of amoebae with the disease known as mosaic has caused considerable discussion in the past few years. Holmes of the Boyce Thompson Institute has definitely proven the existence of Flagellates in the latex tissue of Euphorbia. Living protozoans have been isolated from tobacco plants showing mosaic symptoms but the tendency of investigators now is to discount any causal relationship of the protozoans found to the mosaic disease. Mosaic seems doomed to be classed with measles and smallpox as a virus disease of doubtful or unknown etiology for yet some time.

Through the relative importance of bacterial diseases and fungous diseases is reversed in plants as compared with animals still some of the most interesting and very important plant diseases are due to bacteria.

An American, Thomas Jonathan Burrill, working at the University of Illinois deserves the credit for the discovery of bacteria as a causal agent in plant disease. Burrill was working on fireblight of apples and pears. The causal organism, Bacillus amylovorus, which is motile by peritrichiate flagella, first destroys the blossoms, green fruits and young shoots but passes quickly downward by way of the bark parenchyma into the larger branches and trunk often girdling and killing them.

The common symptoms are wilting and blackening or browning of the blighted twigs or branches, the dead persistent leaves of which look as if they had been scorched thus giving rise to the common name for the disease—fireblight. The death of so many twigs results in a forcing of adventitious buds to form new shoots. The fruit becomes water soaked and later the tissues darken and become soft at the center with yellow honey-like horns, oozing out thru the lenticels. As the inner bark of the shoots becomes firm in late summer, the blight seems to spread, and the organism usually dies off over winter. But in some cases "hold-over-cankers" are formed from which, with increased sap flow in the spring, ooze out living and virulent bacteria.

It is an interesting fact that the role insects may play in the transmission of disease was first clearly proved in connection with fire blight though the connection of mosquitoes with malarial fever was an old story suggested as far back as Roman times. Merton B. Waite's first report on the role of insects as a carrier of the fireblight organism was made to the American Association and published in the Botanical Gazette in 1891, two years before Smith and Kilborne showed that the cattle tick acted as an intermediate host in the case of Texas cattle fever and several years before Ross' work (1895-7) on the connection of mosquitoes with avian malaria. This latter work stimulated the investigations which resulted in the discovery of the relation the Anopheles mosquito bore to malarial fever.

Waite found that insects carried the bacteria from the amber fluid extruded from the hold-over cankers in the spring to the flowers where a short incubation followed, the bacteria multiplying rapidly. Infection occurs by penetration of the nectary, and from here the bacteria work their way thru the fruit spur at whose base a small canker may form. The secondary cycle is the one most responsible for serious damage. The infected nectaries act as sources of inoculum from which the nectary visiting insects such as bees carry the bacterium from one flower to another. The disease may also be carried by sucking insects such as the aphid and leaf hopper, these latter being responsible for infection of many of the new and succulent shoots formed from adventitious buds.

Fire blight is one of the few plant diseases in which therapeutic measures may be taken since eradication of the cankers by tree surgery and systematic cutting out of blighted twigs is as necessary as the removal of a gangrenous area in humans. Most of the diseases of plants must be fought with prophylactic measures.

In concluding we may say that while plant diseases are, by virtue of the difference in nature of the human body and that of the plant, different in some ways, there are the same general types of response to the presence of a parasite, and plants are subject to the same types of pests. As to whether the same organism can create disease in plants and in animals little is known. J. R. Johnson working in Smith's laboratory found an organism causing coconut bud rot in the West Indies which was indistinguishable from Bacillus coli. Cross inoculation studies have been made with plant parasites in animals and animal parasites in plants but the results may be summed up as being doubtful or negative. However, M. Downin recently reported an interesting case of food poisoning in Russia. Rye grains infected with Fusarium roseum. Lk. are responsible for what he calls "inebriant bread". People who ate it suffered from weakness, vertigo, headache, nausea and vomition. He also isolated a species of Fusarium from the flax which was used in making "inebriant" linseed oil in Ukraine. This furnished the same symptoms as the rye.

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SOME ASPECTS OF CHLORINATION CONTROL IN CHICAGO.

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Read before the Medicine and Public Health Section of the Illinois State Academy of Science, Joliet, Ill., April 30, 1927.

In Chicago as chlorination is the first and only line of defense against a more or less dangerously contaminated public water supply, unusually rigid supervision is maintained over this and other measures directed toward safeguarding the water. Chicago conditions are not only different from those in other cities, because of the limited time available for treatment, but also the magnitude of the chlorination program is quite beyond that of most public water supplies on account of the quantity of water which is pumped. Because of these conditions much has been done, particularly during the last three years, towards improving and standardizing chlorination control work.

The water supply of the City of Chicago is obtained from Lake Michigan through six intake cribs located along the lake front from two to four miles from shore. The water taken in through the intakes passes down through a shaft to a tunnel, which conducts it to a suction well under each of the ten pumping stations, from which it is pumped directly into the distribution system. The chlorine used for disinfection is applied to the water in the suction well at the pumping station. The average daily pumpage for the entire city during 1926 was 878 million gallons. The average quantity of chlorine used for disinfection was 3.56 pounds per million gallons.

There are three fundamentals in connection with the chlorination of Chicago's water supply which are given careful attention:

1. The chlorine must be applied uniformly and continuously to the water pumped.

2. There must be good diffusion of the chlorine solution in the water being treated.

3. The quantity of chlorine applied must be adequate for positive disinfection.

To assure uniform and continuous application of chlorine to the water the City of Chicago employs a corps of 35 chlorine attendants whose duty is to attend to the operation of the chlorinating equipment and to make the necessary control tests. During each of the three eight-hour shifts at the ten pumping stations a chlorine attendant is on service. It is his duty to operate the chlorinators so as to apply the prescribed quantity of chlorine in proportion to the rate of pumpage, making an hourly check on the quantity delivered by the chlorinators by determining the loss of chlorine from the batteries which are mounted on weighing scales.

The chlorinators used at the pumping stations now in operation are of the manual type, it being necessary for the attendant to make adjustments to compensate for normal variations in the rate of pumpage and those resulting from the stopping and starting of the different units. The plans for the new Western avenue pumping station, which will be put into operation this summer, call for automatic chlorinators. This type of apparatus delivers the prescribed quantity of chlorine it is set for in direct proportion to the rate of pumpage, by means of control mechanism connected to the venturi meters.

While it is highly important that there be uniformity in the rate of application of chlorine to the water from minute to minute and hour to hour, to avoid tastes due to periodic over-dosing, it is imperative that the application of chlorine be continuous. To assure uninterrupted chlorinating service Chicago has taken unusual precautions. In each pumping station there is sufficient chlorinating equipment to deliver the maximum quantity of chlorine considered necessary at the maximum rate of pumpage for that station. In addition, there is in reserve a complete duplicate set of equipment. Each group of chlorinating units is set up in a special booth with all chlorine lead lines in duplicate and inter-connected. Duplication of booths was decided upon as chlorine is a dangerous gas and in order that operation from one booth might be carried on in case of an accident in the other, making it impossible for the operator to enter. Each booth is connected with a special exhaust system for discharging chlorine gas out of doors when necessary and any employe whose duties require him to handle chlorine has a special gas mask for emergency service. Under normal operation the City has nearly 200 per cent stand-by chlorinating equipment available for service. Although a considerable initial outlay was necessary to provide Chicago pumping stations with this chlorinating equipment, the expense was amply justified. The average cost per capita for safeguarding Chicago's water supply by chlorine is approximately five cents per year, an exceedingly low charge for health insurance.

Under Chicago conditions it is very important that the chlorine be thoroughly diffused in the water before the latter is delivered to the distribution system. This is necessary not only for effective disinfection, but to prevent excess chlorine in the water drawn into one pump with a corresponding under-dosage in the other. The depth of the suction wells in the Chicago system varies from 30 feet to over 100 feet, with usually from two to four pumps supplied by a common well. To avoid short circuiting of chlorine to one or more pumps of a group drawing on a single well it is necessary to apply this sterilizing solution at a sufficient depth in the well to assure complete diffusion before the water reaches the pump suctions. Studies made in 1924 indicated quite clearly that in many instances complaints of excess chlorine in the water were due to short circuiting of this nature. Our experiments indicate that to assure complete diffusion the chlorine should be applied to a depth of at least 30 feet below the pump suction and preferably 50 feet. It is our policy to apply the chlorine at the eye of the incoming tunnel if possible, using rubber hose encased in pipe conduits attached to the shaft wall. To avoid collapsing of the solution hose due to the long down draft of the chlorine solution, they are vented near the top of the wall.

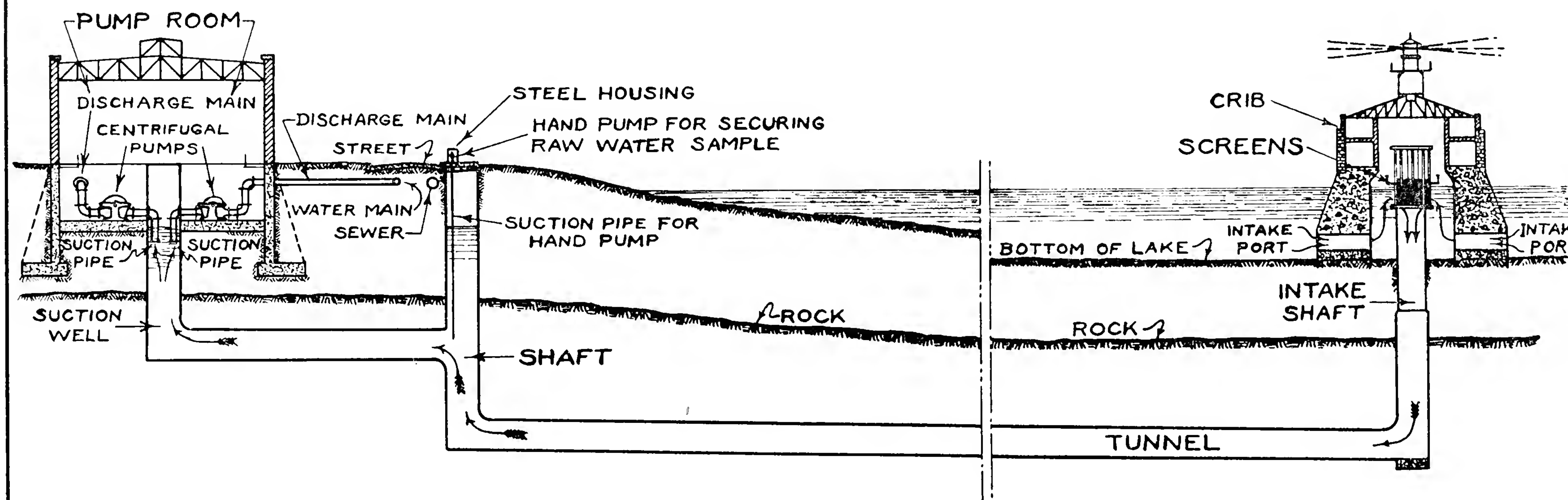
Having perfected arrangements for a uniform and continuous application of chlorine with complete diffusion in the treated water, it is, of course, necessary that the quantity of chlorine used must be adequate for efficient disinfection. Investigators differ widely in their claims for the amount of chlorine required to kill pathogenic organisms. This is partially due to the lack of definite information concerning the action of chlorine on these organisms as well as the concentration and time necessary for sterilization. Pending more definite information on this subject those of us who are charged with the responsibility of safeguarding a public water supply must be guided by our own experiences and the results of bacteriologic examinations of samples of the chlorinated water. In Chicago at certain seasons of the year, especially late winter and early spring, the bacteriologic control is frequently interfered with by the presence in Lake Michigan of non-confirming gas formers which seriously affect the reliability of the presumptive tests for B. coli.

Where the bacterial contamination of the sources of supply varies widely and frequently abruptly, a correspondingly wide margin of safety must be maintained, with the result that often greater quantities of chlorine are used for disinfection than would be necessary if the bacterial load was more uniform. It is fundamental that sufficient chlorine be present in the water to satisfy the demands of organic matter that may be present lest that available for disinfection be inadequate. Since the time interval for killing pathogens by chlorine has not been established it is common practice amongst water purification engineers to carry slight quantity of chlorine in the treated water for a period of at least five minutes after application of the sterilizing agent. In Chicago we make a practice of carrying at least one pound per million gallons residual chlorine in the water as discharged from the pumping stations. Each hour throughout the day and night the chlorine attendant makes a test for free chlorine, using orthotolidin, and comparing the intensity of the color with that of known standards. In case there is excessive absorption of chlorine, as occurs not infrequently at the South Side stations following southerly winds, the operators are authorized to increase the quantity of chlorine until the specified amount of residual can be carried. This frequently requires the application of chlorine in amounts double and even triple the average. The fact that "slugs" of grossly polluted water may be received suddenly at a station makes even the hourly residual chlorine test subject to an element of uncertainty, but it is not considered practical to make these tests routinely at more frequent intervals. Under our present program approximately 220,000 residual chlorine tests are made at the Chicago pumping stations each year. During periods of high absorption, tests are made every 15 minutes, the operator receiving assistance at the time from other employes at the station.

The City is now arranging, through representatives of a large instrument manufacturing company, to conduct studies on apparatus which will automatically record the residual chlorine in the water at pumping stations. Equipment of this kind should supply the "missing link" in the chlorinating control of public water supplies. It does not seem beyond the realm of possibilities that this type of apparatus may even be developed to regulate the quantity of chlorin used so that a definite residual may at all times be maintained in the water supply. The successful development of such an apparatus will be a tremendous advance in the art of chlorination and should make it possible to reduce the safety margin now considered necessary where chlorination is the only treatment given a public water supply for disinfection.

The importance of the time of contact between chlorine and water for the sterilization of pathogens is an outstanding problem under Chicago conditions where the time interval between the point of application of chlorine in the suction well and the discharge to the distribution system may vary from 16 to 90 seconds. In order to protect the first consumers supplied by mains near the pumping station it is necessary to apply larger amounts of chlorine than would be used if a short storage period were available. Our studies indicate that there is a relatively rapid absorption of chlorine in the water circulated through the distribution system. Each day tests are made at various points in the system for residual chlorine, which indicate that with few exceptions, as in the case of service mains in the vicinity of pumping stations, the quantity of free chlorine in the water is relatively small. In general, there is no serious complaint of chlorine in the Chicago water at periods when Lake Michigan is not contaminated by industrial wastes such as phenols and cresols, which combining with the chlorine gas gives an obnoxious "carbolic acid" taste in the water supply.

Although in Chicago we have probably had as wide a range of experiences with chlorination of water as any city in this country, we really feel that the water purification engineers are seriously handicapped by lack of scientific information available only through research work by the bacteriologist, chemist and physicist. Chlorination as a water treatment process is firmly established but in general is rather crudely controlled. Until such time as a better sterilizing agent is discovered or developed it appears evident that chlorine will have an extended use wherever disinfection is required and we are hopeful that the future in this line may attract research men to a service which offers so much of good to mankind.



LONGITUDINAL SECTION
THROUGH CRIB, TUNNEL & PUMPING STA.

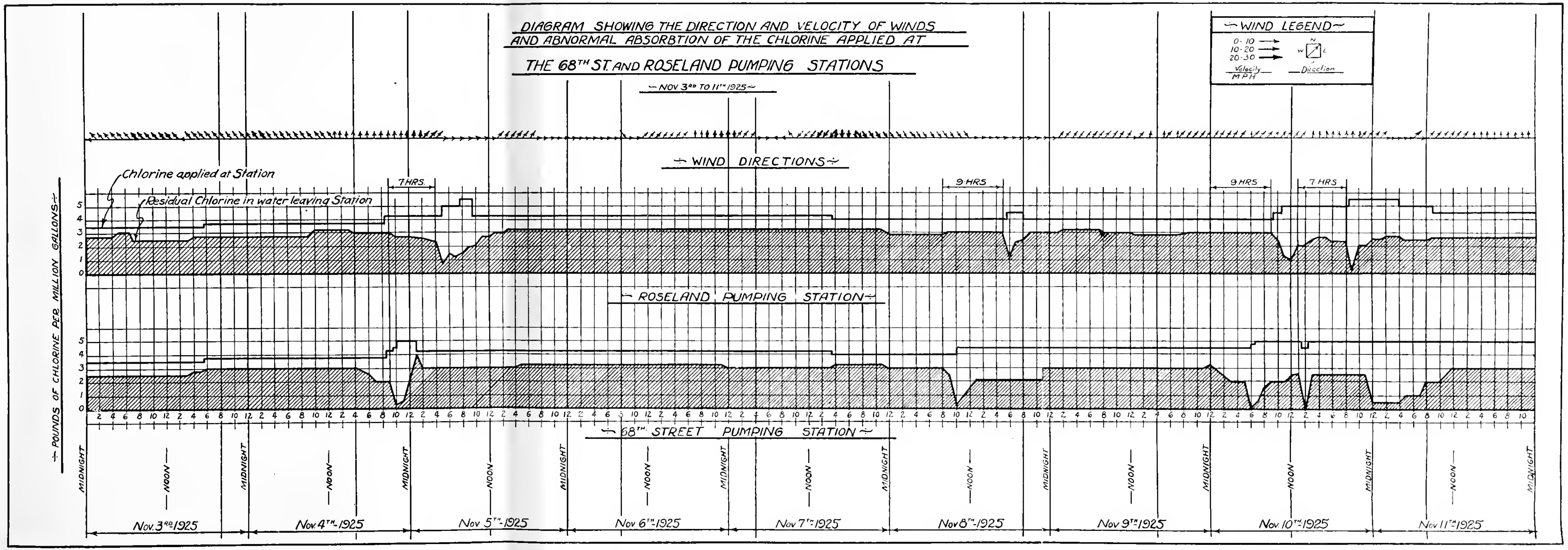
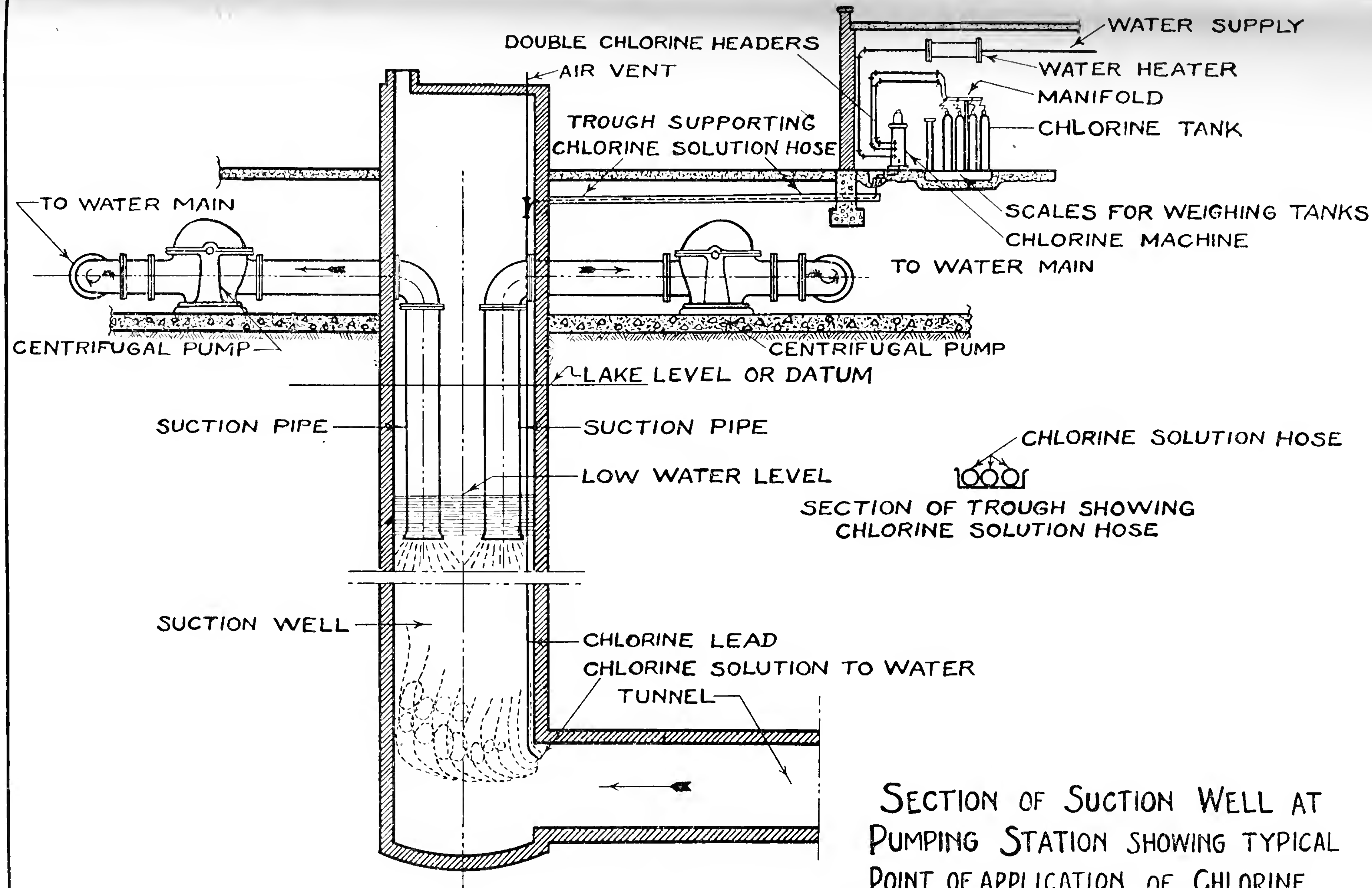


DIAGRAM SHOWING THE DIRECTION AND VELOCITY OF WINDS
AND ABNORMAL ABSORBTION OF THE CHLORINE APPLIED AT
THE 68TH ST. AND ROSELAND PUMPING STATIONS
NOV 3RD TO 11TH 1925
WIND LEGEND
0-10
10-20
20-30
Velocity MPH
Direction
WIND DIRECTIONS
Chlorine applied at Station
Residual Chlorine in water leaving Station
7 HRS.
9 HRS
9 HRS
7 HRS
ROSELAND PUMPING STATION
68TH STREET PUMPING STATION
POUNDS OF CHLORINE PER MILLION GALLONS
MIDNIGHT
NOON
Nov. 3RD 1925
Nov. 4TH 1925
Nov 5TH 1925
Nov 6TH 1925
Nov 7TH 1925
Nov 8TH 1925
Nov 9TH 1925
Nov 10TH 1925
Nov 11TH 1925



SECTION OF SUCTION WELL AT PUMPING STATION SHOWING TYPICAL POINT OF APPLICATION OF CHLORINE

THE ROLE THAT FOOD HANDLERS PLAY IN THE DISSEMINATION OF PARASITIC INFECTIONS.

Bertha Kaplan, University of Illinois, College of Medicine, Chicago, Ill.

O'Connor and Wenyon working in Egypt found the greatest percentage of carriers of encysted Endamoeba histolytica among cooks and prisoners. This may be explained on the basis of unsanitary conditions of the soil as well as of institutions. People working in kitchens become infected with encysted Endamoeba histolytica by handling contaminated vegetables.

However, most of our soil is not contaminated with encysted Endamoeba histolytica, but should there be a carrier among the food handlers, fruit and vegetable salads, as well as various cooked foods, may be contaminated and the diseases readily disseminated.

While it may not be necessary to isolate carriers of encysted Endamoeba histolytica among food handlers in Egypt or other tropical countries where the disease is endemic, the necessity for isolating such carriers among food handlers in our region is quite obvious.

A year ago seven or eight cases of amoebic dysentery occurred simultaneously, or within short intervals of time in one public place in Chicago. The disease was well distributed among the people of that place: two guests, two housemen, one janitor, one policeman, and a cook. Two of those cases terminated fatally.

The simultaneous occurrence of so many cases of amoebic dysentery in one place under climatic conditions found in Chicago led to the suspicion of the possibility of the presence of a carrier or active case among the food handlers. A survey of the kitchen help disclosed the presence of two carriers of Endamoeba histolytica—one vegetable salad girl, one fruit salad girl, and one active case, a night cook. All of them were immediately sent to the hospital for treatment. Since then not a single case of amoebic dysentery has occurred in that place.

Following that the Chicago Department of Health with the cooperation of the University of Illinois College of

Medicine started a general survey of food handlers in all the hotels of Chicago, hospitalizing all carriers of encysted Endamoeba histolytica, as well as of hook-worm infections.

Not only is Endamoeba histolytica transmitted by means of contaminated food and water, but also Ascaris lumbricoides, Oxyuris vermicularis, Trichuris trichiura, frequently Ancylostoma, Nector, Strongyloides, etc.

MIGRAINE OR SICK HEADACHE.

A Sensory Disturbance Due to Protein Sensitization or Idiosyncrasy.

WILLIAM L. BEECHER, M. D., CHICAGO. ILL.

For the benefit of the non-medical portion of my audience I will state that the term migraine or sick headache is applied to a combination of symptoms of which the headache is only a part. There are frequently premonitory symptoms by which the patient knows an attack impends. Among these are flashes of light and other disturbances of vision. Dizziness occurs in some cases. Palpitation of the heart at times precedes the attack and in some cases even seems to substitute for the headache. Some patients are greatly depressed and some are very irritable before the attack begins. The headache, as a rule, follows a short time after the premonitory symptoms appear. The pain usually begins in a small spot, more or less constant in location for each patient. It may be on the forehead, the temple or the eyebrow. It is usually confined to one side of the head, but may be frontal or invade both sides. The pain spreads gradually until it reaches the neck when the nausea usually begins. The pain may be severe or mild and the nausea likewise. There is much prostration, in fact few affections are more prostrating. During the attack the patient may not be able to raise the head from the pillow. Noise or light aggravates the condition. The duration of the attack is variable but is usually constant in the individual. The disease recurs for years, but in some cases ceases to trouble so much after fifty years of age. Severe cases may persist throughout life. The usual medical treatment of migraine has been entirely unsatisfactory, except that more or less relief of the acute attack was usually possible. In the past all treatments designed to prevent attacks failed in the majority of cases. In the light of the probable anaphylactic basis of the condition it seems possible that when the treatments did seem to help it was because the case was not true migraine.

In advancing allergy or protein sensitization as a cause of migraine I do not wish to be understood as claiming that all "sick headaches" are allergic. Certainly many cases diagnosed as migraine have been relieved by the oculist's skill. Some have found relief after nasal or other operations; some by attention to the gastro-intestinal tract. In the operative cases and the gastro-intestinal cases it is probable that some were allergic reactions from bacterial or other foreign proteins.

After all these cases are eliminated from consideration there remains much the greater number of cases that are not relieved. These cases are, I believe, mostly if not entirely due to food sensitizations.

In the consideration of cases as possibly anaphylactic, an earnest effort was made to eliminate all but true migraine. Not all headaches accompanied by nausea are migraine. The so-called "bilious headache" is an example. Pituitary headache and the headache at menstrual period, which is probably often a pituitary disturbance, are often mistaken for migraine. These were eliminated.

It is now conceded by medical men that asthma, hay fever and urticaria are due to protein sensitization or allergy. In these diseases we find a definite hereditary tendency, not always to the same disease, but to some one or more of the group. In taking the family history of patients suffering with asthma, hay fever, or urticaria I have found a remarkably frequent history of migraine in some one or more members of the family. Likewise in taking a family history of migraine cases I have found an equally frequent history of some of the well recognized allergic diseases. In each condition a positive family history of allergy can be found in about fifty per cent of the cases.

Migraine, like asthma, is paroxysmal in type. It frequently recurs with great regularity, often coming on the same day of the week. Patients find that much the same factors predispose to an attack, viz. emotion, fatigue, loss of sleep, etc.

French medical authors have led in the claim that migraine is an anaphylactic disturbance. They have reported some success in treatment by giving peptone by mouth for its non-specific effects. In many cases it is successful but must be given continuously in most cases. When stopped the old condition recurs rather quickly. J. L. Miller and others in this country have reported some success by the hypodermic use of peptone. It frequently fails and practically all patients relapse soon after stopping treatment.

Results of Protein Sensitization Tests

Additional evidence for the anaphylactic basis is furnished by protein sensitization tests and results found by acting on the information gained by that means. I have found that a careful testing of cases almost always gives a reaction to some food substance. At times multiple reactions are had, sometimes single. The reactions are not so well marked as in other allergic disturbances and are frequently different in appearance from the ordinary reaction as generally accepted. This is, I believe, the reason why others who have made these tests have not had success.

Finding substances to which the patient reacts does not, of course, prove that they are the cause of the headache. They may be the cause of some other disturbance of which the patient makes no complaint. However, if we eliminate the foods from the diet entirely and the headaches fails to appear as usual we can begin to suspect that we have found the cause. After a sufficient period of time I advise patients to resume eating the food or foods. Usually this brings on an attack rather quickly. If so, the foods are again eliminated. As a rule the attacks stop again. In case of multiple reactions an attempt is made to find which one is really the cause of the attack.

During the last three years I have had quite a large number of cases which I have tested out more or less completely and have had opportunity to follow up for final results. The results have been so very good that I believe all severe cases should have the tests made to discover the cause if possible. In addition to my own work I have had a verbal report from another specialist in allergic diseases that he has had results comparable to mine.

To illustrate the wide variety of foods causing the trouble I will cite a few typical cases.

Case 1.—W. B., male, age 54.

Family History: Mother had some asthma in later life. One sister had attacks of asthma or migraine, one substituting for the other. One period of several years elapsed without asthma, but with regular migraine attacks, followed by a period of one and a half years of asthma, without migraine. As a rule the attacks are more or less alternated. Another sister had very frequent attacks of migraine.

Patient's earliest recollection was of having headaches often. For the last twenty years attacks were regular and weekly, usually on Sunday, lasting for either twelve or eighteen hours. Frequently attacks came on during the week. Tests showed only a slight reaction to wheat. The complete elimination of wheat resulted in stopping all attacks for a period of seven weeks. A break in the diet at that time caused a mild attack. A resumption of the diet gave four weeks of relief; then another mild attack after eating a small amount of food containing wheat. After a further period of about a month a full diet of wheat was advised with a quickly following headache. A densitization was attempted but never fully carried out. At present the patient reports he only has attacks when he indulges in too much wheat.

Case 2.—A. E., male, age 27.

Family History: Father had asthma.

Patient began to have migraine at about sixteen years of age. At first attacks were only once or twice a year; now more frequently, once a month or so, but irregular in time. Pain was so severe that patient said if he did not get relief he did not care to live. Attacks lasted one to three hours. Tests showed a slight reaction to onions. Elimination of onions from diet seems to have permanently stopped the attacks.

Case 3.—S. M., female, age 18. No family history of allergy. She had headaches for last two years which she believed were caused by milk, cream or butter. Attacks began one to three hours after eating. Formerly she had daily headaches which were relieved by glasses. Sick headaches lasted for a variable time. Tests were all negative except "suspicious" to wheat and positive to tuna fish. Patient was advised to eliminate tuna fish from diet. She returned in about three months and stated that she had tried eating tuna fish and that each time she promptly had an attack. No attacks had occurred except when she had eaten the fish.

Case 4.—Mrs. P. H., age 51. Family history negative. Attacks began when thirteen years of age and at that time were almost daily. More recently attacks were variable in occurrence but from one to three times a week. Tests showed a sensitization to egg and veal. Elimination of these stopped all attacks for five weeks and then an egg was eaten. An attack promptly followed. She had no further attacks unless eggs are eaten in some form.

Case 5.—Female, age 30. Sister has hay fever. Patient also has fall hay fever. Has had migraine only last few months. Attacks come on one to three times per week and are very severe, with profuse vomiting. Tests showed ragweed as a cause of the hay fever and also a sensitization to olives. Elimination of olives stopped all headaches.

Conclusions

Migraine occurs sufficiently often in the family history of patients suffering from diseases of known allergic origin to make it probable that there is an allergic basis for the condition.

Protein tests in migraine cases shows in a majority a reaction indicating a sensitization to some food substance, the withdrawal of which from the diet stops further attacks.

Medical treatment directed towards prevention of attacks of migraine has so generally failed and the condition interferes so much with the patient's welfare that any means which promises relief should be tried.

Migraine treated as an allergic disease gives results so generally good that physicians are urged to cease saying that nothing can be done and to adopt this method in order that they may bring relief to their patients.

DIPHTHERIA IMMUNIZATION

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Since the discovery of vaccination against smallpox by Jenner it has been the ideal of far-sighted physicians to devise an equally simple and effective protection against the other plagues of mankind. The "Golden Age" of bacteriology in the last quarter of the 19th century, with the rapid discovery of the causative germs of such diseases as anthrax, tetanus, diphtheria, typhoid fever and cholera, gave promise that this dream was about to be realized. Prevention, however, has lagged behind the discovery of cause. In two diseases only have the earlier hopes been even approximately realized—typhoid fever and diphtheria.

The conquest of typhoid fever during the World War by preventive vaccination is too well known to require more than passing mention. Suffice it to say that where in former wars typhoid fever was usually more deadly than bullets, in the past war it was practically unknown among vaccinated troops. In diphtheria immunization the results have been less striking only because the disease is less epidemic in character and the work has been done in civil populations where immunization cannot be required of all members of the community.

Since the general use of antitoxin, about 1900, diphtheria has been a curable disease. Practically all cases that are recognized promptly and given adequate doses of antitoxin recover. A substantial number of children still die of diphtheria on account of failure to recognize the disease in time, and in spite of an available specific cure diphtheria is still the most deadly contagious disease of childhood. In Illinois alone some 4,000 to 5,000 children a year contract diphtheria; of these approximately 500 die and many more suffer lasting injury. The economic loss has been reckoned at half a million dollars per year. During the past winter an especially malignant form of diphtheria has been prevalent and up to the present time nearly twice as many deaths from diphtheria have occurred as occurred during the corresponding months of last year. Clearly quarantine and antitoxin treatment are not sufficient to control diphtheria; what of protective immunization?

In the city of Auburn, New York, immunization with toxin-antitoxin was begun in 1922. In that year 58 percent of the school population was immunized. In 1923 among this 58% only one case of diphtheria occurred and no deaths. Among the 42% unimmunized 80 cases of diphtheria, resulting in 13 deaths occurred. In 1924 only six cases and no deaths occurred among the unimmunized children and in 1925 only one case and no deaths. Approximately 85 percent of the children of school age are immunized against diphtheria. In New Haven, Connecticut, there has been a decline from 482 cases and 22 deaths in 1921 to 27 cases and three deaths in 1925. In Chicago the death rate from diphtheria has fallen from 24.3 in 1921 to 8.0 in 1925. Syracuse and Rochester have also shown striking decreases in the diphtheria death rate following the use of toxin-antitoxin.

As the name implies, toxin-antitoxin is a mixture of diphtheria antitoxin and the toxin produced by the diphtheria bacillus. Antitoxin gives complete protection against diphtheria for two or three weeks, but after that the patient becomes as susceptible as before. To confer lasting immunity it became necessary to find some process that would more nearly resemble the last protection conferred by an attack of the disease.

In the production of antitoxin horses are injected with increasing doses of diphtheria toxin till their blood builds up a powerful antitoxin to neutralize the toxin. As the toxin alone is very irritating it occurred to Park to mix with it small amounts of antitoxin so that the horses could stand larger doses of toxin. From this beginning the idea occurred: Why not inject people with such a mixture and let them build up a lasting immunity themselves?

As now used the toxin-antitoxin mixture contains just enough antitoxin to not quite neutralize the toxin. In this proportion the mixture is harmless, but stimulates the body to produce its own antitoxin. Antitoxin is manufactured only in laboratories licensed by the U. S. Treasury on recommendation of the Public Health Service. The strength of both toxin and antitoxin is tested on guinea pigs and the mixture is carefully tested for strength and sterility by the Hygienic Laboratory before it is released for use.

Given in three injections, a week apart, toxin-antitoxin will prevent diphtheria in the great majority of susceptible children. The small percentage of children not protected by the first series of injections almost always acquire immunity in a second series of injections of toxin-antitoxin. Since it requires three to six months for full protection to be established, all children treated should be given the Schick test five or six months after the immunizing injections. Any children found susceptible should then be given a second course of toxin-antitoxin.

The question of requiring a Schick test to determine susceptibility before giving toxin-antitoxin is a matter to be decided largely by local conditions. Natural immunity to diphtheria depends chiefly on two things: age and density of poulation. Children under five, whether in the city or country, are generally susceptible. Up to that age it is not worth while to do a Schick test before giving toxin-antitoxin. In deciding this matter Park says: "The decision simply depends on whether, in any given age group or locality, it is more trouble and annoyance to make the Schick test and so omit unnecessary inoculations, or to omit the Schick test and inoculate all children." In Chicago, where all immunization is done in the kindergarten and first grade or in pre-school clinics, the prior Schick test is not required. In either case a Schick test should be made five or six months after inoculation to see if protection has been secured.

The best time to give toxin-antitoxin is from one to two years of age. At that age children are most susceptible to diphtheria and the disease is most fatal. Since over one-half the deaths from diphtheria occur under five years of age, immunization of school children alone is not sufficient to control the disease. If toxin-antitoxin is to be given in schools it should be given chiefly in the younger grades. If the entering class each year is inoculated on admission, an immune school population will soon result.

It is too soon to say exactly how long protection from toxin-antitoxin will last. In a series of immunized children in New York City, 90 per cent were still immune at the end of nine years. In most cases it seems probable that protection lasts for life. Even if the immunity lasts only eight or ten years, children immunized early are protected during the most susceptible period of life.

Probably the greatest obstacle to the general adoption of toxin-antitoxin immunization has been the fear of serious reactions. Two or three accidents in the early days of immunization have led to a groundless fear of the whole procedure, and blinded the eyes of many parents to the deaths from diphtheria constantly occurring. Under the present methods of supervision the occurrence of serious accidents is practically impossible. With the present dosage reactions are limited to local soreness in a small proportion of subjects, which may last two or three days, and a still smaller proportion of cases which show slight fever or headache. In over 1,000,000 injections of toxin-antitoxin in New York State, no permanent harm to any child has ever resulted. In Chicago no serious reactions have resulted from some 300,000 injections.

To summarize: we have in toxin-antitoxin an immunizing agent against diphtheria which is inexpensive, safe and simple to administer, which confers immunity in practically all cases, and which gives protection lasting through the dangerous period of childhood.

With such a protective agent available to everyone, what explanation can be offered for the continued, needless sacrifice of children to diphtheria? Simply the ignorance and indifference which still tolerates smallpox 130 years after the discovery of an equally simple and effective method of prevention. The success of any method of disease prevention depends no less on the undertanding and cooperation of the population than on the perfection of the process. The time has now come when any city can determine its own death rate from diphtheria. There is no question that the general use of toxin-antitoxin immunization in all communities would be the means of saving the lives of several thousand children each year, to say nothing of preventing tens of thousands of cases of diphtheria. The great task at the present time is to carry this message to the parents of all young children. Indifference must be overcome, skepticism and fear dispelled by accurate information until all classes unite in demanding the elimination of this greatest scourge of childhood.

METHODS OF PRECISION IN MODERN MEDICINE.

W. Henry Wilson, B. S., M. D., F. A. C. P.

In discussing the subject of miracles, John Ruskin stated to a group of scientists, philosophers, and clergymen in a London Meeting that he always expected miracles to happen. Like John Ruskin, the great masses of the people are still unconvinced of the reign of law. They believe that many things just happen and that much may be attributed to luck. This is particularly so when it concerns diseases, their recognition and management. The thesis, therefore, that I wish to defend is:

First—During the past few years the methods of physics, chemistry, and biology have been applied to the solution of medical problems with the result that medicine is approaching more and more to an exact science and consequently a successful art. As a corollary to this proposition, I believe that it follows logically that since these methods of exactness require the use of special instruments and special technique, their application requires the cooperative work of several trained men. It is no longer possible for any one man to master and use all of these procedures. It follows, therefore, as second conclusion, that medicine is no longer a one man art. No man can practice this art alone. Third conclusion and one of equal importance is that after all of the scientific methods have been applied in the evaluation of the patient or in the evaluation of his several organs, there still remains the problem which is the most important of all, and that is the bringing together of all accumulated data, assign to each its proper value, give it a final interpretation and above all, determine what should be done. This is the work of the internist.

It was Josh Billings, many years ago, who made the assertion that it is not ignorance that afflicts us, it is knowing so much that is not so. This is true in all branches of thought.

Self criticism is one of the first signs of progress in any branch of thought.

In our most advanced medical groups, self criticism has become very apparent, with the result that every department of medicine is being re-examined and re-valued.

At the present moment there is scarcely a large educational institution in America, that is not making a resurvey of our knowledge of the organs of the body and their functioning, with the purpose not only of determining what their duties are, but also to establish means and methods of estimating these functions. Modern medicine is not so much concerning itself with the administration of drugs as it is to find out exactly how the several organs function, what they contribute to life and defense, and what the causes are that disturb this functioning and how to remove the cause.

Medicine like religion and politics, has it's fundamentalists and modernists. The fundamentalists are those trained under older methods, who have reached their maturity, and who have developed a great personal capacity for meeting the problems which confront them daily. They view with scorn the introduction of newer instruments, such as the electro-cardiograph for measuring the functioning of the heart, the various laboratory methods that assist in the diagnosis of acute and chronic diseases. They assert with much confidence that these new fangled procedures stunt the physician's mental growth and prevent his developing that individual clinical ability which is so much needed in medicine.

The modernists, however, continue diligently in the developing of new methods and new procedures which enable them to do earlier in life and with much greater accuracy what the old fundamentalists could do only after years of experience.

These modern methods of precision have lead to results which are nothing less than startling in their accomplishments. That modernism is justified, I wish to prove to you by pointing out:

First—What it does for accuracy in diagnosis, and

Secondly—What it has achieved in the matter of treatment.

Under the first title, I shall select a single organ or pair of organs with which you are all familiar, namely the integrity and capacity of the kidneys. This problem may be approached in five different ways. In other words, we have available five entirely different methods of testing which may be applied. The first of these is the examination of the eye grounds or retina. It is not infrequent that the first signal of a kidney damaged, is recognized by the competent oculist.

The second method of approach is one of the oldest in medicine, namely, examination of the kidney excretion. This is so well known that it need not be elaborated. A third method of approach is the determination of kidney functioning, and since the kidneys perform a number of functions, we have a group of tests rather than a single test. For example, we may test by means of a high protein diet, the capacity to excrete urea, and other nitrogenous substances. By another diet, we may determine the capacity to concentrate the urine, by still another, the capacity to eliminate water. And finally, by use of a dye, the general functioning capacity of the kidneys. This latter is known as the phenolsulphonephthalein test and has a particular value to the surgeon.

A fourth procedure is the use of the cystoscope. By the use of it, we are able to determine the kind of material which is being delivered. By cystoscoping each kidney separately, we are enabled to secure secretions of each kidney separately, and we are further enabled to determine the functional capacity of each kidney separately.

The fifth method is determining the renal anatomy and renal physiology by use of the x-ray. This enables us to determine the presence of renal stones, frequently renal tumors, the size of the kidneys, presence of cysts, and sometimes the presence or absence of pus or other fluids in the renal pelvis.

Sixth we have a court from whose decision there is no appeal, it is the chemistry of the blood stream. The witnesses are the several substances which are normally present there in small amounts. It is the kidneys' duty to evict all above a certain number of milligrams. No guessing is needed, these substances are determined and the kidneys acquitted or proved guilty of incompetence. With the exception of the examination of urine, all of these have been developed in recent years, and by their combined use, we are enabled to survey and estimate the structure and function of the kidneys with an accuracy that certainly closely approaches that of the other modern sciences in solving other problems. What we are doing for kidneys we are beginning to do for other organs.

Can modernists show an equally gratifying progress in the treatment as compared with the recognition of disease? I believe it can and I shall mention but two triumphs to confirm the statement.

First—The use of the hormone, Insulin in the treatment of diabetes is not surpassed in its far reaching results by any other single modern discovery. It is not a medicine. It is supplying to the patient with diabetes, a ferment, a hormone, a necessary substance which his own organ cannot produce. What is the result? An almost immediate relief from distress, a return to health, a capacity to perform his regular duties, and above all, instead of confronting an early death, he now has prospects of living to the fourth, fifth, or sixth decade. Instead of being a burden to himself, a victim to every mild infection that comes his way, an impossible surgical risk, he can face the world like a man, and live in the hope of seeing many years of happiness. In other words, the use of Insulin coupled with diet which has also been developed by modern science, has added millions of years to lives of human beings.

A second triumph of modern biological chemistry has a somewhat narrower field, but is no less dramatic. There come to every large contagious hospital, victims of diphtheria, who have been neglected by virtue of ignorance, indifference, or poverty. They are usually received in a dying condition. Either they are found bleeding from the mouth or nose, or their necks are girdled with lumps. In either case, death is an equal certainty. During the past year, at the City Hospital at Cleveland, the blood chemistry of these patients, was studied with great care. It led to the discovery in all of the victims that the blood sugar was extremely deficient, amounting sometimes to one-fifth of normal. Since the blood sugar is a necessary food for muscle tissue and especially for heart muscle tissue, the conclusion was reached that it might be of service to these hopeless victims to administer a solution of sugar intravenously. This was immediately tried with the result that out of 80 cases, 44 were saved.

I know of nothing more dramatic or more inspiring in all history, and yet the adoption of a litter of skunks by a mother cat received one thousand times more publicity.

By the free use of the methods of precision developed in chemistry, physics and biology, medicine is becoming a precise art with a mathematical foundation. Personal equations are diminished and the recent student stands, as it were, on the shoulders of the fathers.

These methods of precision require special trained physicians (not merely technicians) in each fundamental branch. Consequently medicine is no longer a one man job but requires the cooperation of several. This is particularly true of personal health surveys, health surveys which require the recognition of disease in the very incipiency. The one man health survey is of small value.

The greatest advances made in treatment have come through applied biochemestry as noted above.

Since diagnosis and treatment can no longer be carried out by one man alone the medicine of the future must be more and more an institutional function.

PAPERS IN PSYCHOLOGY AND EDUCATION SECTION, JOLIET.

A STUDY IN THE PREDICTION OF SCHOLARSHIP.

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Many lines of investigation in the problem of predicting college scholarship have been followed. The possibilities of estimating at the time of entrance a student's academic success in college, on the basis of physical and sensory traits, of high school grades, of entrance examinations, and of intelligence test scores have all been tried. Predictions based upon physical and sensory traits alone have proved of slight value, and those depending upon high school grades, entrance examinations, or intelligence test scores possess a large element of error. College scholarship undoubtedly is the resultant of many forces and influences, and any single factor will scarcely serve as a basis for an accurate prediction. There is the possibility, however, that a combination of measures, none of which shows a particularly high relationship with scholarship, might enable us to predict scholarship with greatly increased accuracy. The technique for making such a combination is the method of multiple correlation. It may be stated at this point that the chances for a high multiple correlation coefficient are best when each of the measures entering into the combination exhibits a fairly high correlation with the criterion, in this case college scholarship, and a low correlation with one another. Our problem, then, is to determine the factors which influence scholarship, and to make the best combination of these factors for its prediction.

The present study was made to determine the accuracy of predictions of college scholarship made on the basis of the best combination of measures which were available in the case of students of Ohio State University. It was recognized that there are other factors influencing scholarship which were not found among those available for this study. Measures in fourteen factors were secured for each of 416 students selected at random from the class of 1925 of the College of Arts of Ohio State University.

Six of these measures were in physical traits and the zero order correlation coefficient of each of these traits with college scholarship was as follows: weight, minus .12; chest expansion, minus .02; lung capacity, plus .02; height, plus .07; pulse, plus .13; vital index, plus .13. None of these coefficients indicated a close relationship with scholarship, but it was possible that measures in one or two of these traits when combined with measures in other traits might serve to increase the accuracy of the prediction appreciably. The other traits correlated with scholarship and the coefficients of correlation were as follows: age, minus .07; number of units of high school work, plus .21; the total of all high school grades, irrespective of whether the number of units was the same for all students, plus .44; average high school foreign language grade, plus .50; intelligence test score, plus .51; average high school English grade, plus .53; average high school mathematics and science grade, plus .54; average high school grade, which included all subjects, plus .57.

While several of the above correlation coefficients may be regarded as fairly high, it is quite apparent that predictions of scholarship based upon coefficients of such magnitude will in many cases prove to be considerably in error. The next step was, therefore, to determine whether these measures, when combined and weighted in the best possible manner, would permit more accurate predictions of scholarship. The multiple correlation and the multiple ratio correlation techniques, explanations of which may be found elsewhere,[1] were used in answering this question. It was noted just above that the zero order correlation coefficient between college scholarship and the average high school grade was plus .57. Beginning with this measure, which correlated highest with scholarship, which of the remaining measures when combined with this first one will yield the highest multiple correlation coefficient? The measure found to do this was the intelligence test score, the multiple correlation coefficient between scholarship and the best weight-

[1](a) Yule, G. U. An Introduction to the Theory of Statistics, p. 248. London, Charles Griffin and Company, 1922.

(b) Clem, O. M. Detailed Factors in Latin Prognosis, p. 27-28. New York, Teachers College, Columbia University Contributions to Education, No. 144, 1924.

(c) Garfield, Evelyn. The Measurement of Motor Ability, p. 18-20. New York, Archives of Psychology, No. 62, 1923.

ed combination of the average high school grade plus the intelligence test score being plus .648. After these two measures were used in combination as a basis for predicting scholarship, to what extent did the addition of a third measure to the combination serve to raise the correlation coefficient? Of the twelve remaining measures, the one which made the greatest contribution to the two already being used was the vital index. The correlation between scholarship and the best weighted combination of the average high school grade, the intelligence test score, and the vital index was plus .654. Furthermore, the addition of all the remaining measures to the combination served to raise the correlation only to plus .665. That is to say, when a prediction of college scholarship is based upon the average high school grade and the intelligence test score, its accuracy is not appreciably increased even though all of the other twelve variables included in this study are taken into consideration.

It was also desirable to ascertain the relationship between these various measures and college scholarship when all the other factors were held constant. This was done by means of partial correlation. The results indicated that the closest relationship of college scholarship was with the average high school grade and the intelligence test score when the older factors included in the study were held constant. The correlation coefficient between college scholarship and the average high school grade, where the zero order correlation was plus .57, became plus .47 when the influence of all the other factors had been eliminated. In the case of college scholarship and the intelligence test score, where the zero order correlation coefficient had been plus .51, the correlation when the other influences had been ruled out by partial correlation was plus .38. Of the remaining factors, the highest partial correlation with scholarship was found in the case of the vital index, the coefficient being plus .12. It is thus apparent that both the average high school grade and the intelligence test score are unique in their relationship with scholarship. Only these two factors each showed a fairly high correlation with college scholarship when the concomitant influence of all the other variables was eliminated. Each of these two measures supplied a factor for the prediction of college scholarship which could not be gained from any of the other variables included in this study. Furthermore, as might be inferred from what has just been said, the data revealed that the presence or absence of either of these two measures significantly affected the accuracy of the estimation of scholarship.

The next step was the writing of the regression equation by means of which the college scholarship was predicted on the basis of the best combination of the average high school grade and the intelligence test score. This equation was as follows: $X_1 = 3.58\ X_2 + .46\ X_3 - 268.2$. In this equation X_1 is the scholarship score which is to be estimated on the basis of X_2, the average high school grade, and X_3, the intelligence test score. It may be stated here that the scholarship score was the average number of honor points earned per year when each quarter hour of A grade work counted four such points; B, three points; C, two points; D, one point; and E, no points.

Several illustrations will serve to make clear the use of the regression equation in making the estimates or predictions of scholarship. Student A entered Ohio State University as a freshman at the same time as did the group included in this study, but he was not one of this original group. A's average high school grade was 75.5; while the mean of the average high school grades for the group included in the study was 85.4, and the standard deviation 5.2. A's intelligence test score was 92; the mean of these scores for the group was 109.6, and the standard deviation 30.1. Using the regression equation, it was found that A's predicted average number of honor points per year was 45.2. Since a student at Ohio State University carries ordinarily about sixteen hours of work each of the three quarters of the year, this means that a prediction of an average grade of approximately D would be made for this student. A's actual achievement in scholarship turned out to be 55.5 points, which was very close to the predicted score.

In the practical situation of predicting scholarship, however, the scores which would subsequently be made would still be in the unknown future at the time of prediction. It would therefore be important to have some notion at that time as to how accurate the prediction will prove to be. This information is given by the standard error of estimate or the probable error of estimate. The probable error of estimate, when the prediction was based on the average high school grade and the intelligence test score, was found to be 21.7 points. This means that the chances are even that the actual score will be within 21.7 points of the estimated score. When estimates of scholarship were made for thirty additional students by means of the regression equation which was derived in this study, and these estimates were checked with actual achievement scores in scholarship, it was found that in seventeen of the thirty cases the error was less than the probable error of estimate.

In predicting college scholarship, how serious is an error which is equal, for example, to this probable error of estimate? Suppose that an entering freshman student has an estimated scholarship score of 96 points. Assuming that he carries sixteen hours of work each quarter, this means that his predicted average grade is C. The chances are even that he will actually earn not less than 74.3 points, nor more than 117.7 points; or to state it somewhat differently, the chances are even that his grade will not be lower than a combination of grades C and D, in which the C's predominate (for example, 27 hours of C and 21 hours of D), nor higher than a combination of grades C and B in which the C's again predominate (for example, 27 hours of C and 21 hours of B).

Another illustration may be presented which involves the regulation of Ohio State University that students failing to make an average of 1.8 scholarship points for each hour of work carried (an average slightly below C) during the first three years are to be dropped from the university at the end of the third year. Assuming a schedule of sixteen hours of work, this means that a student must make a total of 86.4 scholarship points per year. Suppose that the estimated scholarship score for a given student who will carry sixteen hours of work is 65 points. It will be noted that this is almost exactly one P. E. distance, 21.7

points, below the minimum required. What is the probability that this sudent will meet the minimum requirement, in spite of an estimated score of only 65 points? The chances are even, it has been stated, that his actual score will vary 21.7 points or more from the estimated score. However, there is as much probability that this variation will be in the direction of a lower score as in the direction of a higher score. Consequently, he has one chance in four of meeting this minimum requirement; or, of four students for each of whom a score of 65 points is estimated, one only may be expected to make a score as high as 86.4 points.

Another student who has a percentile intelligence rating of five, or an original score of 60, and a high school record better than that of sixteen percent of entering freshmen at Ohio State University, presents himself for admission. That is, his average high school grade, which is 80.2, is one standard deviation below the mean. Accordingly, his predicted scholarship score is 47.1 points. This is 39.3 points, or 1.81 times the probable error of estimate, below the minimum required of a student with a schedule of sixteen hours. He has but eleven chances out of one hundred of meeting the standard of 1.8 honor points for each hour of work carried.

The data which have been presented do not of course answer the question as to whether such a minimum requirement of an average of 1.8 honor points per hour of work, or some similar regulation, is or is not a desirable requirement. Neither do they answer the question as to whether, if it were possible to determine at the time of application for admission those students who will, to a high degree of probability, fail to meet such a requirement, such students should be denied admission. The data do, however, permit an estimate of college scholarship which may be accompanied by a statement of the probability that the actual accomplishment of the student will vary from this estimate by any given amount.

It seems evident from the data presented that admission to college should not be based alone upon an intelligence test rating. Even where the purpose of the college or university is to admit only those students who will achieve a certain degree of success in scholarship, this object can be attained more satisfactorily if other criteria in addition to the intelligence test score are used. Certainly, to such a score some measure of high school scholarship should be added. The present study has shown that either of these two measures taken singly does not result in as accurate a prediction as the inclusion of both will give. On the other hand, if to the combination of these two factors any or all of the remaining measures included in this study are added, the accuracy of the prediction is increased scarcely at all.

SOCIAL WORK AND HUMAN REMAKING.

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Consider for a few moments such varied types of human beings as the Shelton Brothers, Leopold and Loeb, Thomas Edison, Babe Ruth, Henry Ford, Jane Addams. These are but samples that express the variety which is endless. We might go on and show hundreds of types of personality. Why is there so much difference between human beings? Is there anything that can be done about it? We take it for granted that certain types of personality, such as were represented by the Shelton Brothers, Leopold and Loeb, are not socially desirable, and that the world would be better off if in future generations these types can be eliminated.

What is this thing personality that differs so in various individuals? Does it change? If it does, can these changes be made to take a certain direction?

There are those in this country who say that heredity is the cause of all these differences, others that environment accounts for everything. The evidence of modern psychology and sociology and the evidence of our own common sense points to the fact that personality as it is in any individual at any particular time is the result of a combination of the hereditary forces and the environmental forces. What any individual is today is due to the moulding force environment on the physical entity of the body, the mind—all that was inherited. Heredity gave us the potentiality, the crude clay upon which the forces of environment have worked and moulded the combination that we find at the present time.

Personality is an all-inclusive term that describes any individual. It includes everything that he is—his physical being, his ideals, his habits. It is better in understanding personality to make "habit" include not only those things that we ordinarily speak or as habits, but to include all actions that have been learned and represent the response of that individual to different kinds of situations. We have our work habits that include many minor habits that are very complicated, and differ according to the kind of work that each of us may be engaged in. We have our father habits, our mother habits, our church habits, our citizenship habits, recreational habits, sleeping habits. Pervading all of these what may be called our thought habits, for our so-called mental activities are as subject to certain ways of doing things that we have learned as any habits. Of great importance are emotional habits. The term habits as we shall use it then in conjunction with personality describes the sum total of man's responses to his environment at any particular time, and are the means of measuring the personality, of describing the kind of man.

It is easy to observe that from the period of birth throughout life habits are developing in response to outside forces, a response of the hereditary tendencies of forces with which we were born. Since no two individuals are born with exactly the same hereditary forces and since no two individuals have exactly the same environmental forces acting on them, we see the reason why none of us are alike, and why we have the differences in personality indicated by the few names that were presented at the beginning of this talk.

Further, we see that with this view personality is a continually changing thing in any individual. We have only to look back into our own lives a few years to see the changes that have been made. These changes are evidenced by new habits that we have developed, old habits that we have dropped. Usually the changes are gradual and slow, but like the weather, they may be sudden and catastrophic. We have all of us seen a person that has been so changed in a short time that we wonder. Whether the change is slow or rapid, it may be a change for what we call the better or the worse—meaning by better that the change has been in a direction that we approve, and for the worse in a direction that we disapprove.

What kind of forces are those that are particularly significant in shaping personality? First are the bodily changes due to growth and the reaching of maturity; particularly striking are those attendant upon the sexual development of the early teens. The bodily changes are not subject to much control. How we shall grow depends chiefly on our heredity and the nature of this is evidenced by the responses we make to certain kinds of environment. Second, and of particular interest to us, are the environmental or external forces that bring about changes in personality. In childhood these are primarily the home, parents, brothers, and sisters, the neighborhood, playmates, and later on the school, the church, the playground. With age the circle of environment gradually widens until it includes all of the complicated stimuli that affect the adult. During the adolescent period comes the powerful play of ideals in shaping personality. Ideals are an external force depending on the personalities of other persons with whom one comes in contact, not only in the neighborhood, but in the community, the nation, and to a considerable extent, the whole world, as evidenced by the recent world war. Love, courtship, marriage, birth of children, rearing of children, sickness, death are among the most powerful of the environmental forces.

Would there were time to trace in some detail the kind of things that happen to personality from year to year, or to take some individual and follow up his personality changes from childhood to maturity.

The significant thing is that all through life the human being is subject to the interaction of the internal forces that represent heredity and growth, and the external forces. To illustrate simply, there are not only sounds all about us, but our sense of hearing is reaching out at all times to capture those sounds; there is not only work to be done, but our hands and bodies are eager and reaching forth to perform the things that are waiting to be done. There are not only community points of view, ideals, and customs, but we have natures that are reaching out to accept these and make them part of ourselves.

As was indicated, the internal forces are not subject to control except through outside forces that play on them. We can hear only the sound waves that reach our ears; we can see only the things that are within the range of our eyes, we can do only what we have learned to do with our hands or our bodies, and our thinking, our ideals follow the patterns that have been set for us by outside forces.

The trouble with the external forces is that they are not designed to meet individual pecularities, individual needs whether of strength or weakness. The human beings living in the latter part of the eighteenth century never intended that Napoleon's skill in manipulating human beings and managing wars should result in such wide-spread suffering, such national changes, such an upset of Europe as occurred.

Man has learned, however, that he can change and control some of the external forces and bring about thereby conditions that improve the human being, in other words, a personality change in an approvable manner. Take for example conditions of employment, methods of education, public recreation. These are environmental forces that are applied to groups and by group methods, and thereby affect the individual. Many other forces are, however, as yet seemingly beyond our control, particularly the customs and ideals, which are continually changing but not according to human plan. There are, for example, many persons who would prevent war, but they do not have the power to do so. It is also evident that in addition to influences on groups by social changes, one may deal with individuals in certain parts of his environment to bring about valuable personality changes in the individual. This is usually done by one individual for another, the parent for the child, the clergyman for those who come to him for help, the doctor for his patient. These efforts to change personality are usually limited in their intents and effect. The doctor is concerned with building up health rather than changing the personality in a certain way. The changes may occur indirectly. The parent who has a wayward boy is usually unable to handle that situation unaided. He may, however, by sending the boy into a new environment, such as a particularly good school, bring about a development of new habits that break up the ones that were classed as wayward. The clergyman approaches from his point of view the problem of the individual, dealing particularly with the religious life, although very frequently he goes much further.

Some months ago a former criminal, known as Black Jack, wrote a biography entitled "You Can't Win." It is an excellent demonstration of how personality is swayed for the worse by environment, and how finally the efforts of one man who interposed personal kindness and new environmental opportunities, broke up all of his habits of law breaking, and made him a law abiding citizen. Although this reformer was not a social worker by profession, he used the methods of social case work.

We have noted a number of the chief environmental forces that create personalities. We have pointed out that their action does not take into account individual differences. Unfortunately, some of the same external forces will produce different personalities in different persons, and because of their failure to take into account differences in individual adjustability we have created a large class of dependent, inefficient persons, parasites, law breakers, those who are chronically sick mentally and physically, and those who have bad habits that sometimes produce serious effects, such as reckless drivers, drinkers of bootleg liquor. We have noted that some of these external forces can be controlled and made better adjusted to the needs of individuals, that by social action changes have been made in the industrial, educational, public health and hygiene, and other fields which have reduced the number of individuals that have suffered from them.

Social work is the organized effort of society to adjust environmental forces in order to improve personalities. Part of this is done through group effort. In this program approved ideals, interesting educational programs, recreational and other projects are given to groups. Examples of this type of social work are found in the Y. M. C. A., Y. W. C. A., Boy Scouts, Girl Scouts, City Recreation programs. Not all of the individuals who are brought under the influence of these efforts are benefited thereby, because there is a lack of individualization. It does not fill the need of everyone, and considering the diversity of personality, it can readily be understood that no set program or group work can reach everyone.

There is another type of social work which deals with the individual as a specific problem. Here the personality of the individual is studied in relation to the environmental forces that are acting on him and have acted on him, and the attempt is made to change his external forces, to build up new ways of living which include the development of new habits and throwing off of old habits that are bad.

This is known as social case work, and is the method followed by family welfare organizations, children's welfare and aid societies, juvenile courts, mental hygiene workers, and others who deal with individuals rather than groups.

For example, a mother with two daughters was found living in a hovel, filthy, badly furnished. The mother was drinking heavily and was using her children to beg and steal in order that she might get the means of providing herself with a sufficient quantity of liquor. The social case worker made a diagnosis. There were two forces in the life of this woman which offered promise. These were her fondness for her children and the fact that she had some relatives who were well adjusted to life. The children were immediately taken away and placed in an institution. The mother was also placed in an institution where she could be removed from the temptation of liquor and given training in housekeeping and work. She was put on probation in order that she might put herself in a position where her children might be returned to her, and a home of their own established. It took six or seven years of effort on the part of the case worker to achieve this result. She did it by a skillful control of the environmental forces playing on that woman and her two children. The family is now living in a neat little home that they are purchasing, the younger daughter doing well in school, the older daughter working and about to marry a substantial young man, and the mother living a satisfactory life in friendly relation with her neighbors, relatives, and her church.

We cannot take time to describe the elements of case work in detail. It is still in its infancy, but it is a rapidly developing child, not only in the amount of work it is doing, but more significantly in the technique and science that are the basis of its action. It must find out much more about the relationship of the forces that go to make up personality. It must find out much more about the control of forces that are developing bad personalities and good personalities and how to overcome them. Since social case work must use, to accomplish its results, the achievements of the medical profession, of education, of industry, of religion, of psychology, or sociology, its advance is dependent on the advance of the sciences underlying those activities, and the opportunities they afford for application to individual instances.

Case work is the most complicated of human efforts since its attempts to take into account personality and environment in which it lives, and the possibilities of other environments. In the not too distant future it should be possible for any individual who is in trouble to go to a professional case worker and have his personality straightened up as it is now for a person having appendicitis to have that taken care of by a surgeon, and just as the science of medicine has made it possible to reduce the number of persons suffering from typhoid fever, so it should be possible for case work to furnish information which would enable society to largely reduce the number of persons who are dependent, who are law breakers, who are inefficient.

It is fortunate that the American public has shown so much interest and given so much encouragement to the development of the profession of social case work. The returns up to the present time are not great, but the effort is well worth while, because of the possibilities that lie within it, even though these are possibilities that will not be realized by this generation or the next. It will possibly never be the means of remaking the human race, but it does offer the possibility of remaking many of the individuals who under the present condition of living are unable to make their own lives satisfactory to themselves or their friends or the community in which they live.

PAPERS IN HIGH SCHOOL SCIENCE SECTION, JOLIET.

A RITUAL AND OTHER DEVICES FOR HIGH SCHOOL SCIENCE CLUBS.

LOUIS A. ASTELL, WEST CHICAGO COMMUNITY HIGH SCHOOL, WEST CHICAGO, ILLINOIS.

Because the universe—its mysteries, its allurements, its beckonings—will never let us alone. —Albert Wiggam.

From time to time the question of the relative scarcity of high school science clubs affiliated with the State Academy has presented itself to me. Recent communications from the chairman and the state secretary have served to indicate the possibilities of the ritual and other devices with reference to this particular problem. The matter of creating an appeal to those whose best interests such affiliation would serve—that is, to the high school science instructors and students—must begin with a demonstration of practical values.

Possibly the devices I am about to discuss are being used in other science clubs. In any event, it is not intended that they be considered either new or original. If, however, the applications of the ideas, as suggested, serve in any way toward a more numerous group of affiliated science clubs, I shall feel content. The specific devices which I shall consider are standardized club pins, standardized cards of membership credentials for individuals, and a standardized ritual to include illustrative material. These three devices, in some form, have been employed in the two clubs with which I have been identified. The results, it may be said, were sufficiently satisfactory to warrant their use again, should nothing more appropriate be available.

The first club to which I have just alluded was organized in a more or less isolated community some six years ago. Certain incidents preceding its origin indicated the need of considerate action on the part of any one who attempted to present scientific conceptions to the students there. The idea of the ritual as it was developed, then, may be accounted for in terms of the rule of causation proclaimed by the ancient Leucippus, "Nothing happens without a cause, but everything with a cause and by necessity."

My primary objective at that time was to illuminate a peaceful path between science and religion. It may also be noted, however, that through such a plan it is easy to establish something of the ethics of science and something of its humanism as well as its material benefits, thereby approximating to a more accurate degree the totality of the needs of those who think to travel by its light.

The objectives of citizenship and life interests as concrete examples are easily encompassed by the ritual. The significance of citizenship is being appreciated more and more by educators. Elementary science text books are being built around that essential of human welfare and progress. Such texts may serve well for the time allotted to work, but what of play? Not every boy has the opportunity of being a scout; not every girl has the privilege of being a member of a camp fire organization. Even if they could be, there is still no assurance that they would find in such activities exactly what each needed in this respect. Spencer points to this when he says that to educate rightly is not a simple and easy thing, but the hardest task which devolves upon adult life. Through the ritual and in the presence of the symbols of citizenship accompanied by appropriate interpretations of them, the student may become better acquainted with an adequate appreciation for the traditions and institutions of our democracy. He may also satisfy certain life interests and values for which he is as yet ineligible without indulging in objectionable secrecy. High school students of today have some idea of formal and informal initiations that enter into collegiate fraternities and other (adult) fraternal orders. Sociology indicates that a desire for such activities is more or less instinctive. Furthermore, the use of the ritual in science club work may, through the psychological principle of substitution, help to prevent any tendencies toward the establishment or growth of illegal high school organizations that exist by virtue of carefully planned and executed alibis. The conceptions of good citizenship and life-interests as correlated with the spirit of science have appreciable possibilities.

A standardized ritual worthy of use in clubs affiliated with the Academy would require some effort to prepare. Once completed, however, it should be of real value, particularly if supplemented by carefully edited illustrative material in the form of a series of opaque pictures for use in suitable projectors, films, slides, and the more convenient film-slides. In these three forms almost every possible demand for "picturization" could be met. In the second club with which I have been identified, opaque pictures were used and supplemented by films bearing on the life of Edison whose name was selected to designate the organization. If care is taken in selecting names for the local organizations, much supplementary material in the form of films that will add a further note of interest to the work may be obtained. In many instances such films may be had from industrial and other sources for express charges. Lists of these films with synopses and sources would be advantageous. The series of opaque pictures, the slides, and film-slides should—under specified conditions—be available for loan from the Academy to the affiliated clubs for use in the initiation ceremonies.

A standardized card for membership credentials for each individual should bear a statement of affiliation and also the signatures of the state officers as well as provisions for a counter signature. The ritual and the card, together with the standardized pin, linking individuals and clubs alike, would—it is believed—serve as a further incentive toward increasing the number of clubs. Certainly the dignity of these measures is at once apparent, and the pride necessary to the growth of any institution is apparent as a natural and unescapable consequence.

To reach the instructors, who must in the end sponsor the clubs, may be rather a difficult problem. Science teachers, as a rule, are busy with such a multitude of details that only those who have attempted the work of organizing and conducting simultaneously several courses in science can appreciate the view taken toward the added responsibilities. Yet science teachers, I think, are as quick to recognize values as any other group. If they could have the assurance that distinctive materials for the development of a science club were easily available, this fact would constitute a forceful argument for the furtherance of affiliations. In addition to the use of mailing lists and of space in the scientific magazines, a simple and direct method of approach would be to enlist the aid of those in charge of science teachers' training courses in the several schools throughout the state. A portion of one class hour devoted to the cause of extending the benefits of science beyond the class room is neither too great a thing to ask, nor yet too much to give.

Wiggam has said, "The things science has discovered are as nothing compared with the spirit and kind of life it has brought into the world. The spirit of science is worth vastly more than the discoveries of science." The standardized card of membership credentials, the standardized pin, and the ritual with edited illustrative material, all represent details among the many possible ways of contributing to the significance of that spirit so necessary as a guide in the discovery of our future.

I am glad of the opportunity of addressing this section of the Academy, because I feel that the Academy represents a means whereby the spirit of science may find its way into the consciousness of the commonwealth it is now serving fully in other ways.

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INITIATION CEREMONY OF THE (EDISONIAN SCIENCE) CLUB.

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The initiation ceremony takes place after the regular business meeting, when only members of the club are present. Once in four years the ceremony might well be given before the assembly. It should, of course, follow the annual campaign for membership. The symbol (M) refers to music and (S) to appropriate slides, film-slides, or films.

President. We shall now proceed to the initiation. You are requested to remain in silence until the ceremony is concluded. The vice-president will ascertain if there are any eligible students (or teachers) of this school seeking admission to the (Edisonian Science) Club.

(The vice-president salutes the flag—placed at the right of the president's desk—and at such an angle that the president, vice-president, and flag are in line—then proceeds to the adjoining room. Returning, he stands within the doorway and addresses the president.)

Vice-President. Sir, I find the following who are qualified for membership in the (Edisonian Science) Club and who seek initiation therein.

President. You will conduct them into the meeting hall and place them properly before the flag.

(The vice-president retires to the adjoining room, leads the candidates in file, to the tune of National Emblem or other appropriate march, before the president and addresses the president as follows before retiring to his station:

Vice-President. Sir, I present these candidates for initiation into the (Edisonian Science) Club.

President. The solemnity of the occasion marks this as an hour most fittingly dedicated by prayer. Accordingly, the membership upon the sound of three raps of the gavel shall rise and stand in silence for thirty seconds in token of its foremost obligation to the Creator of all things. Upon the sound of one rap of the gavel all but the candidates shall be seated. . . . Be so governed. (Raps)

(After thirty seconds and following the single rap he continues.) The (Edisonian Science) Club, which is affiliated with the Illinois State Academy of Science, is founded on the ever-enduring cornerstone of Truth. Yesterday, today, and forever, Truth was, is and shall be with us—more certain than Time itself, for it is the material of which Time is made; admired by all; seen only in such degree as we are willing to remember that all things—whether animate, inanimate or spiritual—bear the unmistakable impress of the Divine Creator's hands. It is for us to remember that "knowledge comes, but wisdom lingers"; that it is a part of Man's duty to study, classify, correlate, interpret and build upon the Truths of natural phenomena, for only through such activity may we hope in time to acquire wisdom. "The truth, the whole truth, and nothing but the truth" is the quest of those who propose to follow the beacon light of science. "Only genius can create science", but the humblest man may acquire its spirit. (Pauses) The vice-president will show you in further detail the finishing of this corner stone, this ashlar of Truth. (S).

Vice-President (standing). The Truth is stranger than fiction, and its revelation is worthy of all in all. With Truth as our hammer the Forge of Life will ring for that higher and nobler purpose, the perfect Brotherhood of Man. It is altogether fitting and proper then that you should behold at this time the necessity of truth in all the essential activities of your life (S)—work, play, love and worship—for your success as an individual and as a citizen is not to be measured by worldly wealth but in terms of these four things. Without any one of them success in its fullest sense can not be. (Pauses). The secretary will now instruct you in the object of this organization.

Secretary (standing). The object of this organization shall be to create and foster the best interests of science, to maintain its spirit, to further its methods, to promote relationships between those engaged in scientific work, to assist with investigations and through discussions to make known the material, educational, and other resources and riches of the commonwealth, to find in all these activities the vital correlations between the scientific, the social and the moral activities in this school and community. It is for us to remember that our benefactor (Thomas A. Edison) has through precept and example of work, contributed as largely as any other modern scientist to our present day comfort and happiness. This emblem (pointing to the pin, which he should take care to wear on this occasion and then to the corresponding image on the screen) shall serve as a constant reminder of the wisdom obtained through knowledge; of the power that may come to the individual who walks uprightly and steadfastly by the light of the Truth in scientific, social and moral activities. (Pauses.) The treasurer will inform you concerning the emblematical significance of this organization.

Treasurer (standing). (S.) (Note—The picture involved at this point may be found in R. A. Gregory's, "Discovery, the Spirit and Service of Science," Macmillan, obtained at cost from The Chemical Foundation, Inc., 85 Beaver Street, New York.) It is for me to paint a picture of that which, it is hoped, will remain with you throughout life. It is a portrait not of Science but rather of the Spirit of Science which may be found residing within your personalities. Through this spirit, by lifting a corner of the veil, comes a new breadth of vision; a "new insight into the hidden meaning of things" about you; a growing realization of a greater freedom in the "world, rich in promise and of surpassing interest and wonder". With training, this spirit may be seen in every test tube, detected in the odor of every flower, and heard in the rushing of electrons in obedience to the laws of nature. In all places where man has the privilege of being may the Spirit of Science be found, robed in the blackness of night to signify both the limits of man's vision and the fathomless depths of mystery in which he has found himself. (S) On her extended right hand is borne a white owl, emblematical of the purity and wisdom with which one may hope to look on the future. Clenched in her extended left hand is a lightning bolt symbolical of the command of limitless power. And, lastly, there is to be found coiled about her feet, a large snake indicating health and knowledge as a thing apart from wisdom. This is the Spirit that may be heard to say: "I am what hath been, what is, what shall be. My veil hath been disclosed by none. The fruit which I have brought forth is this—the sun is born." Ours is the duty and privilege of bringing home to every man, the wonders, the significance, and the underlying or "inner harmony of things of the world in which we live, to the end that all undertakings may be better ordered, all lives enriched, all spirits fortified."

President (to candidates). You have heard the principles upon which this organization is based. Are you ready for the obligation?

Candidates. I am.

President (standing). You will repeat after me: I, (here give your name) do solemnly and sincerely pledge myself to defend the truth as I see it; to serve the best interests of American democracy; to perform faithfully any and all duties entrusted to me by this—or any other—organization in the best interest of science. (Pauses). I am pleased to welcome you as members of the (Edisonian Science) Club. You will now sign the membership roll and take your place among the members.

(After the signatures have been obtained, the president calls for a motion for adjournment).

Following this formal work, there should be a speaker, a regular program, or some film of appropriate nature, among the many possibilities. The following is quoted from a pamphlet, "A Message to High School Students of Illinois from the committee on high school science and clubs, for the year 1922-1923:

"The Council of the Academy authorizes the Committee on High School Science to state that High School Science Clubs may have a copy of the Academy's Transactions on application to the Secretary. The Council also agrees to send to any High School Science Club for its *open meeting,* a speaker of experience. The only cost to the Club will be the speakers' traveling expenses. It is hoped that many Science Clubs will avail themselves of these offers."

REFERENCES—ADDITIONAL.

Meister, Dr. Morris—"Managing a Science Club," School Science and Mathematics, Vol. XXIII., No. 3, March 1923. Note: This paper was read before the Science Section of the N. E. A. Meetings in Boston, July 5, 1922.

"A Suggested Constitution for a Science Club." See pamphlet; "A Message to High School Teachers and Students of Illinois," referred to above. I suggest addressing C. Frank Phipps, Professor, State Teachers' College, DeKalb, Ill. If unable to locate the material, the writer will supply a modified constitution, on request.

Wiggam, Albert Edward—"The Religion of the Scientist," World's Work, Vol. 50, No. 4, Aug., '25.

Gregory, R. A.—"Discovery, the Spirit and Service of Science," Macmillan. Obtained as one of a set of five books, each worth the total cost, from The Chemical Foundation, Inc., 85 Beaver Street, New York, for the cost of printing; $2.50 the set. This book contains many pictures worthy of use in opaque or other projection in connection with the ritual.

"School Law of Illinois"—Circular No. 202, "Fraternities," An Act to prohibit fraternities, sororities and secret societies in the public schools of the State, and to provide for the enforcement of the same.

The initiation should be performed before the assembly once in four years—in the four years high schools—to conform with the spirit and letter of the law.

Note: For affiliation of clubs address Dr. Lyell J. Thomas, Secretary, Ill. State Academy of Science, University of Illinois, Urbana, Ill., for application

OUTSIDE READING IN SCIENCE IN SECONDARY SCHOOLS.

L. E. Hildebrand, New Trier Township High School, Winnetka, Illinois.

The textbook, especially to the poor student, is the Universal symbol of a task imposed much as medicine is prescribed by physicians and hence everything contained therein is labelled with the never-ending "have to" while in outside reading one can give much freedom of choice according to the inclination of the students mind; nor will the future interest of the student be maintained by contact with textbooks, but through the reading of current publications and books of popular interest of the times. It is therefore a crime not to train the young people in wide awake and broad reading. We may *think we* are doing our full duty if we try to hammer the facts of the class text into their minds, but not so, because that leaves them helpless in the library as you will see when you ask them to find certain materials there. Direct them to the index of a volume and they will search the contents—strange how long it takes many of them to learn that distinction. They must become acquainted with books and magazines and even the daily papers, in other words learn how to find what is worthwhile and to the point, of whatever they are trying to do, before they can be considered as having anythink like a proper foundation for an education.

Further, considering the wide scope of science, the fact that one cannot escape from it any more than the Psalmist could get away from God as he says, "Whither shall I go from thy spirit? or whither shall I flee from thy presence? If I ascend into Heaven, thou art there: if I make my bed in Hell, behold thou art there. If I take the wings of the morning and dwell in the uttermost parts of the Sea," etc. Scientific phenomena are around, above, beneath, and even within us; it is therefore almost impossible to fail to find *something* to interest every one who comes under our instruction.

If a student seems totally without interest and completely benighted and entirely incapable of learning anything in the textbook, don't give him up, sound him out and find where his mind *may* find contact with his life's interests or experiences and then assign him, at first, light tasks of reading and let him report before the class, and be sure to bestow praise in some form or other for the work he has done. Repeat this sort of experiment often enough and you will find a student so transformed that he will find the material himself to read and will insist on reporting to the Class; and what is more he will become interested even in the textbook and that is an achievement on the part of a teacher. The next thing you will probably hear about the boy or girl from others is that he or she is singing your praises as a teacher and that is worth something too. Through all this trend of events it must not be forgotten that definite credit must be entered on the class record book for the reading and reporting before the class, and more credit if it is also nicely written up.

The great idea in all this teaching is that there must be a desire to learn and that is acquired by an interest in the subject—*but work begets interest and reward stimulates work.*

Another good plan in this line is to let some member of the class who becomes so interested in some subject or topic as to show strong signs of inspiration, talk to all the classes thus exposing them all to his "evangelism." Such a procedure always bears fruit. Inspiration is contagious, especially when it comes from one of their own number. I have witnessed some of the most remarkable cases of "evangelistic awakenings" in my own classes. I recall one case especially of a boy who knew more about the habits of honey bees than any other boy of his age I ever knew; and much of it he learned by actual experience with bees. I let him give a regular series of talks to all our Biology Classes; and the very striking thing was the complete command of attention on the part of his listeners who acquired a very extraordinary interest in bees and *that* was a thing worth while.

The case of another boy deserves mention for two reasons. First his very low standing as a student in the high school and second because of his remarkable ability to talk before his class just as soon as he found something in Biology to interest him. He entered my course and when he showed no signs of interest and seemed little struck with the idea of studying such lowly looking things as grasshoppers and beetles, I took time to find out his likes among living organisms and discovered he was interested in dogs and horses. I gave him a reference and told him to report to the class on the main points of his reading which he did with remarkable success. From this time on his progress was phenomenal. From horses and dogs he went to foxes, wolves, woodchucks, bats etc., and next he began to read entire books beginning with Hornaday's "Vanishing Wild Life", and then "Wild Animals I Have Known". On all these he reported before his class and did it with ever increasing ability. This was grand of course, but his mind had grown so fast during the school year that he now "fell upon" "Men of the Stone Age" by Osborne and here he broke all his former records; he had now found his inspiration so that he could hold his own fellow students to keen attention. He gave it all "straight from the shoulder" and minced no words to soften the meaning; and had Illinois been Tennessee there would have been a change of teachers in the Biology Department before the end of the semester.

To the credit of the community, however, only one complaint came to my notice and that came from the father of the boy. The young man had undertaken to educate the parent and had given him more than he could digest and the first result was resentment and he sent word to the Principal that too much Evolution was being taught for the good of the children. I took the matter up with the boy and told him not to be too persistent with his father, and eventually the boy won out. The father is now an ardent adherent to the Geological conception of time vs. the traditional six-day idea and he never loses an opportunity to tell me that his son got more out of that one study than out of all the rest of his high school course—"it was the making of the boy".

Draw your own conclusion what the result would have been had the textbook method been strictly applied in this case. The fact is he became also a textbook student because he soon learned to see Biology in a new light and the result was the transformation of the life of a young man.

In conculsion let me say such a thing is easier to talk about than to carry out but it is so *highly* worthwhile that science teachers cannot afford to neglect this sort of training for the weaker students especially.

EQUIPMENT OF THE BIOLOGY LABORATORY IN A SMALL HIGH SCHOOL.

E. V. KENNEDY, AVA COMMUNITY HIGH SCHOOL.

According to a report of the Commission on the Reorganization of Secondary Education, appointed by the National Educational Association, some of the aims in a course in Biology should be: "to develop the pupil's purposeful interest in the life of the environment by giving a first hand acquaintance with plants and animals; train the pupil to observe life phenomena accurately and to form logical conclusions; enrich the life of the pupil through the aesthetic appeal of plants and animals studied, to the end that he may appreciate and enjoy nature."

From a recent textbook on Biology, "Biology will take its place as a valuable subject in training only when teachers require accuracy in observation and the recording of these observed facts in suitable notebooks."

In recent years increasing emphasis has been placed on the study of living organisms. Physiological experiments and ecological studies have been introduced.

It is certainly true that as we attempt to understand nature we must not overlook the fact that the best place to study the plants and animals is in their natural habitat. It is comparatively easy to study plants and animals in their homes throughout the fall and in the spring but during the winter months what study is made of living things must be made in the laboratory. The large high school with a liberal allowance for the equipment of a laboratory, and some with access to a green house are not so seriously handicapped, but some small high schools with almost nothing but four walls, tables and chairs, find it hard to give the pupils first hand experience with living things. It is to those of this small type of high school that I am hoping this paper will be of some benefit.

For the past few years the project has been recognized as the obvious method for individual work and for group work by students as well. The assignment of projects to be worked out in a scientific manner greatly increases the value of laboratory work and needs add but little to the expense for equipment. The project method in Biology has not been adopted very generally in small high schools for two principal reasons: First, the necessity for economy; second, too rigid a standardization in laboratory equipment and supplies. This is due partly to requirements made by the State Department and Universities. The first of these causes can easily be eliminated, for as I have stated above the use of projects need not add to the cost of equipment. I will give in the following pages a number of projects carried out in our small high school, some individual and some group, with a very small cost to the school.

During the past two years we have studied in the laboratory the following living specimens: The Cecropia moth has been studied in the egg, caterpillar, cocoon, and adult moth stages. Other moths observed in the laboratory in the caterpillar, cocoon, and adult stages are, the Sphinx Deilephila lineata, and Phlegethontius carolina, Actias luna, Telea polyphemus, and Basilona imperialis. The Monarch butterfly has also been observed in three stages of its life cycle. The Anopheles mosquito has been observed and studied in the egg, larva, pupa and adult stages. The students watched with much interest the development of the mosquito through each of these stages. This animal is particularly interesting to Southern Illinois since about 60% of the malaria of the state was found in twelve counties of Southern Illinois during the years 1922-23 and 24.

Crayfish have been kept throughout the whole school year and we have watched them pass through three molts. The leopard frog has been watched through egg cleavage, blastula and gastrula stages, the tadpole and adult frog. We have kept the common mussel and studied its movements and methods of obtaining food. We have studied the hydra, planaria, water snail, amoeba, paramoecium, and vorticella.

We have grown and observed the following plants: tradescantia, red, variegated, and green species for studying typical closed veination, and effect of chlorophyll in photosynthesis; corn for the study of a typical monocot stem and leaf; ice plant for studying function of epidermis;

beans for studying region of elongation of stems; geraniums for study of typical structure of a leaf and several other plants for various experiments.

All these plants and animals have been kept in the laboratory throughout the school year and pupils have had first hand experience in studying their structure, life history and habits. The total cost of equipment necessary for keeping the above named living specimens amounted to less than five dollars.

An insect cage for hatching and rearing moths and butterflies was made from an orange case donated by a grocer. The two ends of the case made excellent top and bottom to the cage. These were connected by four upright pieces 1 by 2 inches and 30 inches long. Then the three sides were covered with wire screening at a cost of 25 cents. The back was made into a sliding door.

Two window boxes each 4 feet by 1 foot and six inches deep were made from choice cypress and given four good coats of paint. They were placed in south windows on brackets. The total cost of the window boxes was $2.50.

Thirty cents worth of pine lumber made a shelf in another south window 4 feet by 2½ feet, capable of holding ten or twelve eight-inch flower pots.

Our aquarium was made of clear cypress 1 inch by 8 inches. The inside dimensions were 1 foot by 4½ feet and 8 inches deep. This was lined with galvanized tin and carefully soldered. The outside was given two coats of paint. With a shallow layer of sand, gravel and small rocks, this made a comfortable home for frogs, mussels and crayfish.

Stretching boards for mounting insects were made from ½ inch pine board 3 inches wide.

This equipment is listed in a science catalogue at $25.00 and may be made by the pupils themselves for $4.80.

There are lists of standard equipment prepared by scientific companies, State Departments and universities, but all of them contain a large number of articles that a small high school can well get along without. The following equipment is sufficient for a high school whose classes in Biology are not larger than twelve students:

3 compound microscopes	½ dozen cover glasses
6 magnifiers	1 dozen pipettes
4 ring stands with rings	6 watch glasses
6 dissection sets	6 evaporating dishes
1 section razor	1 nest beakers
1 hand microtome	1 thermometer
6 test tube brushes	1 100 cc graduate
6 dissecting pans	6 feet of rubber tubing ¼ inch
2 dozen test tubes	
6 battery jars	filter paper
3 tables (these may be made by local cabinet maker or carpenter)	glass tubing ⅛ to ¼ inch
	6 dozen glass slides

CHEMICALS

100 cc eosin	1 lb. ammonium hydroxide
10 grams iodine	1 gallon alcohol
1 pound ether	1 gallon formalin
1 pound nitric acid	50 grams glycerine
1 pound sulphuric acid	1 pound chloroform
1 pound hydrochloric acid	2 lbs. Fehling solution No. 1
	2 lbs. Fehling solution No. 2

Another valuable part of the laboratory equipment is the collection of the real things of the natural world, and the preserving of them in the laboratory. Our laboratories may be literally filled with materials that will aid in arousing interest in Natural Science and this is one of the chief ends of the study of Biology.

It is altogether possible to make our laboratory a center of community interest. The interest created in the students will soon spread to members of the community and all will join in acquiring some most interesting material.

A THYROID SURVEY OF THE SCHOOLS OF DECATUR, ILL.

WM. S. KEISTER M. D., HEALTH OFFICER, DECATUR, ILL.

On November 10, 1926, the Commissioner of the State Department of Public Health, Dr. Isaac D. Rawlings, suggested to the writer the advisability of conducting a thyroid survey of the school children of the city of Decatur under the direction of the Decatur Medical Society, with the cooperation of the school authorities, the local health department and the Child Hygiene Division of the State Department of Health, provided all agencies desired the survey. There was no difficulty whatever in securing the full cooperation of all the above groups. The reasons for conducting the survey were two-fold, namely: (1) It was desired to learn whether the prevalence of enlarged thyroids was any greater in Decatur, where the city water supply was free of iodine, than was the case in other places where the water supply contained appreciable amounts of iodine. Unfortunately this comparison cannot be made in this paper as up to this time figures are not available for the latter types of communities: (2) It was desired to determine the actual prevalence of the various degrees of thyroid enlargement among the school children of Decatur, and if possible arrive at some satisfactory method of remedying the condition.

Accordingly Dr. R. C. Cook of the Child Hygiene Division of the State Department of Health arrived in Decatur on February 14, 1927 and the actual work of the survey started the following day. It was soon decided that it would be best to examine all the pupils in all the grades of the public and parochial schools, there being no difficulty whatever in securing the full and sympathetic cooperation of the Board of Education, the authorities in charge of the private and parochial schools, the principals, teachers, nurses and others. The splendid spirit of cooperation of the medical profession is shown by the fact that 28 physicians gave generously of their time during the seven days of the survey. The untiring efforts and ability of Dr. Cook contributed very largely to the success of the work. The blanks used, based upon those adopted by the U. S. Public Health Service, and others prepared by Dr. Cook, were furnished by the State Department of Health and the Superintendent's office. In order that the results might be fairly uniform, every examiner worked for a time with Dr. Cook to learn his methods and was given a typewritten sheet of instructions. The actual work proceeded so rapidly that it was frequently necessary to rearrange the schedule of schools to be examined each day. The work of tabulation and notification of parents of results found was accomplished by the school nurses, teachers and an assistant from the Superintendent's office, working under the direction of Miss Gunhild Johnson, Supervisor of School Nursing.

There was a total of 10,055 pupils examined in the nine grades of the elementary and junior high schools, together with the sophomore, junior, senior and post-graduate students of the high school. Of this number, 5,338 or 53% showed some degree of thyroid enlargement, there being 4,717 of nearly 47% of normal thyroids. 3,628 (36%) showed a very slight (No. 1) degree of enlargement, 1,509 (15%) slight (No. 2), 187 (1.9%) moderate (No. 3), 10 (.1%) severe (No. 4), and 4 (.04%) very severe enlargement (No. 5). There were 4,854 (48.3%) white boys, 155 (1.5%) colored boys, 4,828 (48%) white girls and 218 (2.2%) colored girls examined.

Prevalence of Thyroid Enlargement According to Grade.

It is interesting to note that the fifth grade had the largest percentage of normal thyroids with 623 out of 1,160 examined (53.7%). The senior class with 121 out of 229 examined (52.8%) was second and the third and sixth grades with 530 and 573 out of 1.014 and 1,092 respectively, (52.7%) tied for third place. Among the very slight (No. 1) degree of enlargement the post-graduate class was highest with 4 out of 5 (80%), the ninth grade with 253 out of 517 (48.9%) second, and the eighth grade with 384 out of 796 (48.2%) third highest. As to the slight (No. 2) degree of enlargement the sixth grade was highest with 402 out of 1,092 (36.8%), the sophomore class with 171 out of 641 (26.7%) second, and the seventh grade with 153 out of 966 (15.8%) third highest. Moderate enlargement (No. 3) was highest in the Junior class with 14 out of 293 (4.8%), the ninth grade with 22 out of 517 (4.3%) second and the senior class with 9 out of 229 (3.9%) third highest. The severe and very severe enlargements (Nos. 4 and 5) were found most prevalent in the Junior class. Thus it is seen that the more marked enlargements, as a rule, were found in the higher grades, although all grades showed a high percentage of very slight enlargement.

According to Sex.

Of the 5,009 boys (white and colored) examined, 2,331 (46.5%) showed some degree of thyroid enlargement. Of the 5,046 girls (white and colored) examined, 3,007 (59.6%) showed some degree of thyroid enlargement. Although the percentage of enlarged glands was highest among the girls the difference (13.1%) between the boys and girls is not as great as is usually supposed. No doubt the difference is greatest among the more marked degrees of enlargement.

According to Color.

Among the 9,682 white boys and girls, there were 5,147 (53.2%) with some degree of enlargement. Among the 373 colored boys and girls there were 191 (51.2%) with some degree of enlargement. The difference between the white and colored pupils was only 2 percent, though this is usually thought to be greater. From the above it is seen that neither color nor sex seems to have a marked influence on the prevalence of enlarged thyroids.

The Remedy.

Questions have been frequently asked as to the best methods of remedying the conditions found in the thyroid survey. This is a rather difficult problem in view of the conflict of opinions among physicians as to the relative merits and supposed dangers of the various treatments advocated. Owing to the fact that simple goiters respond favorably to the various forms of iodine medication, whereas toxic goiters seem to give the opposite effect when treated with iodine, there have been many theoretical objections raised to the promiscuous use of iodine. However it would seem that very little harm would result in the use of iodine in a wholesale way for school children when we remember that most thyroid enlargements in children are of the simple variety of goiter, which is benefited by this drug. As this question is not yet fully settled, I would like to quote a part of a letter received from Surgeon Robert Oleson, of the U. S. Public Health Service, who has made extensive studies in this field. Dr. Oleson says:

"In replying to our recent goiter questionnaire you asked for information as to the value of iodized table salt and iodized drinking water. Of course a great deal has been written on both of these subjects but so far the results of iodized drinking water are meager in character. It is our intention to prepare an article dealing with the subject of iodization of municipal water supplies and recommend that it be published in the weekly Public Health Reports. So far there appears to be no striking evidence that iodized drinking water is particularly useful in preventing goiter. However, all of the experiments which have been made so far appear to be defective so that a real conclusion cannot be drawn. The method is theoretically correct but there appear to be numerous obstacles in the way of a definite appraisal of its value.

With regard to iodized table salt there is considerable controversy at the present time. Much of the opposition to the use of this commodity comes from Dr. Hartsock of the Crile Clinic in Cleveland. However, he is not alone in assuming that iodized salt is responsible for numerous cases of hyperthyroidism. On the other hand there are numerous striking statements from health officers in the United States and abroad concerning the efficiency of this product as a prophylactic. Experiments are now being made by Dr. Kimball with iodized salt containing 1-20 of the amount of sodium iodide which is used in the Michigan iodized salt. Dr. Kimball informs me that the results following the use of this salt containing minute quantities of iodine are less satisfactory than those obtained from other forms of iodine such as the organic iodide with chocolate.

THYROID SURVEY—DECATUR, ILL.

School	Total Number Examined				Number Enlarged Thyroids				Degree of Enlargement					
	White Boys	White Girls	Colored Boys	Colored Girls	White Boys	White Girls	Colored Boys	Colored Girls	0	1	2	3	4	5
Dennis	140	143	0	0	35	48	0	0	200	56	20	7	0	0
Durfee	505	432	36	38	249	320	25	28	383	394	212	15	1	0
French	93	115	4	10	40	65	2	13	102	80	32	8	0	0
Garfield	165	173	5	5	91	102	1	3	151	168	25	4	0	0
Gastman	131	135	1	11	120	126	0	1	31	164	74	8	1	0
Grant	30	35	0	0	13	20	0	0	32	32	1	0	0	0
Lincoln	163	156	2	1	90	101	1	0	130	156	36	0	0	0
Oakland	103	140	15	14	29	76	3	10	154	108	8	2	0	0
Oglesby	140	152	3	3	45	49	1	2	201	79	13	4	1	0
Pugh	215	186	5	14	80	68	1	1	270	138	9	3	0	0
Riverside	133	136	2	2	50	50	1	0	172	92	8	1	0	0
Roach	421	360	0	0	221	308	0	0	252	328	196	4	1	0
Ullrich	150	149	5	5	64	64	3	1	177	93	29	8	1	1
Warren	196	149	4	8	60	77	2	0	218	115	20	2	1	1
Washington	381	339	36	74	130	117	28	33	522	205	91	10	1	1
St. Johannes	141	136	0	0	114	117	0	0	46	173	52	6	0	0
St. James	105	90	0	0	80	79	0	0	36	100	55	4	0	0
St. Paul	40	26	0	0	8	4	0	0	54	12	0	0	0	0
St. Patrick's	154	113	0	0	77	65	0	0	125	17	121	3	1	0
St. Thomas	67	73	0	0	18	30	0	0	92	32	13	3	0	0
St. Theresa	7	98	0	0	1	49	0	0	55	29	16	5	0	0
7 Day Adventist	11	10	0	0	9	7	0	0	5	3	13	0	0	0
Central Jr.	393	410	27	18	229	295	11	5	308	353	141	45	1	0
Roosevelt	445	470	6	7	230	296	3	4	395	341	182	10	0	0
High School	525	602	4	8	163	368	3	5	600	360	142	35	1	1
Total	4854	4828	155	218	2246	2901	85	106	4717	3628	1509	187 5338	10	4

10055 5338 10055

TYHROID SURVEY—DECATUR, ILL.

Grades	Total Number Examined				Number Enlarged Thyroids				Decatur	*Distance	Degree of Enlargement						Total
	White Boys	White Girls	Col. Boys	Col. Girls	White Boys	White Girls	Col. Boys	Col. Girls			0	1	2	3	4	5	
1st	658	643	28	33	283	333	9	19	1311	51	718	507	129	6	1	1	1362
2nd	499	529	20	28	246	274	10	19	1021	55	527	441	99	9	0	0	1076
3rd	504	477	18	15	222	238	13	17	975	39	530	387	80	13	3	1	1014
4th	443	421	20	20	221	236	9	9	871	33	429	339	121	15	0	0	904
5th	532	558	8	62	246	269	7	15	1102	58	623	387	128	19	3	0	1160
6th	526	513	27	26	239	253	13	14	1060	32	573	103	402	13	1	0	1092
7th	476	453	17	20	282	327	12	8	885	81	337	449	153	27	0	0	966
8th	378	407	6	5	220	290	4	5	764	32	277	384	109	26	0	0	796
9th	312	197	7	1	123	201	5	1	400	117	187	253	54	22	1	0	517
Soph	313	318	3	7	95	283	3	5	594	47	255	200	171	14	0	1	641
Jun	120	172	1	0	43	111	0	0	263	30	139	105	33	14	1	1	293
Sen	91	137	0	1	25	83	0	0	207	22	121	69	30	9	0	0	229
P. G	2	3	0	0	1	3	0	0	3	2	1	4	0	0	0	0	5
Total	4854	4828	155	218	2246	2901	85	106	9456	599	4717	3628	1509	187 5338	10	4	
	10055				5338				10055		10055						

*Persons living in Decatur less than one year but who were probably not affected by local conditions.

In Cincinnati we are finding considerable less endemic goiter at present than appeared three years ago during our original survey. As iodized table salt has been the only prophylactic recommended in this community it appears at least that the salt may have had some influence upon the simple goiter prevalence in this section."

A few cities, such as Rochester, N. Y. and Minneapolis, Minn. have been using iodine in the public water supply, but, as Dr. Oleson states, the results have not been striking. Akron, Cleveland and other cities have preferred to use Marine and Kimball's method of giving some form of iodine medication to the children for a definite period of time each year, or giving small doses once each week all the time. Various preparations, such as sodium iodide, syrup of the iodides of iron, iodostarine, etc. have been used, the latter being especially popular in some sections, particularly Switzerland. The method most in use is that of iodizing the table salt. Although there have been some objections raised to this method, it would hardly seem to be a means of producing the toxic forms of goiter since the quantity of iodine used is infinitesimal and only takes the place of the normal amount present in the crude salt which is destroyed in refining it. Undoubtedly the latter has been the means of greatly reducing the incidence of the disease in many parts of the country.

CONSTITUTION AND BY-LAWS.

CONSTITUTION AND BY-LAWS

Illinois State Academy of Science.

CONSTITUTION.

Article I. Name.

This Society shall be known as The Illinois State Academy of Science.

Article II. Objects.

The objects of the Academy shall be the promotion of scientific research, the diffusion of scientific knowledge and scientific spirit, and the unification of the science interests of the State.

Article III. Members.

The membership of the Academy shall consist of two classes as follows: *National Members* and *Local Members.*

National Members shall be those who are members also of the American Association for the Advancement of Science.

Local Members shall be those who are members of the local Academy only. Each member, except life members of the Academy, shall pay an admission fee of one dollar and an annual assessment of one dollar.

Both national members and local members may be either *Life Members, Active Members,* or *Non-resident Members.*

Life Members shall be national or local members who have paid fees to the Academy to the amount of twenty dollars at one time or complete payments before the annual meeting of 1928. The dues from such a source are to be placed as a permanent fund and only the income is to be used. Life members, if national members, shall pay an annual assessment of four dollars.

Active Members shall be national or local members who reside in the State of Illinois.

Non-resident Members shall be active members or life members who have removed from the State of Illinois. Their duties and privileges shall be the same as active members except that they may not hold office.

Charter Members are those who attended the organization meeting in 1908, signed the constitution, and paid dues for that year.

For election to any class of membership, the candidate's name must be proposed by two members, be approved by a majority of the committee on membership, and receive the assent of three-fourths of the members voting.

Article IV. Officers.

The officers of the Academy shall consist of a President, a First Vice-President, a Librarian, a Secretary, and a Treasurer. The Chief of the Division of State Museum of the Department of Registration and Education of the State Government shall be the Librarian of the Academy. These officers, except the Librarian, shall be chosen by ballot on recommendation of a nominating committee, at an annual meeting, and shall hold office for one year or until their successors qualify.

A Second Vice-President, who may be a resident of the town in which the next annual meeting is to be held, may be appointed by the council each year when the next meeting place shall have been decided upon.

The above officers shall perform the duties usually pertaining to their respective offices.

It shall be one of the duties of the President to prepare an address which shall be delivered before the Academy at the annual meeting at which his term of office expires.

The Librarian shall have charge of all the books, collections, and material property belonging to the Academy.

Article V. Council.

The Council shall consist of the President, First Vice-President, Second Vice-President, Secretary, Treasurer, Librarian, the retiring president and his immediate predecessor. To the Council shall be entrusted the management of the affairs of the Academy during the intervals between regular meetings.

At the Annual Meetings the presiding officer of each of the affiliated scientific societies of the State shall meet with the Academy Council for the discussion of policies.

Article VI. Standing Committees.

The Standing Committees of the Academy shall be a Committee on Publication, a Committee on Membership and a Committee on Affiliation and such other committees as the Academy shall from time to time deem desirable.

The Committee on Publication shall consist of the President, the Secretary and a third member chosen annually by the Academy.

The committees on Membership and Affiliation shall each consist of five members chosen annually by the Academy.

Article VII. Meetings.

The regular meetings of the Academy shall be held at such time and place as the Council may designate. Special meetings may be called by the Council, and shall be called upon written request of twenty members.

Article VIII. Publications.

The regular publications of the Academy shall include the Transactions of the Academy and such papers as are deemed suitable by the Committee on Publications.

All members shall receive gratis the current publications of the Academy.

Article IX. Affiliation.

The academy may enter into such relations of affiliation with other organizations of appropriate character as may be recommended by the Council, and may be ordered by a three-fourths vote of the members present at any regular meeting.

Article X. Amendments.

This constitution may be amended by a three-fourths vote of the membership present at an annual meeting, provided that notice of the desired change has been sent by the Secretary to all members at least twenty days before such meeting.

BY-LAWS.

I. The following shall be the regular order of business:

1. Call to order.
2. Reports of officers.
3. Reports of standing committees.
4. Election of members.
5. Reports of special committees.
6. Appointment of special committees.
7. Unfinished business.
8. New business.
9. Election of officers.
10. Program.

Adjournment.

II. No meetings of the Academy shall be held without thirty days previous notice by the Secretary to all members.

III. Fifteen members shall constitute a quorum of the Academy. A majority of the Council shall constitute a quorum of the Council.

IV. No bill against the Academy shall be paid without an order signed by the President and the Secretary.

V. Members who shall allow their dues to remain unpaid for three years, having been annually notified of their arrearage by the Treasurer, shall have their names stricken from the roll.

VI. The Librarian shall have charge of the distribution, sale, and exchange of the published Transactions of the Academy, under such restrictions as may be imposed by the Council.

VII. The presiding officer shall at each annual meeting appoint a committee of three who shall examine and report in writing upon the account of the Treasurer.

VIII. No paper shall be entitled to a place on the program unless the manuscript or an abstract of the same shall have been previously delivered to the Secretary. No paper shall be presented at any meeting, by any person other than the author, except on vote of the members present at such meeting. No paper shall be published unless the manuscript be handed to the Secretary within thirty days after the Annual meeting. All papers are limited to twenty pages, additional pages are to be paid for by the author. Except by invitation of the Council, no paper may be accepted for the program unless the author is a member of the Academy or an applicant for membership.

IX. The Secretary and the Treasurer shall have their expenses paid from the Treasury of the Academy while attending council meetings and annual meetings. Other members of the council may have their expenses paid while attending meetings of the council, other than those in connection with annual meetings.

X. These by-laws may be suspended by a three-fourths vote of the members present at any regular meeting.

LIST OF MEMBERS.

List of Members

Note—The names of charter members are starred; names in black-faced type indicate membership in the American Association for the Advancement of Science. Numerals in parenthesis after each member indicate the date of joining the Academy.

LIFE MEMBERS.

***Andrews. C. W.**, LL. D., The John Crearar Library, Chicago, Ill. (Sci. Bibl.) (1908.)
*Bain, Walter G., M. D., St. John's Hospital, Springfield, Ill. (Bacteriology.) (1909.)
Barnes, R. M., LL. B., Lacon, Ill. (Zoology.) (1908.)
***Barnes, William**, M. D., 320 Millikin Bldg., Decatur, Ill. (Lepidoptera.) (1908.)
***Bartow, Edward**, Ph. D., University of Iowa ,Iowa City, Iowa. (1908.)
Bliss, Gilbert Ames, B. S., M. S., Ph. D., 5625 Kenwood Ave., Chicago, Ill. (Math.) (1926.)
Chamberlain, C. J., Ph. D., University of Chicago, Chicago, Ill. (Botany.) (1911.)
***Chamberlain, T. C.**, LL. D., University of Chicago, Chicago, Ill. (Geology.) (1908.)
***Cowles, H. C.**, Ph. D., University of Chicago, Chicago, Ill. (Botany.) (1908.)
***Crew, Henry**, Ph. D., Northwestern University, Evanston, Ill. (Physics.) (1908.)
***Crook, A. R.**, Ph. D., Chief, State Museum, Springfield, Ill. (Geology.) (1908.)
Deal, Don W., M. D., Leland Office Building, Springfield, Ill. (Medicine.) (1908.)
Farrington, O. C., Ph. D., Field Museum, Chicago, Ill. (Mineralogy.) (1908.)
***Fischer, C. E. M.**, M. D., 25 E. Washington St., Chicago, Ill. (Medicine.) (1908)
***Forbes, S. A.**, LL. D., Chief, Natural History Survey, Urbana, Ill. (Zoology.) (1908.)
Fuller, Geo. D., Ph. D., University of Chicago, Chicago, Ill. (Botany.) (1912.)
***Gates, Frank C.**, Ph. D., State Agricultural College, Manhattan, Kansas, (Botany.) (1908.)
Hagler, E. E., M. D., Capitol Ave. and Fourth St., Springfield, Ill. (Occulist.) (1910.)
Hankinson, Thos. L., B. S., State Normal College, Ypsilanti, Mich. (Zoology.) (1908.)
***Hessler, J. C.**, Ph. D., Knox College, Galesburg, Ill. (Chemistry.) (1908.)
Hoskins, William, 111 W. Monroe St., Chicago, Ill. (Chemistry.) (1908.)
Hunt, Robert I., Decatur, Ill. (Soils.) (1908.)
Jordan, Edwin O., Ph. D., University of Chicago, Ill. (Bacteriology.) (1912.)
Kuntz, Jacob, Ph. D., University of Illinois, Urbana, Ill. (Physics.) (1919).
Latham, Vida A., M. D., D. D. S., 16414 Morse Ave., Chicago, Ill. (Microscopy.) (1909.)
Lillie, F. R., Ph. D., University of Chicago, Chicago, Ill. (Zoology.) (1912.)
Marshall, Ruth, Ph. D., Rockford College, Rockford, Ill. (Zoology.) (1912.)
Miller, G. A., Ph. D., University of Illinois, Urbana, Ill. (Mathematics.) (1910.)
Moffatt, Mrs. Elizabeth M., 1315 Crown Hill, Los Angeles, Calif. (Zoology.) (1916.)
Moffatt, Will S., M. D., 1315 Crown Hill, Los Angeles, Calif. (Botany.) (1912.)
Mohr, Louis, 349 W. Illinois St., Chicago, Ill. (1909.)
***Noyes, William A.**, Ph. D., LL. D., University of Illinois, Urbana, Ill. (Chemistry.) (1908.)
***Oglevee, C. S.**, Sc. D., Lincoln College, Lincoln, Ill. (Biology.) (1908.)
O'Hara, Fred S., M. D., 509 E. N. Grand Ave., Springfield, Ill. (Medicine.) (1925.)
Payne, Edward W., First State Trust & Savings Bank, Springfield, Ill. (Archeology.) (1909.)
***Pepoon, H. S.**, M. D., Lake View High School, Chicago, Ill. (Zoology, Botany.) (1908.)
Rentchler, Edna K., B. A., Peabody Normal College, Nashville, Tenn. (Biology.) (1912.)
Schaffer, David Nicholas, M. D., 104 S. Michigan Ave., Chicago. (Medicine.) (1925.)
Smith, Frank, M. A., Sc. D., 79 Fayette St., Hillsdale, Mich., (Zoology.) (1909.)
***Smith, Isabel Seymour**, 145 Woodland Ave., Oberlin, Ohio. (Botany.) (1908.)
***Smith, L. H.**, Ph. D., University of Illinois, Urbana, Ill. (Plant Breeding.) (1908.)
Stevenson, A. L., B. S., Field School, 7019 N. Ashland Ave., Chicago, Ill. (1908.)
Stillhamer, A. G., 705 N. East St., Bloomington, Ill. (Physics.) (1908.)
Sykes, Mabel, B. S., South Chicago High School, Chicago, Ill. (Geology.) (1908.)
Trelease, William, LL. D., University of Illinois, Urbana, Ill. (Botany.) (1909.)
Ward, Henry B., Ph. D., Sc. D., University of Illinois, Urbana, Ill. (Zoology.) (1910.)
Washburn, E. W., Ph. D., National Research Council, Washington, D. C. (Chemistry.) (1910.)
Weller, Annie L., Eastern Illinois State Teachers College, Charleston, Ill. (1908.)
Zeleny, Charles, Ph. D., University of Illinois, Urbana, Ill. (Experimental Zoology.) (1910.)

ANNUAL MEMBERS.

Abbott, Howard C., Ph. D., University of South Dakota, Vermillion, South Dakota. (1921.)
Adams, L. A., Ph. D., University of Illinois, Urbana, Ill. (Zoology.) (1923.)
Adams, William A., B. S. A., 2235 N. 75th Ave., Elmwood Park, Ill. (Archeology.) (1927.)
Adams, Roger, Ph. D., 603 Michigan Ave., Urbana, Illinois. (Chemistry.) (1926.)
Adamstone, F. B., M. A., Ph. D., University of Illinois, Urbana, Illinois. (Zoology.) (1926.)
Adler, Herman, M., M. D., 721 S. Wood St., Chicago, Ill. (Medicine.)
Agersborg, H. P. K., Ph. D., James Millikin University, Decatur, Ill. (Zoology.) (1925.)
Aldrich, Frank W., Ph. D., 1506 E. Washington St., Bloomington, Ill. (Anthropology.) (1925.)
Alexander, Alida, M. A., Illinois Woman's College, Jacksonville, Ill. (Botany.) (1918.)
Alexander, C. P., Ph. D., Fernald Hall, Mass. Agr. College, Amherst, Mass. (Entomology.) (1920.)

Alldredge, Samuel M., A. B., P. O. Box 682, Johnston City, Ill. (Chemistry.) (1922.)
Allee, W. C., Ph. D., University of Chicago, Chicago, Ill. (Zoology.) (1913.)
Alonzo, A. S., M. A., University of Chicago, Chicago, Ill. (Psychology.) (1920.)
Ames, E. S., Ph. D., University of Chicago, Chicago, Ill. (Psychology.) (1920.)
Anderson, Flora, Ph. D., 710 S. Fess Ave., Bloomington, Ind. (Botany.) (1925.)
Appleton, John B., M. S., Ph. D., University of Illinois, Urbana, Ill. (Geography.) (1926.)
Armstrong, Christie, A. B., Princeville, Ill. (Geography.) (1921.)
Arn, William G., B. S., Illinois Central Station, I. C. R. R. Co., Chicago, Ill. (Math., Geology, Physics.) (1927.)
Ashman, George C., Ph. D., Bradley Institute, Peoria, Ill. (Chemistry.) (1913.)
Astell, Louis A., B. A., Box 37, West Chicago, Ill. (Physiology and Hygiene.) (1925.)
***Atwell, Chas. B.**, Ph. M., Northwestern University, Evanston, Ill. (Botany.) (1908.)
Augur, Allison W., M. A., 5423 Woodlawn, Chicago, Ill. (Physics.) (1921.)
Bacon, Chas. Sumner, Ph. D., M. D., 2333 Cleveland Ave., Chicago, Ill.
Bailey, Mrs. Alice Allen, M. S., University of Chicago, Chicago, Ill. (Botany, Path.) (1927.)
Bailey, Wm. M., M. S., 701 S. Poplar, Carbondale, Ill. (Botany.) (1921.)
Baird, S. H., 708 Woodland Ave., Springfield, Ill. (Chemistry.) (1925.)
Baker, C. J., B. S., 460 E. Ohio St., Chicago, Ill. (Chemistry.) (1926.)
Baker, Frank C., University of Illinois, Urbana, Ill. (Zoology.) (1908.)
Balduf, W. V., Ph. D., 308 Old Law Bldg., University of Illinois, Urbana, Ill. (Entomology.) (1924.)
Banck, Hans J. E., M. E., 1422 Dial Court, Springfield, Ill. (Engineering.) (1925.)
Bangs, Edward H., 212 W. Washington St., Chicago, Ill. (Agriculture and Electricitly.) (1920.)
Barnes, Cecil, LL. B., M. A., 1522 1st National Bank Bldg., Chicago, Ill. (Physical Geography.) (1920.)
Barwell, John Wm., Madison and Sand Sts., Waukegan, Ill. (Anthropology.) (1908.)
Bastin, E. S., Ph. D., University of Chicago, Chicago, Ill. (Geology.) (1925.)
Bates, Onward, LL. D., 332 S. Michigan Ave., Chicago, Ill. (Civil Engineering.) (1926.)
Bauman, Harold Ed. B., Farina, Ill. (Zoology.) (1926.)
***Bayley, W. S.**, Ph. D., University of Illinois, Urbana, Ill. (Geology.) (1908.)
Beal, James Hartley, Sc. D., 801 Nevada, Urbana, Ill. (Medicine.) (1916.)
Beecher, Wm. L., M. D., Ph. D., 25 E. Washington St., Chicago, Ill. (Medicine.) (1927.)
Behre, Chas. H., Jr., Univ. of Cincinnati, Cincinnati, Ohio. (1921.)
Bell, Alfred H., Ph. D., University of Illinois, Urbana, Ill. (Geology.) (1927.)
Bell, Marie, Box 114, Albany, Indiana. (Biology.) (1926.)
Bengel, George A., 808 S. 4th St., Springfield, Ill. (Engineering.) (1925.)
Bentley, Madison, Ph. D., University of Illinois, Urbana, Ill. (Psychology.) (1920.)
Benton, Curtis, B. A., Macomb, Ill. (Entomology.) (1925.)
Bergman, Ross M., 613 S. Hale St., Wheaton, Ill. (Biology.) (1926.)
***Betten, Cornelius**, Ph. D., Cornell University, Ithaca, N. Y. (Biology.) (1908.)
Bevan, Arthur, Ph. D., 248 Nat. Hist., University of Illinois, Urbana, Ill. (Geology.) (1924.) (1924.)
Bigger, J. H., B. S., 305 N. Prairie, Ave., Jacksonville, Ill. (Entomologist.) (1925.)
Black, Arthur D., M. D., D. D. S., Northwestern University, Evanston, Ill. (Dentistry.) (1921.)
Blackstock, Ira B., M. A., 213 E. Jefferson St., Springfield, Ill. (Agriculture.) (1925.)
Blair, Mary Constance, Ph. D., 1011 Grove St., Evanston, Ill. (Botany and Zoology.) (1926.)
Blake, Anna M., B. S., 409 W. Willow St., Normal, Ill. (Botany and Physiology.) (1917.)
Blake, Mrs. Tiffany, 25 East Walton Place, Chicago, Ill. (1921.)
Blanchard, W. O., Ph. D., 305 Washington Blvd., Urbana, Ill. (Geography.) (1925.)
Bleininger, A. V., B. S., Homer Laughlin China Co., Newell, W. Va. (Ceramics.) (1908.)
Block, D. Julian, Ph. D., 222 E. Ontario, Chicago, Ill. (Chemistry.) (1920.)
Bohannon, F. C., B. S., Galesburg High School, Galesburg, Ill. (Geography and Geology.) (1924.)
Bonnell, Clarence, Township High School, Harrisburg, Ill. (Biology.) (1926.)
Boomer, S. E., M. A., 207 Harwood St., Carbondale, Ill. (Physics.) (1921.)
Boos, Mrs. Margaret Fuller, Ph. D., Care of Empire Gas & Fuel Co., Bartlesville, Okla. (Geology.) (1924.)
Boot, G. W., M. D., 813 Sherman Ave., Evanston, Ill. (Medicine and Geology.) (1920.)
Bracken, Ellis F., B. S., 7003 Eggleston Ave., Chicago, Ill. (Physics.) (1927.)
Brannon, James Marshall, Ph. D., University of Illinois, Urbana, Ill. (Plant Physiology Cytology and Bacteriology.) (1926.)
Breed, Frederick S., Ph. D., 5476 University Ave., Chicago, Ill. (Education.) (1921.)
Bregowsky, Ivan M., 4600 W. Harrison St., Chicago, Ill. (Chemistry and Metallurgy.) (1926.)
Bretz, J. Harlan, Ph. D., University of Chicago, Chicago, Ill. (Geology.) (1921.)
Brokaw, Raymond Voorhees, M. D., 1001 S. Second St., Springfield, Ill. (Medicine.) (1925.)
Brown, Agnes, 1205 W. State St., Rockford, Ill. (1921.)
Brown, George A., 304 E. Walnut St., Bloomington, Ill. (Education.) (1920.)
Brown, H. Clark, B. S., 409 Hamilton St., St. Charles, Ill. (Botany.) (1924.)
Browne, George M., 902 S. Normal St., Carbondale, Ill. (Chemistry.) (1921.)
Brundage, John T., A. B., A. M., Univ. of Ill., Urbana, Ill. (Physiological Chem.) (1927.)
Buckingham, B. R., Ph. D., Director of Bureau of Educational Research, Ohio State University, Columbus, Ohio. (Education.) (1920.)
Burmeister, Wm. H., M. D., 536 Deming Place, Chicago, Ill. (Experimental Medicine.) (1920.)
Buswell, A. M., Ph. D., Chief. State Water Survey, University of Illinois, Urbana, Ill. (1921.)
Buzzard, Robt. G., M. S., Ill., 608 Normal Ave., Normal, Ill. (Geography and Geology.) (1922.)

Cahn, Alvin R., Ph. D., University of Illinois, Urbana, Ill. (Zoology.) (1925.)
Caldwell, Delia, M. D., 590 W. Main St., Carbondale, Ill. (Medicine.) (1921.)
Cammack, R. R., B. S., 200 E. Blvd., Marion, Ill. (Chemistry.) (1926.)
Campbell, Ian, M. A., Louisiana State University, Baton Rouge, La. (Geology.) (1925.)
Card, H. H., Botany Department, University of Illinois, Urbana, Ill. (Botany.) (1925.)
Carleton, Ralph Pimball, M. A., 3012 Edwards St., Alton, Ill. (Chemistry.) (1926.)
Carlson, A. J., Ph. D., University of Chicago, Chicago, Ill. (Physiology.) (1911.)
Carlson, Fred, E. B., State Teachers College, DeKalb, Ill. (Geography.) (1923.)
***Carman, Albert P.**, Ph. D., University of Illinois, Urbana, Ill. (Physics.) (1908.)
***Carpenter, Chas. K.**, D. D., Baileyville, Ill. (Ornithology.) (1908.)
Causey, David, Ph. D., Zoology Department, Princeton University, Princeton, N. J. (Biology.) (1922.)
Caven, Jordon, M. A., Rockford College, Rockford, Ill. (Psychology.) (1926.)
Challis, Frank E., 121 N. Wabash Ave., Chicago, Ill. (Chemistry.) (1921.)
Chandler, S. C., B. S., Carbondale, Ill. (Entomology.) (1921.)
Chapman, Hazel, 301 W. Washington St., Urbana, Ill. (Zoology.) (1925.)
***Child, C. M.**, Ph. D., University of Chicago, Chicago, Ill. (Zoology.) (1908.)
Christie, J. R., B. S., East Falls Church, Va. (Biology.) (1929.)
Clark, Albert Henry, B. S., 701 W. Wood St., Chicago, Ill. (Chemistry.) (1920.)
Clark, H. Walton, M. A., California Academy of Sciences. Golden Gate Park, San Francisco, Calif. (Biology.) (1917.)
***Clawson, A. B.**, B. A., Dept. of Agri., Washington, D. C. (Biology.) (1908.)
Cletcher, J. O., M. D., 10 N. Main St., Tuscola, Ill. (Medicine.) (1921.)
Clute, W. N., Editor, "The American Botanist," Joliet, Ill. (Botany.) (1918.)
Coale, Henry K., Highland Park, Illinois. (Ornithology.) (1926.)
Coffin, Fletcher B., Ph. D., Lake Forest, Ill. (Physical Chemistry.) (1911.)
Coggeshall, Ruth, B. S., 3927 N. Hamlin Ave., Chicago, Ill. (Biology.) (1924.)
Colby, Arthur Samuel, Ph. D., University of Illinois, Urbana, Ill. (Horticulture.) (1920.)
Colby, Chas. C., Ph. D., University of Chicago, Chicago, Ill. (Geography.) (1920.)
Cole, Fay-Cooper, B. S., Ph. D., 5710 Blackstone, Chicago, Ill. (Anthropology.) (1927.)
Cole, Herman H., M. D., 517 E. Capitol Ave., Springfield, Ill. (Medicine.) (1915.)
Colyer, F. H., M. S., State Normal University, Carbondale, Ill. (Geography.) (1915.)
Combs, Ralph Marion, 1106 Natchitoches, La. (Biology.) (1924.)
Compton, James S., Eureka, Ill. (1914.)
Cox, F. W., M. A., Clark University, Worchester, Mass. (Geography.) (1926.)
***Crandall, Chas. S.**, University of Illinois, Urbana, Ill. (Horticulture.) (1908.)
Crandle, Ellis R., Ed. B., 509 S. Poplar, Carbondale, Ill. (Biology.) (1927.)
Crathorne, A. R., Ph. D., University of Illinois, Urbana, Ill. (Mathematics.) (1920.)
Creager, Gail, Ed. B., Pinckneyville, Ill. (Biology.) (1924.)
Cribb, Aubrey, "The Associated Press," Springfield, Ill. (1921.)
Crompton, Mabel, M. S., 310 Normal Ave., Normal, Ill. (Geography.) (1927.)
Crosier, W. M., M. D., Alexis, Ill. (Medicine.) (1921.)
Crowe, A. B., M. A., Eastern State Teacher's College. Charleston, Ill. (Physics.) (1910.)
Croxton, Orson, B. S., Ed., 413 E. Cherry St., Watseka, Ill. (Chemistry.) (1927.)
Crummer, Mrs. Emma C., 134 S. Kenillworth Ave., Oak Park, Ill. (Botany.) (1925.)
Culler, Elmer A., Ph. D., University of Illinois, Urbana, Ill. (Psychology.) (1927.)
Cullison, Aline, 7855 South Shore Drive, Chicago, Ill. (Biology.) (1923.)
Curran, Gordon, C., B. S., 407 W. Illinois St., Urbana, Ill. (Botany.) (1925.)
Currens, Frederick Hawley, Ph. D., 130 N. Normal St., Macomb, Ill. (Chemistry.) (1914.) (1926.)
Curtis, George M., B. A., M. A., Ph. D., M. D., Billings Hospital, Univ. of Chicago, Chicago. Ill. (Anatomy.) (1927.)
Darling, Elton R., Ph. D., 1293 W. Macon Ave., Decatur, Ill. (1920.)
Dart, Carlton R., 706 Greenleaf Ave., Wilmette, Ill. (Civil Engineering.) (1921.)
Davenport, Eugene, LL. D., Woodland, Mich. (Agriculture.) (1910.)
Davies, D. C., Director, Field Museum. Chicago, Illinois. (1921.)
*Davis, J. J., B. S., Purdue University, Lafayette, Ind. (Entomology.) (1908.)
Day, William B., Ph. G., 715 S. Wood St., Chicago, Ill. (Botany.) (1927.)
Deam, Hon. Chas. C., M. A., Bluffton, Ind. (Forestry and Flora.) (1921.)
Dean, Ella R., B. Ed., 221 S. Mill St., Olney, Ill. (Chemistry.) (1921.)
Deffenbaugh, R. A., B. S., 630 W. Edwards St., Springfield, Ill. (Physics.) (1925.)
DeLee, Jos. B., M. A., 5028 Ellis Ave., Chicago, Ill. (1921.)
DeLoach, R. J. H., M. A., 5541 Dorchester, Chicago, Ill. (Botany, Soils, Economics.) (1926.)
Dempster, A. J., Ph. D., University of Chicago, Chicago, Ill. (Physics.) (1921.)
De Ryke, Willis, Ph. D., 1051 Grove, Jacksonville, Ill. (Biology.) (1927.)
De St. Cyr, William H., D. O., 30 N. Michigan Ave., Chicago, Ill. (Medical Sci. & Physics.) (1927.)
DeTurk, Ernest E., Ph. D., 707 W. Green St., Urbana, Ill. (Agriculture.) (1920.)
Dilts, Charles D., A. B., 3121 Fairfield Ave., Ft. Wayne, Ind. (Chemistry.) (1921.)
Dodge, Lawrence E., B. S., 500 Broadway, Gillespie, Ill. (Chemistry.) (1926.)
Donoghue, Julia O., 5538 Magnolia, Chicago, Ill. (Nature Study.) (1927.)
Doolittle, Rilus, B. S., 313 W. Walnut St., Harrisburg, Ill. (Biology.) (1926.)
Downie, Thos. R., 1216 N. Kellogg St., Galesburg, Ill. (Geology.) (1923.)
Downing, Eliot R., Ph. D., University of Chicago, Ill. (Zoology.) (1913.)
Dufford, R. T., University of Missouri, Columbia, Mo. (Physics.) (1918.)
Dungan, Geo. H., B. S., M. S., Ph. D., University of Ill., Urbana, Ill. (Plant physiology.) (1927.)
Earle, C. A., M. D., DesPlaines, Ill. (Botany.) (1920.)
East, Clarence W., M. D., F. A. S. C., 326 W. Jackson St., Springfield, Ill. (Preventive Medicine.) (1921.)
Eaton, Scott V., Ph. D., University of Chicago, Chicago, Ill. (Botany.) (1925.)
Eddy, Samuel, M. A., Vivarium Bldg., University of Illinois, Urbana, Ill. (Biology.) (1925.)
Edwards, Linden F., B. A., M. S., 301 Nat. Hist. Bldg., University of Illinois. Urbana, Ill. (Zoology.) (1926.)

Ehrman, E. H., M. E., Homan Ave. and Fillmore St., Chicago, Ill. (1920)
Eifrig, C. W. G., 504 Monroe Ave., River Forest, Ill. (Ornithology, Botany, Zoology.) (1920.)
Ekblaw, George Elbert, A. M., 308 Lincoln, Urbana, Ill. (Geology.) (1924.)
Ekblaw, W. E., Ph. D., Clark University, Worchester, Mass. (Geology.) (1908.)
Eklund, Edwin G., M. A., 1451 S. Lincoln St., Springfield, Ill. (Psychology.) (1925.)
Eldredge, Arthur G., University of Illinois, Urbana, Ill. (Photography.) (1916.)
Ellison, Lewis M., 214 W. Kinzie St., Chicago, Ill. (Engineering.) (1927.)
Eller, W. H., S. B., 230 N. Ward St., Macomb, Ill. (Physics.) (1924.)
Englis, Duane T., Ph. D., University of Illinois, Urbana, Ill. (Chemistry.) (1917.)
Esmaker, John Benjamin, M. A., 1076 W. Roosevelt Road, Chicago, Ill. (Physics.) (1926.)
Evans, Frank N., M. D., 407 S. Seventh St., Springfield, Ill. (Medicine.) (1925.)
Ewing, H. E., U. S. Nat. Museum, Washington, D. C. (Biology.) (1908.)
Falk, I. S., Ph. D., University of Chicago, Chicago, Ill. (Bacteriology and Hygiene.) (1925.)
Farnam, Bertha L., Carbondale, Ill. (Biology.) (1927.)
Fasoldt, Karl N., B. Ph., Johnston City, Ill. (Botany.) (1927.)
Faught, Eva E., 841 S. English Ave., Springfield, Ill. (Bacteriology.) (1925.)
Faust, Mildred E., M. S., 848 Lancaster Ave., Syracuse, N. Y. (Botany.) (1925.)
Ferguson, Harry F., S. B., Dept. Public Health, Springfield, Ill. (Sanitary Engineer.) (1925.)
Fetter, Dorothy, M. S., Rockford College, Rockford, Ill. (Physiology.) (1926.)
Feuer, Bertram, M. S., 2634 Argyle St., Chicago, Illinois. (Chemistry and Bacterology.) (1921.)
Finley, C. W., M. A., State College of Education, Upper Montclair, N. J. (Zoology.) (1910.)
Fisher, D. Jerome, Ph. D., Rosenwald Hall, University of Chicago, Chicago, Ill. (Geology.) (1926.)
*Fisher, Fannie, Ass't Curator, State Museum, Springfield, Ill. (General Interest.) (1908.)
Fiske, David, M. S., Amer. Soc. Refrigerating Engineers, 29 W. 29th St., New York, N. Y. (Physics.) (1926.)
Flint, W. P., Ass't State Entomologist, 1006 S. Orchard St., Urbana, Ill. (Entomology.) (1914.)
Foberg, J. Albert, B. S., Camp Hill, Pa. (Mathematics.) (1917.)
Folsom, Justus W., Sc. D., Tallulah, La. (Entomology.) (1916.)
Foreman, Blye E., B. E., 801 Hester Ave., Normal, Ill. (Zoology.) (1927.)
Franing, E. C., M. D., 404 Bank of Galesburg Bldg., Galesburg, Ill. (Medicine.) (1921.)
Franing, Russell, A. B., Dundee Community High School, Dundee, Ill. (Chemistry.) (1924.)
Frank, O. D., 6207 Kimbark Ave., Chicago, Ill. (Biology.) (1918.)
Freeman, Harriette, M. S., 111 S. Eastern, Joliet, Ill. (Botany.) (1927.)
French, G. H., M. A., Herrin Hospital, Herrin, Ill. (Botany and Entomology.) (1921.)
Frison, Theodore H., Ph. D., 316-A-Natural History Bldg., University of Illinois, Urbana, Ill. (Entomology, General Biology.) (1917.)
Fryxell, Fritiof M., M. A., 715 3rd St., Moline, Ill. (Geology.) (1925.)
Funk, Donald S., B. A., Sangamo Electric Co., Springfield, Ill. (1925.)
Gamble, Faith, 206 Clintin Ave., Oak Park, (1926.)
Gantz, R. A., 411 N. Talley St., Muncie, Ind. (Botany.) (1917.)
Garnett, H. W., B. S., Bloomington, Ill. (Chemistry.) (1927.)
Gault, B. T., 564 N. Main St., Glen Ellyn, Ill. (Ornithology.) (1910.)
Gawlt, Robert H., Ph. D., Northwestern University, Evanston, Ill. (Psychology.) (1926.)
Gay, Berry E., Ph. G., 720 W. Olive St., Decatur, Ill. (Bacteriology.) (1927.)
Geauque, H. A., Lombard St., Galesburg, Ill. (Chemistry.) (1923.)
Gerhard, Wm. J., Field Museum, Chicago, Ill. (1908.)
Gerould, T. F., M. D., 115½ N. Locust St., Centralia, Ill. (Medicine.) (1921.)
Gersbacher, Willard M., Ed. B., 301 Nat. Hist. Bldg., Urbana, Ill. (Zoology.) (1926.)
Givens, Harry V., B. S., Midland Ave., Joliet, Ill. (Biology.) (1927.)
Glattfeld, J. W. E., Ph. D., Kent Chemical Laboratory, University of Chicago, Chicago, Ill. (Chemistry.) (1921.)
Goldstine, Mark T., M. D., L. M., Chicago, Ill. (Medicine.) (1926.)
Goode, J. Paul, Ph. D., 6227 Kimbark Ave., Chicago, Ill. (Geography.) (1912.)
Gore, G. W., M. D., 231 N. McCleamsboro St., Benton, Ill. (Internal Med.) (1921.)
Gorrell, T. J. H., M. D., Chicago Heights, Ill. (Medicine.) (1921.)
Gould, Prof. Wm. C., M. A., 625 DeKalb Ave., DeKalb, Ill. (Geography.) (1925.)
Gradle, Harry S., M. D., 22 E. Washington St., Chicago, Ill. (Opthalmology.) (1920.)
Graham, Robert, B. S., D. V. M., 105 Animal Pathology, University of Illinois, Urbana, Ill. (Pathology.) (1910.)
Graham, V. O., M. S., 4028 Grace St., Chicago, Ill. (Botany.) (1926.)
***Grant, U. S.**, Ph. D., Northwestern University, Evanston, Ill. (Geology.) (1908.)
Greathouse, G. A., B. E., West Salem, Ill. (Biology.) (1927.)
Green, Bessie, M. A., Oregon State Agr. Coll., Corvallis, Ore. (Zoology.) (1911.)
Green, Helen R., A. B., 309 W. Church St., Benton, Ill. (1927.)
Greenman, J. M., Ph. D., Missouri Botanical Garden, St. Louis, Mo. (Botany.) (1911.)
Greer, Frank E., A. B., M. S., 5458 Kimbark Ave., Chicago, Ill. (Bacteriology.) (1927.)
Griffin, J. P., A. B., 909½ S. Fifth St., Champaign, Ill. (Geology.) (1927.)
Griffith, Coleman R., Ph. D., University of Illinois, Urbana, Ill. (Psychology.) (1920.)
Gronemann, Carl F., 310 N. Liberty St., Elgin, Ill. (Artist, Naturalist.) (1921.)
Grove, P. F., M. A., 603 E. Ridge St., Mt. Carroll, Ill. (Botany.) (1926.)
Gurley, William F. E., 6151 University Ave., Chicago, Ill. (Paleontology.) (1908.)
Haas, William H., M. A., Northwestern University, Evanston, Ill. (Geography.) (1914.)
Haefuer, R., M. A., 1538 4th St., Charleston, Ill. (Psychology.) (1926.)
Hagler, Mrs. E. S., 1900 W. Lawrence Ave., Springfield, Ill. (1910.)
*Hale, John A., M. D., 117½ W. Ninth St., Los Angeles, Calif. (Medicine.) (1908.)
Hamilton, Angelina G., M. D., State Hospital, Anna, Ill. (Psychiatry.) (1926.)
Hamp, Mattie S., Rosiclare High School, Rosiclare, Ill. (Biology.) (1926.)
Hanke, Martin E., S. B., Ph. D., 8424 Rhodes Ave., Chicago, Ill. (Physiology and Chem.) (1927.)
Hanks, Mary E., M. D., 307 N. Michigan Ave., Chicago, Ill. (Roentgentheraphy.) (1927.)
Hansen, Paul, 9741 Avenue H, Chicago, Ill., (Geology.) (1927.)

Hansen, Paul, 6, No. Michigan Ave., Chicago, Ill. (Sanitation.) (1913.)
Hardin, Sarah M., Ph. B., 402 W. Walnut St., Carbondale, Ill. (Biology.) (1924.)
Harding, H. A., Ph. D., 685 Mullett St., Detroit, Mich. (Bacteriology.) (1916.)
Harland, Marion B., B. S., 655 Old Agriculture Bldg., University of Illinois. Urbana, Ill. (Soils.) (1925.)
Hartman, Ernest, B. S., M. S., Sc. D., 602 W. High, Urbana, Ill. (Parasitology.) (1927.)
Hartsough, Ralph C., A. M., 3808 Grove Ave., Berwyn, Ill. (Biology.) (1922.)
Harvey, Alice L., B. A., 2036 Spruce St., Murphysboro, Ill. (Chemistry.) (1926.)
Hauberg, John H., B. S., LL. B., 23rd St. Hill and 13th Ave., Rock Island, Ill. (Botany.) (1921.)
Hauberg, Mrs. John H., 23d St., Hill and 13th Ave., Rock Island, Ill. (1921.)
Haupt, Arthur W., University of California, Los Angeles, Calif. (Botany.) (1912.)
Hawkes, Joseph Bulkley, A. B., 825 N. Church St., Rockford, Ill. (Botany.) (1925.)
Hawley, Gladys, B. S., Editor, State Geological Survey, Urbana, Ill. (Geology.) (1926.)
Hawthorne, W. C., B. S., 1410 E. 58th St., Chicago, Ill. (1908.)
Hay, Logan, B. A., 1220 S. Grand Ave., W., Springfield, Ill. (Mathematics.) (1925.)
Hayes, Wm. P., Ph. D., 306 Old Law Bldg., Urbana, Ill. (Entomology.) (1926.)
Hazell, E. F., D. D. S., 608 E. Capitol Ave., Springfield, Ill. (Meteorology.) (1925.)
Hedrick, Leslie, A. B., 410 Conover Ave., Eureka, Ill. (Zoology.) (1927.)
Heflin, H. N., M. D., Kewanee, Ill. (Medicine.) (1921.)
Hemenway, Henry B., M. D., 620 Amos Ave., Springfield, Ill. (Public Health.) (1918.)
Henbest, Lloyd G., A. B., 305 Ceramics Bldg., Univ. of Ill., Urbana, Ill. (Geology and Biology.) (1927.)
Henderson, Lena B., M. S., Rockford College, Rockford, Ill. (Botany.) (1926.)
Henderson, Luther B., M. A., B. D., 176 Woodlawn Ave., Decatur, Ill. (Psychology.) (1925.)
Hendrickson, Eliz., B. S., 3501 Montrose Ave., Chicago, Ill. (Botany.) (1926.)
Henkel, H. B., M. D., 401 E. Capitol Ave., Springfield, Ill. (Medicine.) (1925.)
Herndon, R. F., 407 S. Seventh St., Springfield, Ill. (Medicine.) (1925.)
Herrick, C. Judson, Ph. D., University of Chicago, Chicago, Ill. (Anatomy.) (1920.)
Herrick, Julia F., M. A., Mayo Foundation, Rochester, Minn. (Physics.) (1926.)
Herron, James C., 1417 W. Jackson Blvd., Chicago, Ill. (Illuminating Engineer.) (1926.)
Hieronymus, R. E., LL. D., 109 New Agricultural Bldg., University of Illinois. Urbana, Ill. (1926.)
Higgins, George M., Ph. D., Inst. Experimental Medicine, Rochester, Minn. (Zoology.) (1921.)
Higginson, Glenn D., Ph. D., 1117 W. Illinois St., Urbana, Ill. (Psychology.) (1927.)
Higley, L. A., Ph. D., Box 336, Wheaton, Ill. (Chemistry.) (1926.)
Hildebiand, L. E., M. A., New Trier Township High School, Winetka, Ill. (Zoology.) (1911.)
***Hill, W. K.**, Carthage College, Carthage, Ill. (Biology.) (1908.)
Hinchliff, Grace F., 715 N. Broad St., Galesburg, Ill. (1916.)
Hines, Murray A., Ph. D., 1416 Hinman Ave., Evanston, Ill. (Chemistry.) (1914.)
Hinrichs, Marie A., Ph. D., University of Chicago, Chicago, Ill. (General Physiology.) (1926.)
Hockenyos, Geo. L., 1003 Oregon St., Urbana, Ill. (Botany.) (1927.)
Hoffman, Frand F., M. D., 3117 Logan Blvd., Chicago, Ill. (Phys. Surg.) (1921.)
Holgate, T. P., LL. D., 617 Library St., Evanston, Ill. (Mathematics.) (1908.)
Holmes, Harriet F. (Miss), A. B., South Batavia Rd., Batavia, Ill. (Plant Pathology.) (1927.)
Holmes, Leslie A., 249 Nat. Hist. Bldg., University of Illinois, Urbana, Ill. (Geology.) (1926.)
Holmes, Manfred J., B. L., 703 Broadway, Normal, Ill. (Social and Education.) (1920.)
Holmes, Ralph R., M. D., 458 W. 61 St., Chicago, Ill. (Astronomy.) (1926.)
Holtz, F. C., B. S., 1358 Dial Court, Springfield, Ill. (Mathematics.) (Physics.) (1925.)
Honey, Edwin E., B. S., 2028 Monroe St., Madison, Wis. (Plant Pathology, Botany, Entomology.) (1921.)
Hopkins, B Smith, Ph. D., 706 W. California St., Urbana, Ill. (Inorganic Chemistry.) (1920.)
Hopkins, Frank, Makanda, Illinois. (Optometry.) (1926.)
Horrell, C. R., B. S., Sangamo Electric Co., Springfield, Ill. (Electrical Engineering.) (1925.)
Hottes, C. F., Ph. D., University of Illinois, Urbana, Ill. (Botany.) (1908.)
Howe, Samuel W., Ed. B., 311 N. 14th St., Herrin, Ill. (1925.)
Howe, T. D., Ph. D., 1310 W. Main, Decatur, Ill. (Botany.) (1925.)
Hudelson, C. W., M. S., 206 S. Main St., Normal, Ill. (Agriculture.) (1921.)
Huey, Walter B., M. D., Elgin, Joliet & Eastern Ry., Joliet, Ill. (Medicine.) (1921.)
Hufford, G. N., A. B., 216 Seeser, Joliet, Ill. (Botany.) (1927.)
Hull, Thos. G., Ph. D., State Board of Health, Springfield, Ill. (Health.) (1921.)
Hungerford, Warren, H., 1920 City Hall Square Bldg., Chicago, Ill. (Physics.) (1927.)
Hunter, George W., Ph. D., 210 Mesa Ave., Claremont, Calif. (Biology.) (1921.)
***Hutton, J. Gladden**, M. S., State College, Brookings, S. D. (Geology.) (1908.)
Illinois State Library, State House, Springfield, Ill. (1921.)
Isenbarger, Jerome, B. S., 2200 Greenleaf Ave., Chicago, Ill. (Zoology.) (1921.)
Jackson, George H., Jr., M. D., 310 S. Michigan Ave., Chicago, Ill. (Medicine.) (1926.)
Jacobi, Wm. H., M. E., Springfield Boiler Co., Springfield, Ill. (Physical Chemistry.) (1925.)
Jacobs, Margaret C., 413 Leland St., Baraboo, Wis. (Botany.) (1925.)
Jane, Wm. T., 5 N. Wabash Ave., Chicago, Ill. (Bausch & Lomb Opt. Co.) (1921.)
Janson, Ardylle A., 636 Church St., Evanston, Ill. (Bacteriology.) (1927.)
Jelliff, Fred R., B. A., Editor, Daily Republican-Register, Galesburg, Ill. (Geology.) (1917.)
Jenks, Ira J., M. S., State Teachers College, DeKalb, Ill. (Chemistry.) (1922.)
Jensen, Jens, Ravinia, Ill. (Geology-Botany.) (1921.)
Johnson, George F., 625 Black Ave., Springfield, Ill. (Astronomy.) (1914.)

Johnson, John H., B. Ed., Supt. of Schools, Tremont, Ill. (Biology.) (1923.)
Johnson, T. Arthur, M. D., 503 7th St., Rockford, Ill. (Medicine, Science and Surgery.) (1920.)
Jones, Elmer E., Ph. D., Northwestern University, Evanston, Ill. (Mental Development-Heredity.) (1920.)
Jurica, Hilary S., St. Procopius College, Lisle, Ill. (Botany.) (1922.)
Kaplan, Bertha, M. S., B. S., 1350 S. Avers Ave., Chicago, Ill. (Bacteriology and Parasitology.) (1927.)
Karr, Gertrude, B. A., Fredericksburg, Va. (Botany.) (1925.)
Karraker, Edward L., Jonesboro, Ill. (Forestry.) (1921.)
Kauffman, J. S., M. D., 5605 Woodlawn Ave., Chicago, Ill. (Medicine.) (1920.)
Kelsey, Alice B., A. M., So. Ill. State Normal, Carbondale, Ill. (Mathematics.) (1926.)
Kelso, Margut A., 6 Cedar Crest, Normal, Ill. (Chemistry.) (1925.)
Kempton, F. E., M. S., Centerville, Ind., (Plant Pathology.) (1917.)
Kennedy, E. V., Ed. B., Ava, Ill. (Biology.) (1925.)
Kennicott, Ransom, 547 Cook Co. Bldg., Chicago, Ill. (Forestry.) (1921.)
Kent, R. A., Ph. D., 625 Emerson St., Evanston, Ill. (Education.) (1926.)
Keyes, D. B., B. A., M. A., Ph. D., 107 Chem. Bldg., Urbana, Ill. (Chemistry.) (1927.)
Kibbe, Alice L., Denhart Hall, Carthage, Ill. (Botany.) (1925.)
Kienholz, Aaron Raymond, Ph. D., 606 Washington St., Urbana, Ill. (Botany.) (1925.)
Kirkpartick, Amy R., Anna, Ill. (Artist.) (1926.)
Kirn, George H., Ph. D., D. D., Northwestern College, Naperville, Ill. (Psychology and Philosophy.) (1923.)
Kline, R. G., M. D , Hoopeston, Ill. (Medicine.) (1921.)
*Kneale, Elmer J., Ill. State Register, Springfield, Ill. (Astronomy.) (1908.)
***Knipp, Charles T.**, Ph. D., University of Illinois, Urbana, Ill. (Physics.) (1908.)
Koch, Fred Conrad, Ph. D., University of Chicago, Chicago, Ill. (Physiological Chemistry.) (1920.)
Koontz, D. Lionel, 902 Reba Place, Evanston, Ill. (Mechanical Engineer.) (1926.)
Kordiemon, Anna M., 825 Washington, Quincy, Ill. (1926.)
Krause, Heinrich, D. D. L., 2938 Normal Ave., Chicago, Ill. (Anthropology.) (1926.)
Krenz, Mathilde H., B. A., A. M., 1002 W. Oregon St., Urbana, Ill. (Botany.) (1925.)
Kuh, Sidnev, M. D., 30 N. Michigan Ave., Chicago, Ill. (Medicine.) (1911.)
Lackie, G. D., M. D., Springfield, Ill. (Medicine.) (1927.)
Lacy, Robert, M. E., 1354 Dial Court, Springfield, Ill. (Engineer.) (1925.)
Lake, Bae M., B. E., 203 Grand Ave., Lincoln, Ill. (Biology.) (1927.)
Lamar, J. Everts, B. S., State Geological Survey Div., Urbana, Ill. (Geology.) (1924.)
Lambert Earl L., B. S., 217 N. 1st St., Carthage, Ill. (Botany and Zoology.) (1917.)
Land, W. J. G., Ph. D., University of Chicago, Chicago, Ill. (Botany.) (1911.)
Landon, R. E., 4122 N. Keystone Ave., Chicago, Ill. (1926.)
Langford, George, B. S., McKenna Process Co., Joliet, Ill. (Paleontology.) (1908.)
Lanphier, Robert C., Ph. B., Sangamo Electric Co., Springfield, Ill. (Electricity.) (1914.)
Large, J. M., A. B., 105 Mound, Joliet, Ill. (Geography.) (1927.)
Larned, S. J., M. E., 212 W. Washington St., Chicago, Ill. (Physics.) (1926.)
Larson, E. A., B. A., M. S., 115 Cagwir, Joliet, Ill. (Chemistry.) (1927.)
Larson, Karl C., B. A., Augustana College, Rock Island, Ill. (Chemistry.) (1917.)
Lathrop, W. G., Principal Township High School, Johnston City, Ill. (Geology and Geography.) (1922.)
Laufer, D. Berthold, Ph. D., Field Museum, Chicago, Ill. (Archaeology.) (1925.)
Laves, Kurt, Ph. D., University of Chicago, Chicago, Ill. (Astronomy and Mathematics.) (1920.)
Leech, Bert S., Ph. B., A. M., Highland Park, Ill. (Biology.) (1927.)
Leighton, Morris Morgan, Ph. D., Chief, Illinois Geological Survey Division, Urbana, Ill. (Geology.) (1920.)
Leonard, Thos. H., M. D., 509 S. 6th St., Springfield, Ill. (Medicine.) (1925.)
Lessman, Lem. L., 412 N. Monroe, Peoria, Ill. (1926.)
Lewis, Howard B., Ph. D., University of Michigan, Medical School, Ann Arbor, Michigan (Physiology, Chemistry.) (1920.)
Lewis, Julian H., D. D., Ricketts Laboratory, University of Chicago, Chicago, Ill. (Pathology.) (1921.)
Lichty, Daniel, M. D., Harlem Blvd., Rockford, Ill. (Collateral Anthropology.) (1926.)
Linder, O. A., 208 N. Wells St., Chicago, Ill. (1910.)
Link, T. A., Geology Department, Imperial Oil, Ltd., Calgary, Alberta, Canada. (Geology.) (1926.)
Linkins, R. H., M. A., 706 Broadway, Normal, Ill. (Zoology.) (1917.)
Loach, R. J. H., A. M., 5541 Dorchester Ave., Chicago, Ill. (Biology.) (1927.)
Lockie, G. D., M. D., Springfield, Ill. (Archeology.) (1927.)
Lodge, Fred S., B. S., 423 S. Stone Ave., LaGrange, Ill. (Zoology, Agriculture, Chemistry.) (1926.)
Logan, C. C., B. S., So. Ill. Normal University, Carbondale, Ill. (Agriculture.) (1926.)
Logan, Hay, A. B., 1220 S. Grand Ave., Springfield, Ill. (Mathematics.) (1927.)
Logsdon, Mrs. M. I., Ph. D., University of Chicago, Chicago, Ill. (Mathematics.) (1923.)
Longbons, Elizabeth, B. S., 2 E. Walnut, Harrisburg, Ill. (Chemistry.) (1925.)
Longden, A. C., Ph. D., Knox College, Galesburg, Ill. (Physics.) (1917.)
Lukens, Herman T., Ph. D., 330 Webster Ave., Chicago, Ill. (Geography.) (1920.)
Lutes, Neil, 1595 Atlantic St., Dubuque, Iowa. (Chemistry.) (1912.)
Lyon, William I., 124 Washington, Waukegan, Ill. (Ornithology.) (1926.)
Mac Dowell, Charles H., D. Sc., 111 W. Jackson Blvd., Chicago, Ill. (Chemistry.) (1926.)
Mackie, Arthur D., 400 E. Monroe St., Springfield, Ill. (Electricity.) (1915.)
MacLeod, J. B., 1046 W. Division St., Chicago, Ill. (Chemistry.) (1927.)
MacMillan, W. D., Ph. D., University of Chicago, Chicago, Ill. (Astronomy.) (1922.)
Madison, Wm. D., M. D., Eureka, Ill. (Medicine.) (1921.)
Magill, Henry P., 175 W. Jackson Blvd., Chicago, Ill. (Geology, Sociology, Finance.) (1920.)
Main, Helen, B. S., Gladstone Hotel, Chicago, Ill. (Botany.) (1927.)

Malinovsky, A., Washington Iron Works, Los Angeles, Calif. (Chemistry.) (1920.)
Mann, A. L., M. D., 392 E. Chicago St., Elgin, Ill. (Medicine.) (1921.)
Mann, Jessie R., B. S., State Teachers College, DeKalb, Ill. (Biology.) (1923.)
Marks, Sarah, Pecatonica, Ill. (Biology.) (1917.)
Markus, H. C., Vienna, Ill. (Geology.) (1926.)
Martin, George W., Ph. D., Washington and Jefferson College, Washington, Penn. (Biology.) (1923.)
Marvel, Carl S., Ph. D., University of Illinois, Urbana, Ill. (Chemistry.) (1927.)
Mason, Arthur J., 5715 Woodlawn Ave., Chicago, Ill. (1921.)
Mason, Carol Y., M. A., 1201 W. Oregon St., Urbana, Ill. (Geography, Botany.) (1926.)
Maynard, M. M., A. B., A. M., 734 E. Boston, Monmouth, Ill. (Psychology and Education.) (1927.)
McClure, S. M., Box 57, Lebanon, Ill. (1921.)
McCollom, Roy M., 101 Broadway, Normal, Ill. (Geography.) (1923.)
McCoy, Herbert N., Ph. D., 161 E. Grand Blvd., Chicago, Ill. (Chemistry.) (1914.)
McCulloch, E. C., D. V. M., 8 Bungalow St., Champaign, Ill. (Parasitology.) (1927.)
McDavitt, Neva, 303 North St., Normal, Ill. (Geography.) (1925.)
McDougall, W. B., Ph. D., University of Illinois, Urbana, Ill. (Botany.) (1916.)
McEvoy, S. Aleta, B. S., Rockford High School, Rockford, Ill. (Chemistry.) (1923.)
McGinnis, Helen A., 6400 S. Maplewood Ave., Chicago, Ill. (General Science.) (1923.)
McKee, W. A., D. D. S., East Side Square, Benton, Ill. (1922.)
McMaster, Archie J., 102 W. Iowa St., Urbana, Ill. (Physics and Chemistry.) (1922.)
McShane, John J., 811 S. State St., Springfield, Ill. (Medicine.) (1925.)
Mecham, John B., Ph. D., 118 S. Center St., Joliet, Ill. (1917.)
Metcalf, C. L., Ph. D., Nat. Hist. Bldg., University of Illinois, Urbana, Ill. (Entomology.) (1925.)
Metzner, Albertine E., M. S., 24 Marshner St., Plymouth, Wis. (Geology, Physics.) (1918.)
***Michelson, A. A.**, LL. D., University of Chicago, Chicago, Ill. (Physics.) (1908.)
Miller, Isiah Leslie, M. A., College Station, Box 53, Brookings, So. Dakota. (Mathematics and Chemistry.) (1920.)
Miller, P. H., High School, Henning, Ill. (Biology.) (1920.)
Miller, R. B., M. F., 121 Capitol Bldg., Department of Conservation, Springfield, Ill. (Forestry and Ecology.) (1920.)
Mitchell, Catharine, A. B., 144 Fairbank Road, Riverside, Ill. (Botany and Ornithology.) (1925.)
Mohme, Fred S., A B., 255 Natural Hist. Bldg., Univ. of Ill., Urbana, Ill. (Geography.) (1927.)
Mongerson, Oscar V., B. S., Chenoa, Ill. (Physics.) (1925.)
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TRANSACTIONS

OF THE

Illinois State Academy of Science

TWENTY-FIRST ANNUAL MEETING

BLOOMINGTON—NORMAL
ILLINOIS
May 4 and 5, 1928

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A. R. Crook, *Librarian.*

State Museum, Springfield, Ill.

	PRICE.
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Vol. III, 1910, paper binding. Published by the Academy......	1.50
Vol. IV, 1911, paper binding. Published by the State..........	Gratis
Vol. V, 1912, paper binding. Published by the State...........	Gratis
Vol. VI, 1913, paper binding. Published by the Academy......	1.50
Vol. VII, 1914, paper binding. Published by the Academy......	1.50
Vol. VIII, 1915, paper binding. Published by the Academy.....	1.50
Vol. IX, 1916, paper binding. Published by the Academy......	1.50
Vol. X, 1917, paper binding. Published by the Academy.......	1.50
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Vol. XII, 1919, paper binding. Published by the State.........	Gratis
Vol. XIII, 1920, paper binding. Published by the State........	Gratis
Vol. XIV, 1921, paper binding. Published by the State........	Gratis
Vol. XV, 1922, paper binding. Published by the State........	Gratis
Vol. XVI, 1923, paper binding. Published by the State........	Gratis
Vol. XVII, 1924; paper binding. Published by the State........	Gratis
Vol. XVIII, 1925, paper binding. Published by the State......	Gratis
Vol. XIX, 1926, paper binding. Published by the State........	Gratis
Vol. XX, 1927, paper binding. Published by the State.........	Gratis
Vol. XXI, 1928, paper binding. Published by the State........	Gratis

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OFFICERS AND COMMITTEES FOR 1928-1929.

President, CLARENCE BONNELL, Harrisburg Township High School, Harrisburg.

First Vice-President—R. H. LINKINS, Illinois State Normal University, Normal.

Second Vice-President, FRED H. CURRENS, Western Illinois State Teachers College, Macomb.

Secretary, LYELL J. THOMAS, University of Illinois, Urbana.

Treasurer, GEO. D. FULLER, University of Chicago, Chicago.

Librarian, A. R. CROOK, State Museum, Springfield.

The Council.

The Council is composed of the above officers and the last two retiring presidents.

Committee on Membership.

MRS. ELEANOR C. SMITH, Englewood High School, Chicago, Chairman.
W. P. HAYES, University of Illinois, Urbana.
R. G. BUZZARD, Illinois State Normal University, Normal.
V. A. LATHAM, 1644 Morse Ave., Chicago.
J. H. RANSOM, James Millikin University, Decatur.

Committee on Affiliation.

H. R. GEAUQUE, Lombard College, Galesburg, Chairman.
W. G. WATERMAN, Northwestern University, Evanston.
W. S. BAYLEY, University of Illinois, Urbana.
C. T. KNIPP, University of Illinois, Urbana.
L. W. SMITH, Joliet Township High School, Joliet.

Committee on Ecological Survey.

E. L. STOVER, State Teachers' College, Charleston, Chairman.
W. G. WATERMAN, Northwestern University, Evanston.
V. O. GRAHAM, University of Chicago, Chicago.
SAMUEL EDDY, University of Illinois, Urbana.
W. B. McDOUGALL, University of Illinois, Urbana.
R. B. MILLER, Dept. of Conservation, Springfield.
C. J. TELFORD, State Natural History Survey, Urbana.
RUTH MARSHALL, Rockford College, Rockford.
C. E. MONTGOMERY, State Teachers' College, DeKalb.
L. W. TURNER, Blackburn College, Carlinville.
MARY M. STEAGALL, State Normal University, Carbondale.

Committee on Conservation.

H. C. COWLES, University of Chicago, Chicago, Chairman.
M. M. LEIGHTON, Chief, Geological Survey Division, Urbana.
W. N. CLUTE, Editor, American Botanist, Joliet.
W. H. HAAS, Northwestern University, Evanston.
JENS JENSEN, Landscape Architect, Ravinia.

Committee on Legislation and Finance.

FRED R. JELLIFF, Editor, Daily Republican Register, Galesburg, Chairman.
DON W. DEAL, Leland Office Building, Springfield.
EDWARD W. PAYNE, First Trust & Savings Bank, Springfield.
H. C. COWLES, University of Chicago, Chicago.
F. H. COLYER, Southern Illinois State Teachers' College, Carbondale.

Committee on Publications.

THE PRESIDENT.
THE SECRETARY.
R. E. RICHARDSON, State Natural History Survey, Urbana.

Committee on High School Science and Clubs.

MISS S. ALETA MCEVOY, Rockford High School, Rockford, Chairman.
LOUIS A. ASTELL, West Chicago Community High School, West Chicago.
H. H. RADCLIFFE, Decatur.
ROSALIE M. PARR, University of Illinois, Urbana.
H. W. GARNETT, Bloomington High School, Bloomington.

Delegate to the American Association for the Advancement of Science.

H. B. WARD, University of Illinois.

Delegates to the Conservation Council of Chicago.

W. G. WATERMAN, Northwestern University, Evanston.
V. O. GRAHAM, University of Chicago, Chicago.

PAST OFFICERS OF ILLINOIS STATE ACADEMY OF SCIENCE.

1907

(Organization meeting, Dec. 7, 1907, Springfield.)

Chairman, U. S. GRANT, Northwestern University.
Secretary, A. R. CROOK, State Museum, Springfield.

1908

(First annual meeting, Decatur, Feb. 22, 23, 1908.)

President, T. C. CHAMBERLAIN, University of Chicago.
Vice-President, HENRY CREW, Northwestern University.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, J. C. HESSLER, James Millikin University.

1909

(Second annual meeting, Springfield, Feb. 20, 1909.)

President, T. C. CHAMBERLAIN, University of Chicago.
Vice-President, HENRY CREW, Northwestern University.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, J. C. HESSLER, James Millikin University.

1910

(Third annual meeting, Urbana, Feb. 18, 19, 1910.)

President, S. A. FORBES, University of Illinois.
Vice-President, JOHN M. COULTER, University of Chicago.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, J. C. HESSLER, James Millikin University.

1911

(Fourth annual meeting, Chicago, Feb. 17, 18, 1911.)

President, JOHN M. COULTER, University of Chicago.
Vice-President, R. O. GRAHAM, Illinois Wesleyan University.
Secretary, A. R. CROOK, State Museum, Springfield.
Treasurer, J. C. HESSLER, James Millikin University.

1912

(Fifth annual meeting, Bloomington, Feb. 23, 24, 1912.)

President, W. A. Noyes, University of Illinois.
Vice-President, J. C. Udden, University of Texas.
Secretary, Frank C. Baker, Chicago Academy of Science.
Treasurer, J. C. Hessler, James Millikin University.

1913

(Sixth annual meeting, Peoria, Feb. 21, 22, 1913.)

President, Henry Crew, Northwestern University.
Vice-President, A. R. Crook, State Museum, Springfield.
Secretary, Otis W. Caldwell, University of Chicago.
Treasurer, J. C. Hessler, James Millikin University.

1914

(Seventh annual meeting, Evanston, Feb. 20, 21, 1914.)

President, Frank W. DeWolf, State Geological Survey, Urbana.
Vice-President, H. S. Pepoon, Lake View High School, Chicago.
Secretary, E. N. Transeau, Eastern Illinois State Normal School, Charleston.
Treasurer, J. C. Hessler, James Millikin University.

1915

(Eighth annual meeting, Springfield, Feb. 19, 20, 1915.)

President, A. R. Crook, State Museum, Springfield.
Vice-President, U. S. Grant, Northwestern University.
Secretary, E. N. Transeau, Eastern Illinois State Normal School, Charleston.
Treasurer, J. C. Hessler, James Millikin University.

1916

(Ninth annual meeting, Urbana, Feb. 18, 19, 1916.)

President, U. S. Grant, Northwestern University.
Vice-President, E. W. Washburn, University of Illinois.
Secretary, A. R. Crook, State Museum, Springfield.
Treasurer, H. S. Pepoon, Lake View High School, Chicago.

1917

(Tenth annual meeting, Galesburg, Feb. 23, 24, 1917.)

President, William Trelease, University of Illinois.
Vice-President, H. E. Griffith, Knox College, Galesburg.
Secretary, J. L. Pricer, State Normal University, Normal.
Treasurer, H. S. Pepoon, Lake View High School, Chicago.
Librarian, A. R. Crook, State Museum, Springfield.

1918

(Eleventh annual meeting, Joliet, Feb. 22, 23, 1918.)

President, J. C. Hessler, James Millikin University.
Vice-President, James H. Ferriss, Joliet.
Secretary, J. L. Pricer, State Normal University, Normal.
Treasurer, T. L. Hankinson, State Normal School, Charleston.
Librarian, A. R. Crook, State Museum, Springfield.

1919

(Twelfth annual meeting, Jacksonville, March 21, 22, 1919.)

President, R. D. Salisbury, University of Chicago.
Vice-President, Isabel S. Smith, Illinois College, Jacksonville.
Secretary, J. L. Pricer, State Normal University, Normal.
Treasurer, T. L. Hankinson, State Normal School, Charleston.
Librarian, A. R. Crook, State Museum, Springfield.

1920

(Thirteenth annual meeting, Danville, Feb. 20, 21, 1920.)

President, Henry B. Ward, University of Illinois.
Vice-President, Geo. D. Fuller, University of Chicago.
Secretary, J. L. Pricer, State Normal University, Normal.
Treasurer, W. G. Waterman, Northwestern University.
Librarian, A. R. Crook, State Museum, Springfield.

1921

(Fourteenth annual meeting, Carbondale, April 29, 30, 1921.)

President, Henry C. Cowles, University of Chicago.
Vice-President, Chas. T. Knipp, University of Illinois.
Secretary, J. L. Pricer, State Normal University, Normal.
Treasurer, W. G. Waterman, Northwestern University.
Librarian, A. R. Crook, State Museum, Springfield.

1922

(Fifteenth annual meeting, Rockford, April 27, 28, 29, 1922.)

President, Chas. T. Knipp, University of Illinois.
Vice-President, Miss Ruth Marshall, Rockford College, Rockford.
Secretary, C. Frank Phipps, State Teachers' College, DeKalb.
Treasurer, Wm. F. Schulz, University of Illinois.
Librarian, A. R. Crook, State Museum, Springfield.

1923

(Sixteenth annual meeting, Galesburg, May 3, 4, 5, 1923.)

President, W. S. Bayley, University of Illinois.
Vice-President, W. G. Waterman, Northwestern University.
Secretary, C. Frank Phipps, State Teachers' College, DeKalb.
Treasurer, Wm. F. Schulz, University of Illinois.
Librarian, A. R. Crook, State Museum, Springfield.

1924

(Seventeenth annual meeting, Elgin, May 1, 2, 3, 1924.)

President, W. G. Waterman, Northwestern University.
Vice-President, H. J. Van Cleave, University of Illinois.
Secretary, C. Frank Phipps, State Teachers' College, DeKalb.
Treasurer, Wm. F. Schulz, University of Illinois.
Librarian, A. R. Crook, State Museum, Springfield.

1925

(Eighteenth annual meeting, Springfield, Feb. 20, 21, 1925.)

President, Dr. W. G. Bain, St. John's Hospital, Springfield.
First Vice-President, C. H. Smith, Hyde Park High School, Chicago.
Second Vice-President, R. C. Lanphier, Sangamo Electric Co., Springfield.
Secretary, C. Frank Phipps, State Teachers' College, DeKalb.
Treasurer, W. B. McDougall, University of Illinois.
Librarian, A. R. Crook, State Museum, Springfield.

1926

(Nineteenth annual meeting, Harrisburg, April 30, May 1, 1926.)

President, Stuart Weller, University of Chicago, Chicago.
First Vice-President, Mrs. Eleanor C. Smith, Englewood High School, Chicago.
Second Vice-President, Clarence Bonnell, Township High School, Harrisburg.
Secretary, C. Frank Phipps, State Teachers' College, DeKalb.
Treasurer—W. B. McDougall, University of Illinois.
Librarian; A. R. Crook, State Museum, Springfield.

1927

(Twentieth annual meeting, Joliet, April 29, 30, 1927.)
President, Willard N. Clute, Editor, American Botanist, Joliet.
First Vice-President, Mary M. Steagall, Southern Illinois State Teachers' College, Carbondale.
Second Vice-President, C. E. Spicer, Joliet High School, Joliet.
Secretary, Lyell J. Thomas, University of Illinois, Urbana.
Treasurer, W. B. McDougall, University of Illinois, Urbana.
Librarian, A. R. Crook, State Museum, Springfield.

1928

(Twenty-first annual meeting, Bloomington-Normal, May 4, 5, 1928.)

President, H. J. Van Cleave, University of Illinois, Urbana.
First Vice-President, C. Frank Phipps, State Teachers' College, DeKalb.
Second Vice-President, R. H. Linkins, Illinois State Normal University, Normal.
Secretary, Lyell J. Thomas, University of Illinois, Urbana.
Treasurer, Geo. D. Fuller, University of Chicago, Chicago.
Librarian, A. R. Crook, State Museum, Springfield.

ILLINOIS STATE ACADEMY OF SCIENCE

Office of the Secretary

University of Illinois, Urbana, Illinois.

Council Meeting, Joliet, April 30, 8:00 A. M., 1927.

The new council at its first meeting transacted unfinished business and appointed the following committees:

Committee on Membership: Mrs. Eleanor C. Smith, Chairman, Englewood High School, Chicago; W.P. Hays, University of Illinois, Urbana, R. G. Buzzard, Illinois State Normal University, Normal, V. A. Latham, 1644 Morse Ave., Rogers Park, Chicago, J. H. Ransom, James Millikin University, Decatur, Illinois.

Committee on Affiliation was continued for another year as follows: H. R. Geauque, Chairman, Lombard College, Galesburg, F. H. Colyer, Southern Illinois State Teachers' College, Carbondale, L. E. Hildebrand, New Trier Township High School, Kenilworth, Ill., and C. F. Groneman, Elgin, Ill.

Committee on Ecological Survey: C. L. Stover, State Teachers' College Charleston, Chairman, W. G. Waterman, Northwestern University, Evanston, V. O. Graham, University of Chicago, Chicago, Samuel Eddy, University of Illinois, Urbana, W. B. McDougall, University of Illinois, Urbana, C. J. Telford, State Natural History Survey, Urbana, Ruth Marshall, Rockford College, Rockford, C. E. Montgomery, State Teachers' College, DeKalb, L. W. Turner, Blackburn College, Carlinville, Mary M. Steagall, State Normal University, Carbondale, Ill.

Committee on Conservation was continued as follows: H. C. Cowles, Chairman, University of Chicago, Chicago, M. M. Leighton, State Geological Survey, Urbana, W. N. Clute, Editor, American Botanist, Joliet, Ill., W. H. Haas, Northwestern University, Evanston.

Committee on Legislation and Finance was continued as follows: Fred R. Jelliff, Chairman, Editor, Daily Republican-Register, Galesburg, Don W. Deal, Leland Office Bldg., Springfield, Edw. W. Payne, First Trust and Savings Bank, Springfield, H. C. Cowles, University of Chicago, Chicago, and F. H. Colyer, Southern Illinois State Teachers' College, Carbondale.

As the third member on the Committee of Publications, Fred R. Jelliff, Editor of Daily Republican-Register, Galesburg, was re-elected to that position.

Committee on High School Science and Clubs: H. H. Radcliffe, Principal of Night School, 1346 W. Macon St., Decatur, Ill. was appointed chairman with the power to appoint other members of his committee.

Through correspondence and by means of a ballot, the Council announces the selection of Bloomington-Normal as the place for the 1928 annual meeting.

L. J. Thomas, *Secretary.*

Council Meeting, Botany Department, University of Chicago, October 22, 1927.

The Council met and transacted the following items of business:

(1) Dr. Waterman, Northwestern University, Evanston, Illinois was appointed as the delegate to the Chicago Conservation Council to replace Dr. Weller who died while on field duty in southern Illinois last August.

(2) The date of the Academy meeting as suggested by the local committee of arrangements was set for May 4th and 5th, Bloomington-Normal. This comes at the time the Chicago schools will have their spring vacation.

(3) The treasurer reports that the money of the Academy has been put out at interest in the savings-bank at three (3) per cent. Since there is continually on hand a balance of approximately five hundred dollars ($500) the Council by vote approved the treasurer investing as much as he thinks advisable in a good bond to draw interest for the society.

(4) The secretary reported that the copy for the Transactions was being sent to the printers within a few days.

The Council urges that all members send the accompanying blank properly filled out either to the secretary or to Mrs. Eleanor Smith, 104 Winston Avenue, Joliet, Illinois, chairman of the membership committee.

Titles for papers accompanied by an abstract should be sent to the following chairmen of the Sections: Biology and Agriculture—Dr. William P. Hayes, 306 Old Law Building, University of Illinois, Urbana, Illinois; Chemistry and Physics—Dr. Fred H. Currens, Western Illinois State Teachers' College, Macomb, Illinois; Geology and Geography—Dr. Morris M. Leighton, Chief, State Geology Survey, 305 Ceramic Building, University of Illinois, Urbana, Illinois; Medicine and Public Health—Dr. V. A. Latham, 1644 Morris Avenue, Rogers Park, Chicago, Illinois; Psychology and Education—Dr. R. A. Kent, Dean, College of Liberal Arts, Northwestern University, Evanston, Illinois, High School Science and Clubs—Mr. H. H. Radcliffe, Principal of the Night School, 1346 West Macon Street, Decatur, Illinois.

LYELL J. THOMAS, *Secretary.*

Council Meeting, Bloomington, Illinois, March 2, 1928.

Members of the Council, the President, Secretary, Treasurer, and the Librarian met with Vice-President, R. H. Linkins, also chairman of the local committee, at luncheon, 1 P. M., at the Illinois Hotel, to discuss the business of the Academy and the plans for the Annual Meeting to be held May 4th and 5th at Bloomington-Normal.

Items of business under consideration were as follows. It was thought wise to adopt some policy for the Academy in its relation to affiliated societies. This was brought up for discussion by President Van Cleave at the suggestion of Prof. Geauque, Chairman of the Affiliation Committee. It was suggested that the Academy seek to gain affiliation with present organized and going societies of the State rather than expend energy in the organization of new societies and clubs.

The Council is very much in favor of affiliating with the going societies of the state and asks the Affiliation Committee to formulate a line of action.

The Council recommended that persons entering the Academy within the limits of any calendar year, receive a copy of the Transactions.

The Librarian, Dr. A. R. Crook, reports that a few copies of early volumes of the Transactions are still obtainable by sending postage to cover the cost of mailing.

The Treasurer reports that in addition to $500.00 invested in bonds, there is $266.00 in the treasury.

The Secretary reports that Volume XX of the Transactions will soon be ready for distribution.

The Council met with members of the Local Committee and discussed the places of meeting, the type of program for the general sessions, and speakers for these sessions.

Two splendid field trips are planned for Saturday morning, a Commercial and Botany trip and a Geology trip.

In as much as the Academy seeks to encourage the attendance of High School teachers at the section meetings the Council recommended that the section meeting of the High School Science and Clubs be held Saturday morning thus allowing teachers time to attend any section Friday afternoon.

The Secretary urges that persons planning to present papers send the title of the paper accompanied by an asbtract in duplicate to the following Chairmen of Sections: Biology and Agriculture, Dr. William P. Hays, 306 Old Law Building University of Illinois, Urbana, Illinois; Chemistry and Physics —Dr. Fred H. Currens, Western Illinois State Teachers' College, Macomb, Illinois; Geology and Geography—Dr. Morris M. Leighton, Chief State Geology Survey, 305 Ceramic Building, University of Illinois, Urbana, Illinois; Medicine and Public Health—Dr. V. A. Latham, 1644 Morris Avenue, Rogers Park, Chicago, Illinois; Psychology and Education—Dr. L. W. Webb, Department of Psychology, Northwestern University, Evanston, Illinois; High-school Science and Clubs—Mr. H. H. Radcliffe, Principal of the Night-school, 1346 West Macon Street, Decatur, Illinois.

LYELL J. THOMAS, *Secretary.*

Council Meeting, 8:00 A. M., Bloomington High School, May 4, 1928.

Delegates from affiliated societies met with the Council. The meeting was called to order by President Van Cleave.

The affiliation policy of the Academy was discussed and it was recommended that the present chairman of the Affiliation Committee, H. R. Geauque, be retained and that the Committee work through members of the State Academy, who also belong to other organizations, to bring about affiliation with the various scientific societies of the State.

The Secretary was empowered to employ any clerical help necessary to facilitate the work of his office.

It was recommended that the attention of the section chairmen and sections be again directed to the desirability of electing their own chairmen. A symposium group of the best papers in all sections was suggested for consideration by the new council, also the possible change in the order of future programs so as to have an opening session Friday forenoon with field trips that afternoon so as to allow all day Saturday for section meetings.

The new council was also advised to keep in mind the necessity of splitting sections when ever needed in order to make the program of any one section less unwieldy and to allow more time for discussion. Chairmen of sections were also asked to consider such a division in making up their program for the coming year. The following division was suggested: Botany and Agriculture; Zoology and Animal Husbandry.

Meeting adjourned.

L. J. Thomas, *Secretary.*

Business Meeting, Assembly Hall, 11:00 A. M., Bloomington High School, May 4, 1928.

President VanCleave presided at the business meeting and called for the following reports of officers:

REPORT OF THE TREASURER, GEO. D. FULLER, FOR YEAR ENDING APRIL 24, 1928.

RECEIPTS

Balance on hand April 29, 1927	$ 621.89	
Initiation fees and dues	708.50	
Received for reprints of articles	148.83	
Received for sale of Transactions	57.00	
Received interest	18.16	
		$1,554.38

EXPENDITURES.

Expenses of 1927 meeting:			
Programs, envelopes, postage	$ 109.70		
Expenses of secretary and treasurer	31.69		
Expenses of chairmen of sections, for postage, etc.	16.49		
Badges	20.00		
Stenographic service	19.87		
Postage, telegrams, etc.	5.67		
		$ 203.42	
Stationery for 1928		34.00	
Printing reprints of articles		130.91	
Expenses of Secretary's office		211.04	
Expenses of Treasurer's office		69.66	
Expenses of Council meetings		45.48	
Mortgage bonds and interest		502.33	
Secretary's Salary		150.00	
Chairmen of sections, postage, etc.		10.25	
			$1,357.09
Balance in Bank			197.29
			$1,554.33
Mortgage Bonds			$ 500.00

As the President had already appointed the auditing committee its findings were received at this time:

We, the committee appointed to audit the report of the Treasurer of the Illinois State Academy of Science have examined the accounts, have verified the entries of expenditures against approved vouchers or cancelled checks. We find the cash balance of $197.29 and mortgage bonds of $500.00 as reported April 24, 1928 correct.

H. C. Cowles,

V. O. Graham,

A. C. Noé.

The above reports of the Treasurer and of the Auditing Committee were voted approved by the Academy.

The Secretary reporting for the Publication Committee stated that the 1928 Vol. XX Transactions had been sent to all members and urged members to co-operate in correcting any errors found in the membership list.

REPORT OF THE LIBRARIAN, A. R. CROOK, STATE MUSEUM, SPRINGFIELD,

In response to a rather steady call for Transactions about two hundred have been sent out. The plan of sending out free volumes with the announcement that sets may still be completed results in the sale of a number of volumes.

No. of Volumes Transactions Sold May 1, 1927 to May 1, 1928.

	Amount
24 Volumes at $1.50 each	$36.00
No. of Volumes Transactions Sold Before May 1, 1927 for which Money was not Received until after May 1, 1927.	
14 Volumes at $1.50 each	21.00
Total 38	Total $57.00

These reports were also voted approved by the Academy.

The President then called for the reports of Committees as follows:

REPORT OF MEMBERSHIP COMMITTEE.

No. of new members	137
No. of members resigned	13
No. deceased	6

At the suggestion of our secretary, Dr. Thomas, I have prepared a list of those members who have been instrumental in securing new names for membership, as follows:

Dr. V. A. Latham	15
Dr. H. J. VanCleave	5

O. M. Schantz, W. B. Flint, D. B. Keyes, A. Weichelt, V. O. Graham, H. P. K. Agersborg, four new members.

R. G. Buzzard, Dr. F. C. Koch, B. K. Richardson, Mark E. Penny, O. C. Simonds, E. C. Smith, each three.

F. H. Frison, O. W. Blanchard, A. R. Crook, Flora Anderson, Dr. Jos. B. DeLee, W. H. Welker, J. K. White, J. P. Sheid, D. R. Sherretz, O. C. Simonds, each two members.

Beulah K. Plummer, Dr. Mary Steagall, E. C. McCulloch, W. S. Bayley, R. K. Carleton, F. H. Currens, E. S Stover, S. L. Neave, W. D. Madison, O. V. Mongerson, A. C. Vestal, Bertha Royce, W. P. Hayes, F. D. Tounsley, Anna W. Blake, one new member each.

The list of new members, members resigned and deceased, is in the hands of the Secretary.

Respectfully submitted,

W. P. Hayes,
B. G. Buzzard,
V. A. Latham,
J. H. Ransom,
Eleanor C. Smith, *Chairman.*

A motion was made and carried approving this report.

Chairman of the Affiliation Committee, H. R. Geauque, reported at length the difficulties of affiliation with other than going societies and reported the following for affiliation: The Edisonian Science Club, West Chicago.

He also suggested the desirability of joint meetings with other societies.

REPORT OF THE COMMITTEE ON ECOLOGICAL SURVEY

The committee of last year decided to make a complete list of all publications containing ecological data for this state. This collection is now being made and the chairman has in his possession over one hundred and fifty papers. At the last meeting the committee organized a program for continuing this work. We propose to make a study of the distribution of the dominant species of plants and animals for this state.

The groups organized for this are as follows:

The Plankton................Samuel Eddy
Ferns and their Allies....Mary M. Steagall
The Trees.....................R. B. Miller
Woody Shrubs............W. G. Waterman
Grasses.......................E. L. Stover

The committee invites the cooperation of all members of the Academy in this work, which will of necessity extend over a period of several years.

E. L. Stover, *Chairman.*

The above report was approved.

In the absence of Prof. H. C. Cowles, Chairman, the report of the Conservation Committee was deferred until the final business meeting.*

H. H. Radcliffe, Chairman, reporting for the High School Science and Clubs suggested that the Academy offer prizes for original work among high school students to help stimulate interest in science. The work involved and difficulties encountered in handling such a competitive scheme were considered too great for the present organization. The Secretary, however, brought to the attention of the Academy the Phi Sigma Society prize of

* By letter dated May 28, 1928, Henry C. Cowles, Chairman of the Conservation Committee reports as follows: "I have used every effort possible to push conservation measures, and am glad to report that through the purchase of the white pine woods in Ogle county and through the purchase of extensive tracts in Southern Illinois for forests, the year has really made a very significant gain from the point of view of conservation."

$50.00 to be awarded the most meritorious paper presented by a non-member junior research worker, before their scientific program at the New York meeting on December 27, 1928.

REPORT OF THE LEGISLATIVE COMMITTEE

At its last meeting, the Illinois State Academy of Science went on record as favoring the passage by the State Legislature of a bill to prohibit further pollution of the streams and lakes of Illinois. Such a bill was prepared by Senator W. S. Jewel of the Forty-third Senatorial district and was introduced by him in the Senate March 27, 1927. On April 28, the bill was reported out favorably and May 11th was passed by a large majority. The bill then went to the House, and on June 1st was reported out favorably by the committee on canals and waterways. At this point, the Illinois Manufacturers' Association manifested hostility to the measure, and had several speakers arguing against it. On June 3rd, the chairman of your committee received a letter stating that the bill was on its second reading and that the Manufacturers' Association and especially the paper manufacturers were using every effort to defeat it on the floor of the House. On June 9th, Senator Jewell wrote to the same effect. Late in June, the bill was taken out of its place on the calendar, enabling clause was stricken out and the bill was laid on the table.

Notwithstanding this defeat at a late moment, your committee in view of the increasingly strong sentiment throughout the State against stream pollution, recommends that the State Academy of Science, reaffirm its position against the further pollution of Illinois streams, and pledge its support to any reasonable measure that may be introduced in the next Legislature that will abate the evil.

However, the legislature gave assistance to municipalities by the passage of several drainage acts that will facilitate the construction of sanitary sewage systems and reduction works. By a validating act it removed largely one cause of litigation. A Sanitary district can now have more than one outlet, and certain industries can be assessed for the treatment of excessive waste. The Chicago Sanitary district is given power to control the discharges of factory and industrial wastes into sewers within its territory and can determine payments for treatment of such waste.

Under the appropriation given the division of waterways,

$27,000 can be used to prevent the dumping of garbage, waste or refuse matters on or along the shores of streams and $70,000 was made available for a survey of State lands and streams and for an investigation of encroachment and pollutions.

One of the achievements of the year was the issuance of Bulletin No. 24 by the State water survey on "Pollution of Streams in Illinois" containing numerous maps, showing points of pollution, and making clear the necessity of legislative action.

To aid reforestation in the State your committee favored state nurseries of forest trees to be supplied those desiring to replant waste ground. While there was no legislation directly establishing such nurseries, yet a $5,000 appropriation for State nurseries and a $10,000 one for the education of the public were made, and $50,000 was appropriated for land for State Forestry purposes. The State forester R. B. Miller has been enabled to make a number of addresses and to issue literature to arouse interest in reforestation and has endeavored to secure the cooperation of nurserymen throughout the State, and is to be commended for his interest and enterprise.

Your committee also requested that in the appropriation for the State Museum an allowance for the State Academy's publication be included and was given assurance that this would be done.

In the appropriations there are generous allowances for the buying of land and water for game farms, rest grounds, public fishing grounds, feeding of game, birds, etc.

A bill was passed providing for the submission to a vote of the people at the fall election of a $20,000,000 bond issue to establish state wide fishing and hunting grounds, the system to spread over the State, to be open to the public and to be under the control of the Department of Conservation.

Other new laws are those enabling cities of 500,000 or over to establish national center parks and to create educational exhibits, providing for the abatement of mosquitoes in mosquito districts, for the cutting of noxious weeds along the highway, for the preventing of the spread of insect pests and plant diseases, for eradicating bovine tuberculosis, for which $2,000,000 is appropriated, and for a levy for the establishment of museums and aquariums in public parks.

For the natural history survey $133,589 was appropriated; for the topographic work of the Geological survey $100,000; for the Division of State Waterways $71,620; for the State Museum

$45,150; for the control of European corn borer, $100,000, and for the foods and dairies department $401,000.

The purchase of Blackhawk Tower Park at a cost of $200,-000 was ordered, and is consummated. The Ogle county pine forest area has been acquired by the State, making the seventh state park. The forestry act makes possible the creation of forest preserve parks. The department of Public works and buildings is authorized to set out trees and shrubs and otherwise to beautify the sides of State highways.

We recommend that the State Academy request the State Legislature to increase the present appropriation of $50,000 a year for the completion of the program of topographic mapping of the State by the State Geological survey to $100,000 a year, provided the United States Geological Survey appropriates an equal sum, this being necessary to meet the needs of the State Highway building program and of the engineering and mining professions.

Respectfully submitted,

FRED R. JELLIFF, *Chairman.*

The report of this committee was most heartily approved by the Academy and Fred R. Jelliff was chosen by unanimous vote from the floor as chairman of this committee for the coming year.

President Van Cleave then appointed the following committees to make reports at the final business meeting 5:00 p. m. Assembly Hall:

The Resolutions Committee: W. P. Flint, Fred Jelliff, M. C. Turton.

The Nominations Committee: J. C. Hessler, W. S. Bayley, W. G. Waterman, V. A. Latham, Clarence Bonnell.

REPORT OF THE COUNCIL MEETING OF THE A. A. A. S. AND AFFILIATED ACADEMIES.

The first meeting of the Council of the American Association for the Advancement of Science and affiliated state academies, held December 26, 1927, at Nashville, Tennessee, was devoted largely to the question of setting up a national organization of state academies.

A motion was made that such an organization be established and a committee named to draw up a constitution and by-laws. A general discussion followed the making of this motion. A number of the representatives of the state academies spoke on the question and nearly all were opposed to the setting up of a new organization. The reason advanced in opposition to the proposal was that a new organization was not necessary. It was felt that the plan followed in 1927 was highly desirable as it would bring together the representatives of the state academies once each year in a meeting where they could compare notes as to their various problems and gain from one another's experience. It was the general opinion that there would be profit in the discussion of such questions as the limitation of membership, type and manner of getting out publications, academy programs, the maintenance of state museums, and other like topics. The method taken by the A. A. A. S. in calling representatives of the state academies into conference at Nashville seemed to meet all needs for presenting an opportunity for such discussion.

It was finally voted to adhere to that method and to recommend to the Council of the A. A. A. S. that a conference of the representatives of the state academies be called at the time of the annual meeting of the association in New York in December, 1928, and thereafter at the time of the annual meeting. The other meetings of the Council were largely devoted to current matters not having a particular bearing on the work of the state societies.

Respectfully submitted,

W. P. Flint,

Delegate from Illinois Academy of Science.

Meeting adjourned until 5:00 P. M.

Final Business Meeting, Assembly Hall, 5 P. M., May 4, 1928.

REPORT OF THE RESOLUTIONS COMMITTEE.

The following resolution brought out considerable diversity of opinion on the part of the members present and was finally approved provisionally after the disputed points have been investigated by the following committee made up of the Council, the Legislative Committee, and the Conservation Committee with power to act for the Academy.

The resolution for approval is as follows:

Whereas: There is to be submitted to referendum on November 6, 1928, the proposition of the issuance of twenty million dollars of State bonds to purchase land for game, fish and forest preserves and public recreation grounds, and

WHEREAS: A large part of the lands purchased will be forest land or will be reforested, and

WHEREAS: These areas, properly managed and protected, will be of great value to the scientists and others of the state interested in preserving natural conditions for instruction and research, and

WHEREAS: The establishment of preserves in every county of the State as contemplated, constitutes the greatest conservation program ever offered to the people of the State of Illinois, and

WHEREAS: The entire expense of both principal and interest on these bonds will be paid by hunting and fishing licenses, without one cent of direct taxation; therefore, be it

Resolved, That the Illinois State Academy of Science does hereby endorse this bond issue as a non-partisan public project of benefit to all the people of this state, and further urges all the members of this Academy to exert every possible effort to secure its adoption at the election November 6, 1928.

By correspondence with the various members of the Committee appointed to review the above resolution the Secretary was unable to obtain letters approving this resolution by the majority of the Committee.

I. *Resolved,* That the Academy express sincere thanks and appreciation to the Bloomington Chamber of Commerce, the Bloomington Board of Education, the Faculty of the Illinois State Normal School and other civic organizations of Bloomington that have supplied meeting places for the Academy and in many other ways aided in making this meeting a success.

II. *Resolved,* That the Academy express its thanks to the local scientists for the luncheon given the members of the Academy on May 4th.

III. *Resolved,* That the Academy express thanks to the band and to the orchestra at Normal for the music furnished during the meeting.

IV. *Resolved,* That the Society express their sincere regret over the death during the past year of the following members: Truman W. Brophy, A. K. Auden, T. F. Gerould, M. P. Somes, Mrs. Frances C. Farwell and a recent former president of the Society, Stuart Weller.

V. *Resolved,* That since men of science and men of business have long felt the need of an improved calendar and since several admirable proposals have been made by expert students in various European countries and in this country, the Illinois State Academy of Sciences again urges Illinois senators and congressmen at the National Capitol to unite with other countries in providing a calendar, which from astronomical, mathematical and business points of view will correct many of the glaring inconveniences and inconsistencies in the so-called Gregorian Calendar, now in use.

FRED R. JELLIFF,
CHAS. M. TURTON,
W. P. FLINT,
Committee on Resolutions.

The report of the Nominating Committee is as follows: For President, Clarence Bonnell; First Vice-President, R. H. Linkins; Secretary, Lyell J. Thomas; Treasurer, George D. Fuller; Librarian, A. R. Crook. It was moved and seconded that the Secretary cast a unanimous ballot for the above slate.

Membership Committee—Renominated.

Affiliation—H. R. Geauque, Chairman, with the request that he form his committee.

Ecological Survey—Renominated.

Conservation—Renominated, with the addition of Jens Jensen, Ravinia.

Legislation and Finance—Members, other than the chairman already elected, to be renominated.

Third member of the Publication Committee—R. E. Richardson.

The above nominations were voted approved by the Academy.

Meeting adjourned.

L. J. THOMAS, *Secretary.*

New Council Meeting, 8:00 A. M., Illinois Hotel, Bloomington, May 5, 1928.

President Clarence Bonnell called the meeting to order and the following items of business were discussed:

The place of meeting for next year was not decided on at this time although a cordial invitation was extended by Professor F. H. Currens of Western Illinois State Normal Teacher's College to meet at Macomb. It was suggested that the Secretary correspond with the State Mathematic's Society and see if a joint meeting might be possible for the spring of 1929.

Delegates to the Chicago Conservation Council, V. O. Graham and W. G. Waterman, were reappointed.

The delegate to the A. A. A. S. was left for appointment later by the President and the Secretary.

An honorarium of $20.00 was allowed Professor H. L. Shantz for his part in the program.

Additional thanks were extended to the Chairman, R. H. Linkins and the Local Committee for the splendid entertainment provided for the Academy, making possible one of the most enjoyable meetings. A total of 226 members registered for the meeting.

Meeting adjourned.

L. J. Thomas. *Secretary,*
313 Natural History Hall,
Urbana, Illinois

ACKNOWLEDGMENT.

The Secretary wishes to acknowledge the valuable assistance of Mr. Henry Carl Osterling, Editor, The Illinois State Natural History Survey, in the preparation of this volume for the press.

Lyell J. Thomas, *Secretary.*

PAPERS PRESENTED IN GENERAL SESSION

CONCERNING CERTAIN ECOLOGICAL METHODS OF THE ILLINOIS NATURAL HISTORY SURVEY.

Stephen A. Forbes.

It gives me great pleasure to appear on a biological program at this place and at this time, especially because it was here that I made my debut in biology 56 years ago—that I began my career as a scientific investigator; and it was here that I devised and began to use in research the methods of inquiry and inference which are the principal subject of my present paper—methods that are now so generally understood and utilized that they may seem to you merely common-place and well-known standards in ecological investigation. Still some of the objects to which they have been applied, some of the forms of use which I shall describe and some of the illustrations which I shall present, are of rather recent origin, and may be suggestive to you of other kinds of problems which they may help to solution.

From the beginning of organized biological survey work in Illinois, back in the seventies of the last century, it has been a part of our program to record our data of observation, so far as possible, in definite numerical terms, substituting ratios and percentages of quantities, numbers, and frequencies for the vague estimates and variable forms of expression then in general use among field biologists. Besides thus giving to our records and averages an unmistakable meaning, such that they might be brought into accurate comparison with others made at other times and places, a compact body of knowledge being thus built up by a uniform process of gradual accumulation, we presently found that by an analysis of our product, it was possible to establish generalizations and frame hypotheses whose validity could be tested by additional data similarly organized, and to disclose relations which would otherwise remain imperceptible. It is the purpose of this brief paper to give examples of the way in which a few of these things have been done.

In our studies of the local or ecological distribution of species, we have made frequent use of frequency ratios, by which is meant the relative frequency of the occurrence of a species in collections made from any given ecological situation as compared with its average frequency in all the collections made over the whole area of its distribution; or this frequency ratio may be defined as the actual frequency of the local occurrence of a species compared with its hypothetical frequency if the same numbers of it were equally distributed everywhere, regardless of ecological situations, in which latter case its frequency ratio would have been invariably one in every situation. Thus when I say that a minnow known as the stone-roller (*Campostoma anomalum*) had in our 105 collections of it a frequency ratio of 3.26 in water with clean bottom, and one of only .31 in water with a bottom of mud, this means that it occurred about three and a fourth times as often in the first situation, and less than one-third as often in the second, as would have been the case if it had been uniformly and equally distributed everywhere.

By the use of this terminology we are able not only to place on record ecological preferences and avoidances of a species as shown by our collections of it, and the comparative strengths of such tendencies of preference and avoidance, but we can readily compare one species with another in these respects, and can make up lists of those agreeing in their ecological preferences and brought together thus in definite societies; and can further learn whether such ecological associations are permanent and continuous, or whether they are subject to temporary dissolution with a change of seasonal conditions, as in the migration period, for example, or in the winter or spring as compared with the summer or fall. This form of record has also the inestimable advantage that it gives, in each case, the numerical basis of the computation, to which additions may be made at any time by any one anywhere, the conclusions indicated being thus tested and revised, or perhaps disproved and discarded as the evidence accumulates.

It is by the use of such data of observation so recorded that evidence has begun to accumulate of the existence of what we may call ecological barriers to the intermingling of closely allied species where there is no other apparent obstacle to their distribution in every direction—barriers which may be as effective for the isolation and establishment of nascent species as are the geographical barriers now generally regarded as indispensable to the permanent differentiation of species arising from a common stock.

An example may be found in the Illinois distribution of three little fishes of the cat-fish family generally known as the stone-cats. Two of these, the common and the brindle stone-cats, *differ* in their Illinois distribution, the former inhabiting the northern half of the state only, and the latter only its southeastern Wabash drainage, but they *agree* in their absence from ponds and lakes and in their preference for running water with rapid current and clean bottom; while the third species, the tadpole-cat, whose *distribution* covers in Illinois the areas of both the other species, is in strong contrast with them ecologically, occurring in still water with a muddy bottom more frequently than in clean, running streams. In other words, two of these little fishes, which are separate from each other by a difference in distribution, agree in ecological affinities; while the third, which coincides with the others in distribution, avoids them nevertheless by its different ecological preferences. We have other similar cases among the 151 species of Illinois fishes, but this must answer as an illustration.

Of course any number of such cases of complete and permanent separation of allied species by differences of ecological relation would not of themselves prove that this segration was a true cause or a condition *sine qua non* of their specific differentiation; it would appear only to be a possible part of the cause which must be taken into account in any complete theory of the origin of the species.

Our use of statistical data in a study of the distribution and numbers of the several species of the birds of Illinois has enabled us to analyze the migration movements in a way to measure their development, climax, and decline, to determine their composition in their different stages and to disclose internal features otherwise not distinguishable.

These results are arrived at by a determination of the number of each bird species per square mile in any given district at the beginning, climax, and decline of the migration movement, and these numbers for each species show the changing proportional make-up of the migration wave as it progresses, all expressed numerically and hence proportionally. By this means the migration may be followed in detail from south to north in spring and from north to south in fall.

The culmination and subsequent decline of a migration wave is thus shown to be due in part to the fact that the bird population of an extended area does not merely move northward or southward in a mass at an equal rate, but that the movement begins first at the farther edge of the area of distribution, the most northerly robins, for example, starting south sooner than the more southerly ones and a temporary congestion of the robin population resulting. By this method of investigation and record, it is also shown that there is often—perhaps always—a concealed internal movement of a seasonal migration in each species classed as a permanent resident in its area, its numbers becoming less dense at the north in winter, and at the south in summer, although the whole area is occupied by it continuously throughout the year. As an example of such a wave of migrants, we may take our data of all birds per square mile in the late winter and spring of northern and central Illinois at four intervals between March 2d and May 29th, 1907. In the *first half* of March in *northern* Illinois, winter still reigned, but there was already a forecast of the change to spring in the fact that while 96.7 per cent of the birds seen were either winter residents or belonged to permanent resident species, 3.3 per cent were summer residents and one-half of one per cent were migrants lately arrived from the south. The number of all birds in northern Illinois in early March was 394 to the square mile; while in central Illinois, March 20, it was 543 to the square mile, in early April it rose to 790, and in late April to May it fell again to 549. The migration wave had thus culminated in central Illinois in early April, when the square mile number was 45 per cent greater than the week before and 44 per cent greater than some three weeks afterwards. This could only mean that the more southerly birds had felt the migration impulse first—that birds were coming in more rapidly from the south than winter residents were leaving for the north, and the crest of the wave was followed by a downward slope in its rear, as the winter residents hastened their departure and dwindling numbers of the latest migrants and summer residents came in.

A closer analysis of these data, showing the square mile numbers of each species at each of the above periods, enables us to follow the shifting composition of each residence class—that is, permanent resident, winter resident, summer resident, and migrant—as the season advances, due to the quicker response of some species of each class to the migration stimulus and the slower response of others.

To illustrate the way in which a partial or concealed seasonal migration movement of a permanent resident species is disclosed and the importance of it is measured numerically, we may take our data for the well-known northern flicker (*Colaptes* *auratus*), called also the yellow-hammer or high-hole. Although this is a species classed as a permanent resident throughout the state, being found from our northern to our southern boundaries at all times of the year, our seasonal and sectional averages per square mile nevertheless show a strong *fall* migration movement to southern Illinois and beyond, and a return movement, of course, in *spring*. Thus our winter square mile average of flickers was 14.4 for southern Illinois, 1.7 for central, and 10.28 for northern; but when the spring readjustment began, the southern Illinois number rose from 14.4 to 24 to the square mile and then fell to 9.5 in summer after the migration had passed, bringing the central Illinois summer average up from 1.7 to 22 and the northern Illinois average from 10.28 to 21.

The common crow, also a permanent resident of Illinois, gives another striking example of a similar seasonal movement within our borders. Its numbers to the square mile for the state as a whole averaged, according to our data, 54 in fall, 96 in winter, 19 in spring, and 12 in summer, differences which can only mean that as winter approaches it is driven into Illinois from the north in much greater numbers than those which leave the state for a warmer latitude. An escape from Illinois southward in winter is shown, however, by the fact that we found in 1907 southern Illinois numbers to be 138 to the square mile in fall, and in winter only 16.

In our record for the successive seasons of the square mile numbers of another permanent resident, the prairie horned lark, we have similar evidence of an ebb and flow, a movement to and fro, not only within the state, but in the larger area of the general distribution of the species. The number here is largest in winter—48 to the square mile—due no doubt to the fact that the colder weather northward has driven even this hardy bird to shift, in part, to the warmer latitude of Illinois; but when spring comes on, it begins to flit northward again, our square mile number for the state now dropping to 41. This movement is slow, however, and the lowest stage of its ebb is not reached until summer, when the number falls to 21, rising again in fall through 36 to the 48 for the winter season.

These are very simple applications of the statistical record; but I have found a more complex one in attempting to use the data of our collections to *distinguish ecological associations*, to *determine their limits*, and to *evaluate the strengths* of the ties which hold an assemblage of species together as a more or less permanent natural community. This I have done by taking note of the frequencies with which the several species inhabiting an area actually occur together in the same collections, then subtracting from these numbers the frequencies of what may be called merely chance joint occurrences—those which we should have had if each species had been scattered at random over its area—and determining the ratio of the *actual* to the *chance* number of joint occurrences, which ratio I have called the coefficient of association. If I have, for example, a thousand collections of fishes made from all kinds of waters in all parts of the state and at all times of the year, and I find on examining and comparing the contents of these collections that one of two species of fishes occurring in them has been taken 150 times and another of the two 100 times, but that both of them have been taken together 50 times in the same collection, the question at once arises, "Is this collocation merely accidental, or does it signify, in part, that the two species are being brought and held together by like preferences for certain features of the environment in which they are living?" The calculus of probabilities gives a ready means of answering this query, and by its use we find that 15 of these 50 joint occurrences may be ascribed to what we commonly call chance and that the remaining 35 must have an ecological explanation. As the 50 actual joint occurrences are 3⅓ times those attributable to chance, this number is the coefficient of association for these two species. By repeating such comparisons on each pair of species of any area or of any group and tabulating the results, we get the data for a selection of the species most closely allied ecologically, and a measure also of the closeness of the ecological alliance.

I have applied this method also to our ornithological observations, using the species and numbers of birds seen on a strip 150 feet wide in crossing a single field or other unit of area as the equivalent of a collection, and in this way distinguishing and measuring the ecological affinities of the bird population of any given area or situation in any part of the state for a recognition of definite associations among them and the relative strengths of the bonds by which all such associations are held together. But many species are members of several ecological communities and we need to know with which of these communities they are most closely identified and what are the comparative degrees of such identification; and furthermore species endowed, like fishes and birds, with powers of rapid and long-continued locomotion, may change their social relations with changes of season, food supply, and other features of their environment, and a means is needed of following them statistically in these changes. Finally, as I have said elsewhere, "A knowledge of definitely circumscribed, or merely distinct, local association does not by any means exhaust the subject of associate relations, for the animals of a region can not be wholly divided up into such definite societies, and such society groups as can be clearly recognized rarely have any precise boundaries. For a full knowledge of the intricate web of the relations to their physical environment, and through that to each other, of the animals of any composite area, it is necessary that the entire assemblage of the inhabitants of that area should be studied as a compound unit," and it is in part with a view to their use in such an inquiry that the foregoing methods have been developed, and they are now being so used by our state natural history survey.

OUR CHANGING FAUNA.*

HARLEY J. VAN CLEAVE, UNIVERSITY OF ILLINOIS, URBANA.

There are two radically different approaches to a consideration of the problems of conservation. A strictly scientific procedure lacks in appeal to the general public. A wholly sentimental approach usually savours of the utopian and of the emotional rather than of the practical. The problems of conservation have so many scientific aspects and such great emotional appeal that both sentiment and science should be enlisted in an educational program for the advancement of conservation principles. If such a program were carried out, conservation would cease to be a mere matter for discussion and would become a real living issue.

Statistical studies and popular impressions unite to provide us with ample evidences that our native animals and plants are being treated with exactly the same degree of consideration that has been accorded to the Indian. As a nation we have cherished the tradition of freedom from taint of conquest for territory. But within our own borders we have waged a continuous conquest against the native life of our continent which has been as cruel and unrelenting as the sword of a Tartar. Like a Roman gladiator, with heel on the chest of a vanquished wild life, we have paused and have looked around the arena. Nearly half of the thumbs are down but many of the spectators are either asleep or not interested enough to turn a thumb one direction or the other in favor of or against the remnants of our depleted native life.

When we begin to think and to talk of conservation, our minds usually turn to the problems in terms of the desirability of increased numbers of indigenous plants and animals. In face of the dilemma of diminishing numbers we long for conditions that would augment the population of our native species. At such times rarely do we think of the fact that there may be limits which if exceeded would render some of our most desirable animals pests. We contrast the millions of passenger pigeons of a generation ago with the complete disappearance of this bird from our fauna. We compare the roaming herds of bison with the sparse, fenced-in, semi-domesticated herds of to-

* Address of the retiring president.

day. We talk of the good old past when bass and trout were as plentiful as the carp is today. Nothing is more evident than the fact that our fauna is changing. But what factors are responsible for the changes which we lament?

Man's Responsibility For Changes.

It is well known that long before man entered upon the stage of Earth's pageant of life, comparable changes took place. Forms of life abundant in one period of the Earth's history became reduced or entirely exterminated in succeeding periods. Under conditions of nature these changes were slow and gradual. Man in a single generation may wipe out species that are so well adapted to their environment that they have withstood all other forms of competition.

Too frequently attention is directed to the obviously criminal aspects of human responsibility for reducing the numbers of native plants and animals without realization that responsibility for change in the flora and fauna does not stop here. Without for a moment condoning the guilt or minimizing the responsibility for the pollution evil or the greed of poor sportsmanship, I would like to have you look at a fuller picture of the varied ways in which man has served as an agent in producing changes within our fauna.

The Balance of Nature.

At times when we witness the rapid decimation of the ranks of our native wild life we wish for and even exert our efforts toward indefinite increase in numbers of individuals. Such attitude fails to give consideration to certain principles of balance which seem to operate throughout nature. The law of overpopulation in the writings of Malthus is credited as one of the stimulating factors in starting Darwin upon his studies in evolution. Every school boy has read and has stood in awe of computations which demonstrate that even in the slow breeding animals the offspring of a single pair would overrun the entire face of the earth were it not for the catastrophes of one sort or another which tend to keep down the numbers of individuals. Of the numerous factors working toward the maintenance of this so-called "Balance of Nature," predatory enemies and parasites are important while limitation of food supply is also operative though probably in smaller measure than many writers have maintained. The links in the chain of interrelationship between the organisms of a given habitat are numerous and have been admirably portrayed in that excellent study by Professor Forbes entitled "The Lake as a Microcosm."

Under conditions of nature, the population of any given species does not remain an absolute constant. The Balance of Nature is not so sensitively poised as to permit of perfect and immediate adjustments. The population of many species seems to run in cycles during which progressive increase through one period is followed by a check imposed by predatory enemies or disease. Man's chief influence upon plant and animal life has been in the direction of disturbing the Balance of Nature. Some of this disturbance has been inevitable and essential for man's continued existence. Other elements in the disturbed balance have been produced only incidentally and yet other conditions have resulted in ruthless and uncalled-for slaughter.

Dependents and Pests.

Few animals in the wild state can endure contact with man. Close association with him usually spells either extermination or some degree of domestication. Depending upon the basis along which the new adjustment is made, the animal becomes either a servant, a pest, or a pauperized dependent upon his human associate. Flies, bedbugs, rats and mice and the hordes of insects attacking crops and stored food-stuffs have become pests as the consequence of surviving the relationship with man. They have become successful competitors with man in the new artificial environment which man has created. Their present day condition stands in sharp contrast with that of the swans, the deer, antelope, bison and dozens of lesser forms which have retreated before the advance of human frontiers and were unable to become adjusted to the new environment created by man and including the human species. Pauperization is a sort of half-way adjustment which some species have attained. Bears in the national parks and squirrels in the cities have reached that stage in domestication which might well be designated as pauperization. Even some birds have successfully solved the problem of relationship with man. The English sparrow, the pigeon, and the starling fit into the human environment as readily as we who have arranged it, and because of their acceptance of this new order of things we brand them as pests. Who is able to predict what the future holds in store for the martins, swifts, bluebirds, wrens and some of the woodpeckers? All of these are becoming adapted in varying degrees to human surroundings. So far they have retained their native habits to such an extent that neither they nor their human associates reap anything but profit from the association.

Wanton Destruction of Life.

Extermination is not always by way of direct brutal slaughter of individuals. Direct slaughter is fortunately fairly obvious and its course is capable of being checked before a species becomes completely anihilated. By intelligent laws the antelope of our western plains has been given a new lease on life, though for a time this animal stood on the edge of the chasm of extermination. Thanks to the operation of many conservation agencies, chief among them the federal treaty with Canada protecting migratory bird life, many of the migratory wild fowl seem to be actually increasing in abundance after a period of marked gradual decline. These are examples aiming to show how extermination may be averted, not by adjustments to the new conditions upon the part of the animal, but by consideration and protection afforded through legal enactment. Some of the outstanding instances of averting anihilation make it seem worth while for us to look at the problem from its various angles to see wherein evils exist and to enumerate some of the remedies or to cite methods of preventing the elimination of our indigenous animals.

Changes Due To Development of Agriculture.

By the ever increasing intensity of cultivation of land and because of inevitable increase in density of population we are forced to alter conditions which are either directly or indirectly essential for the life of many species of animals. The grazing range of mammals is thus restricted or entirely taken away. Nesting sites for birds are destroyed and many species of amphibians, reptiles and mammals are deprived of natural living conditions when new ground is put under cultivation. Many of these emigrants from human contact find refuge in swamps and waste lands only to be routed out by the "improvements" of a drainage project or local development which more frequently than otherwise yields profit only to the promoter. The drainage of swamps and lakes, ostensibly for agricultural development, has rarely proved profitable in this country while the loss of life entailed is beyond grasp of the imagination. The burning of fields, and of pastures as a means of controlling insect pests under some conditions inflicts heavy damage. The toll of nestling birds and of eggs as well as of amphibian and reptile life may be great if an improper season is chosen for this practice.

Many of the most valued fishes which we associate with the open waters of lakes and rivers seek the shallower waters of backwater lakes and lagoons to lay their eggs and to rear the young. Moreover, these same regions have long been known to produce much of the plankton which finds its way into the larger bodies of water and there serves as an indispensible link in the chain of food relations. Consequently, the drainage of swamps and lakes has much greater biological significance than the direct slaughter of the aquatic animals that happen to perish when the water is drained off. In fact the most insidious of the attacks upon our animal life are these instances of murder in the second degree. As a people we have progressed far enough in civilization to formulate and administer rather effective measures against outright wanton murder at the hands of the sportsman and market hunter. For the fisherman, we impose a rigid limit upon the number of black bass which he may take per day, but at the same time we permit other individuals, corporations, and municipalities to murder millions of fish by dumping untreated sewage wastes and industrial byproducts into the streams.

The removal of hedges advocated by some of our present day authorities in agriculture and the clearing of all brush from pasture lands destroy the nesting sites for many species of seed eating and insectivorous birds. Ground nesting birds such as the bob-white and the pheasants are becoming more and more restricted to uncultivated and ungrazed areas such as are found along the right of way of railroads. Birds are not the only sufferer from the intensity of modern agriculture. Snakes, many species of which are not only harmless but have direct value as rodent and insect destroyers, are being rapidly and inevitably exterminated in Illinois because of the destruction of conditions suitable for their protection.

Changes In Streams.

In addition to the conditions already referred to under the topics of drainage of swamps and lakes and pollution there are many other directions in which human intervention is militating against the aquatic life which never comes into direct competition with man. Power dams are known to have marked influence upon the breeding of migratory fishes such as the Pacific salmon. Even small dams in local streams are apt to influence the life of a stream profoundly. Physical conditions for existence such as depth of water, temperature, and amount of oxygen are apt to vary above and below a dam and many species of animal found below a dam never reach the waters above it. In many localities the drainage of agricultural lands is facilitated by dredging the beds of streams to a lower level. Though such practice may inflict no direct injury to the larger aquatic life of the stream the whole fauna may become radically changed by this procedure. Many of the bottom forms of molluscs may be eliminated outright, while others find themselves unable to survive in the new type of bottom left after the dredging operations. Changes in type of bottom and removal of the plant life similarly react upon the insect and crustacean life. Incidentally, fishes depending upon insects, crustaceans, and mollusks for their food supply, disappear when these elements are withdrawn, even though all other conditions might remain favorable for their continued existence.

Toll of Life On the Highways.

Even the hard roads, with their wide popular appeal, present new and serious problems in conservation. Two of these problems are peculiarly outstanding. Regions which a generation ago stood as isolated, self-appointed refuges to game birds and animals because of inaccessibility, are today the paradise of the hunter and stand easily accessible from the great centers of population. If scientifically valid laws are framed and enforced such natural sanctuaries need not be desecrated even though frontiers have been obliterated because of the ease of travel. Another direction in which the modern roads and the automobile militate against conservation is in the destruction of animal life by traffic. Smaller mammals and birds suffer heavy toll along the highways. In these days the tourist may see more dead rabbits and red-headed woodpeckers flattened on the pavement than he is able to observe in living condition by the roadside. Especially in the instance of the woodpeckers, man's indirect influence upon these birds has been marked. With the progress of deforestation they have become accustomed to accept telegraph and telephone poles in lieu of the dead trees which originally served them as nesting sites. But with the destruction of the trees much of the normal food supply of wood-boring insects has disappeared. As what seems to be an adjustment to all of these new conditions the red-headed woodpecker seeks much of his food on wing after the custom of the fly-catchers. The roadside nesting sites provided by the lines of poles make this a dangerous habit. Mammals and birds are not the only animals slaughtered on the highways. Where roads pass through bottom lands and swamps the toll levied against the lives of snakes, turtles, and frogs becomes astounding.

Successful Adjustment.

Most of the illustrations cited so far have been instances wherein man has been responsible for a decrease in numbers of individuals. Unfortunately illustrations in the opposite directions are restricted to the pests which thrive under the new man-made environment. The chinch bug is a native insect which under primeval conditions lived upon native vegetation and never became conspicuous. When man through his cultivated fields provided an unlimited food supply the balance of nature became upset and this insect increased in proportion to its increased possibilities and became a serious competitor with man for the grains which man cultivates. Such is the inglorious history of scores of native insects which thrive at man's expense and stand as challenging contenders to every human advance. Among the insects, our foreign born invaders are the penalty which we pay for the development of ready communication between the corners of the Earth. The San Jose scale, the Japanese beetle and the European corn borer are illustrations of immigrants which have prospered inordinately under the artificial conditions created by man for they have left their predatory and parasitic enemies behind and in their new home find no checks available to hold them within restricted bounds. In a new country these immigrants have escaped their natural enemies and are running rampant before a new Balance of Nature may be struck. Mouse plagues and the ravages of rats are further examples of the abnormal increase made possible under the favorable conditions prepared by man. The English sparrow and the starling are foreigners who have found an adaptation so readily that they have given up desirable traits from a human standpoint and have become little short of a plague threatening extermination for some of our native species of birds.

Similar conditions exist even among the lower animals. The large European earthworm *(Lumbricus terrestris)* is in some localities actually replacing desirable native species of earthworms and is wreaking damage to lawns. The carp, intentionally introduced into our streams and lakes, has become so numerous that some of the game fishes are unable to maintain themselves because their breeding grounds are so seriously disturbed by the bottom feeding activities of the carp. The foregoing are but a few of the isolated instances taken from local problems in readjustments necessitated by introduced species. If were were to turn to the continent of Australia there we would find similar problems except that there the problem of amalgamating the immigrant fauna is much more serious than anything experienced in this country.

As previously indicated, the native and invading hordes of enemies we term pests, because they cope successfully with man. Until recently control measures directed against these pests held as an aim the extermination of the undesirables. The mere fact of their achieving success in competition with man speaks loudly for their powers of adjustment. In a diversified country such as ours the extermination of insect pests is impracticable if not wholly impossible. Only recently have scientists sensed the futility of efforts toward extermination and directed their attention toward feasible methods of control. In the disturbed balance of nature where man has created new conditions more favorable for some species than ever existed under a natural order, man must divide the spoils with these creatures whose very existence has been made easier by his practices.

Restoring Our Native Life.

It would be an unfortunate though realistic picture if we stopped our sketching here. We have left in relief only the cold facts of a fauna suffering transformations. In numerous instances species are facing decimation because of conditions which man has imposed. On the other hand we view a protracted struggle between man and other animals, all competing for supremacy with only a relatively small margin of the advantage in man's favor. This struggle is as old as man and will doubtless continue as long as man and the insects stand as the two pinnacles in the evolutionary process. Let us then drop this less promising phase of the discussion and turn to possibilities of remedying some of the deplorable circumstances for which man is responsible.

We have gone far in squandering the natural resources of both plant and animal life. It might well be recognized that any active program of conservation must operate along two distinctly different lines. These we may for convenience refer to as the restorative and the preventive aspects of conservation. Even in the face of rapid disappearance of their native habitats many species are capable of readjustment to new conditions produced by man if merely allowed to live. The enactment of laws protecting the bob-white and the beaver furnishes examples of preventive measures operating to avoid extermination in regions where extermination seemed imminent. But enactment of laws afford little protection to the animals and plants which the laws are designed to protect unless there is an intelligent attitude of the public regarding the reasons for the laws and a strong public sentiment supporting their enforcement. The general public too often looks upon laws for the protection of birds and game as open infringement of personal liberty.

For many species of indigenous plants and animals the conflict has gone too far to enable them to come back under a truce with their human competitors. The only means of avoiding total extermination of these lies in the direction of applying effort beyond mere protection. Reforestation, provision of sanctuaries and purification of streams are constructive aspects of conservation that must operate along with the enactment of protective measures for a program of restitution that may be capable of effectual rejuvenation of natural conditions.

Even the restoration of natural conditions may in many instances prove inadequate. Species are frequently reduced so near the vanishing point that revival cannot follow the return of correct environment. Here artificial rearing under controlled conditions is resorted to. In our own State, as well as in many others, support is granted for the rearing of game birds and game animals for distributing and restocking purposes in regions where game has become scarce or entirely exterminated. Under carefully controlled conditions this serves well as a factor to offset the destructive influence of man upon his animate environment. In like manner, the fish hatcheries maintained by federal, state, and private agencies provide a means of restocking streams and lakes which have become depleted. Only very recently has it been discovered that direct liberation of fishes from the hatcheries is poor conservation practice. A new provision in the form of fish nurseries has been added to the list of compensating agencies. Newly hatched fishes held for some months in nursery ponds become established with a minimum of loss when transplanted to natural waters. Another form of conservation of aquatic life is practiced at times of floods. When the waters recede following the overflow of a river immense numbers of fishes are left marooned in backwater ponds and lagoons. Ultimately, these die if not rescued. Federal and State agencies have been carrying on rescue work of this nature for some time. The fishes are seined out from the temporary ponds and are returned to the main watercourses. In saving the lives of these stranded fish another conservation measure is commonly practiced. The fresh water mussels which provide the shells for the pearl button industry, must live for a time as parasites upon certain species of fish before they are able to lead independent lives. Taking advantage of this fact, the rescue workers subject the fishes to a heavy infection with larval mussels before they are liberated. Thus the one act of rescuing the fishes simultaneously increases the mussel population of the stream.

Wild Life Refuges.

As a sanctuary for species that find it impossible to adjust themselves to the environment produced by man it is difficult to estimate the value of the National Forests and National Parks. Some of our neighboring states have gone far in a systematic program of founding natural parks which become game and wild life refuges. In our own State, we have been preposterously passive in directing any adequate policy toward this type of conservation. It is unfortunately true that it at times becomes difficult to separate conservation measures from political entanglements. Some of the most effective proposals for conservation have failed, not because of lack of favorable sentiment but because of the weight of interests of an opposing minority. If stream pollution were an inseparable consequence of civilization and modern industry, I think that most of us would admit that the life of our streams must go. But when pollution is known to be only a matter of expediency or convenience or of financial saving, then the justice of permitting pollution vanishes.

In attempting to restore conditions favorable for the native fauna, we sometimes forget that the habitat or conditions under which animals live is not a simple thing. Detailed studies have been carried out in many regions to show how conditions favorable for the maintenance of the present inhabitants have evolved. Under conditions of nature a region progresses from one type of plant and animal life to other types with fairly well defined sequence. This succession, as it is termed, is seriously altered by human intervention. Most species of plants and animals can live only under restricted kinds of surroundings. In contrast, man is able to modify his surroundings to meet his needs. The changes which man makes for his own convenience or purely incidental to his dwelling in a given locality modify the normal conditions for the native plant and animal life. Many species are unable to make the needed readjustment and become reduced in numbers or even become obliterated. Others find the new conditions more favorable than the original state of their environment. These withstand their ground and assume the role of competitors with man or become dependents upon him.

Plea For Conservation Program.

Change is inevitable but we as a race cannot be proud of the wanton destruction of life which is laid at our threshold. Yet we are doing little to compensate. Our Academy should unite with other available agencies in a program of education and of conservation. Such a program would of necessity be diversified and would include as objectives the purification of streams, and the adequate protection of our native wild life through the enactment of legislation and the establishment of natural parks and sanctuaries commensurate with the needs of a native fauna rapidly changing under human contact.

PAPERS IN BIOLOGY AND AGRICULTURE

ATOXIC BOTULISM TOXIN (BOTULISM TOXOID, BOTULISM ANATOXIN).

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More than twenty years ago Lowenstein[1] pointed out that tetanus toxin treated with formalin lost its toxicity in a large measure without appreciable alteration of its antigenic or immunizing value. More recently Ramon[2] and his collaborators have developed the possibilities of atoxic bacterial toxins (anatoxin) as immunizing agents of merit. As the result of their investigations diptheria toxoid has replaced diptheria toxin-antitoxin in European countries as well as Canada in the field of public health. The same principle of detoxification has been applied to snake venom and tetanus toxin with encouraging results, while Weinberg and Goy[3] demonstrated that rabbits could be actively immunized to botulism toxins A and B with formalin treated toxin. The detoxified toxin was also regarded as substitute for the unaltered toxin in repeated injections of small animals in preparing antitoxin. The results of their experiments permitted the suggestion that horses could be similarly treated.

The potential advantages of formalized atoxic botulism toxin as an immunizing agent prompted a series of experiments at the Illinois Experiment Station with Cl. botulinum cultures and filtrates A, B, and C. Varying amounts of formalin (.3 to .6 percent) were added to filtered and unfiltered botulism cultures. The formalized toxins were then incubated for varying lengths of time at 37°C to 42°C. The formalin treated toxins were tested weekly for toxicity by injecting .5 cc to 2 cc subcutaneously into guinea pigs (250 to 300 grams). If inoculated pigs remained healthy and maintained their weight, the toxoid was regarded as nontoxic. The time required for detoxification

1. Cited by Pfeiffer, R. and Lubinski, H. Ueber die Wirkung des Formalins auf Endotoxin (Anatoxinbildung?) Centralbl. F. Bakt. Parasitenk. u. Infect. I., Orig. 102, 459-470, June 8, 1927.

2. Ramon, Ann. de 1, Institut Pasteur—1923 XXXVII—1001. Ibid. 1925 ——XXXIX, 1.—Compt. Rend. Soc. Biol., 1927, XCVI, 30.
Ramon, Berthelot, Grasset et Amoreux, Compt. Rend. Soc. Biol., 1927, XCVI, 30.

3. Weinberg, W. and Goy, P.—Vaccination Anti-botulinique Par Voie sous-cutanee et peos—Compt. Rend. des Sec. de Biol., 93, 1925, 430-432. Ibid 92, 1925, 564-5, Ibid 91, 1924, 1140-41, Ibid 91, 1924, 148-149, Ibid 90, 1924, 269-271.

varied from one to eight weeks, depending somewhat on the amount of formalin and the degree of heat.

The protective or immunizing value of the toxoid was determined in guinea pigs and other animals. Ten days after receiving 1 cc to 3 cc of toxoid guinea pigs were given 5 to 10 lethal doses of unaltered toxin subcutaneously. Death in the control or untreated pigs receiving the unaltered toxin clearly showed the protective character of botulism toxoids. (See Tables 1 and 2). A single injection of B and C toxoids provided protection in guinea pigs, while larger doses of C toxoid (5 cc) provided protection in quarter and half grown chickens.

In attempting to protect horses and mules it was found that a single subcutaneous injection of potent B or C toxoids (20 cc to 30 cc) followed by exposure in ten days failed to protect against lethal injections of the unaltered toxins. (See Table 3). Both B and C toxoids that proved nontoxic in guinea pigs were nontoxic in horses (700 to 1000 pounds) in 20 cc to 30 cc doses subcutaneously, but the immunizing value in single doses of 30 cc was negligible. Two injections of B and C toxoids in 20 to 30 cc doses given a week apart to horses provided protection seven days after the last injection to the unaltered toxin. (See Tables 4 and 5).

A combination of B and C toxoids administered to horses simultaneously in amounts which separately protected failed to protect against a combination of the respective unaltered toxins, while the immunizing value of botulism toxoid A gave irregular and uncertain results in the preliminary trials.

Summary:

1. Formalin (.3 to .6 per cent) added to filtered or unfiltered liquid cultures of Cl. botulism B and C upon incubating 1 or more weeks at 37°C. to 42°C. becomes relatively atoxic.

2. A single subcutaneous injection of 1 to 3 cc atoxic botulism toxins B and C possesses immunizing value in guinea pigs. Horses and mules were not protected by single injections of botulism toxoids B and C (20 cc and 30 cc) but two injections a week apart protected against the unaltered toxins.

TABLE I.

Protective Character of Botulism Toxoid B.

Guinea Pig	Weight in Grams	Treatment 10-29-28	Treatment 11-8-27	Results
509	350	1 cc Botulism Toxoid 2699B subcutaneously.	1/500 B. Toxin subcutaneously	11-17-27 Released Healthy
993	310	2 cc Botulism Toxoid 2699B subcutaneously.	1/500 B. Toxin subcutaneously	11-17-27 Released Healthy
390	420	1 cc Botulism Toxoid 1413B subcutaneously.	1/500 B. Toxin subcutaneously	11-17-27 Released Healthy
379	350	2 cc Botulism Toxoid 1413B subcutaneously.	1/500 B. Toxin subcutaneously	11-17-27 Released Healthy
381	320	1 cc Botulism Toxoid 1267B subcutaneously.	1/500 B. Toxin subcutaneously	11-17-27 Released Healthy
395	300	2 cc Botulism Toxoid 1267B subcutaneously.	1/500 B. Toxin subcutaneously	11-17-27 Released Healthy
946	250	Control	1/500 B. Toxin subcutaneously	11-10-27 Died

TABLE 2.

PROTECTIVE CHARACTER OF BOTULISM TOXOID B.

Guinea Pig	Weight in Grams	Treatment 1-5-28	Treatment 1-21-28	Results
883	420	2 cc Botulism Toxoid 6757C subcutaneously.	1/1000 C. Toxin subcutaneously	1-28-28 Released Healthy
899	330	3 cc Botulism Toxoid 6757C subcutaneously.	1/1000 C. Toxin subcutaneously	1-28-28 Released Healthy
884	320	Control	1/1000 C. Toxin subcutaneously	1-23-28 Died

TABLE III.

NONPROTECTIVE CHARACTER SINGLE INJECTION OF BOTULISM TOXOID B

Horse	Weight	Treatment 9-2-27	Treatment 9-12-27	Results
I	1050 Lbs.	20 cc Botulism Toxoid 1413B subcutaneously	1 cc Botulism Toxin subcutaneously.	9-17-27 Died.
K	950 Lbs.	30 cc Botulism Toxoid 1413B subcutaneously	1 cc Botulism Toxin subcutaneously.	9-15-27 Died.
M	750 Lbs.	Control	1 cc Botulism Toxin subcutaneously.	9-17-27 Died.

TABLE IV.

PROTECTIVE CHARACTER TWO INJECTIONS OF BOTULISM TOXOID B

Horse	Weight	Treatment 9-18-27	Treatment 9-24-27	Toxin 10-1-27	Results
L	850 Lbs.	20 cc Botulism Toxoid 1413B subcutaneously	20 cc Botulism Toxoid 1413B subcutaneously	1 cc B. Toxin subcutaneously	10-26-27 Released Healthy
N	850 Lbs.	20 cc Botulism Toxoid 1267B subcutaneously	20 cc Botulism Toxoid 1267B subcutaneously		10-26-27 Released Healthy
S. M.	1300 Lbs.	Control			10-3-27 Died

TABLE V.

PROTECTIVE CHARACTER TWO INJECTIONS OF BOTULISM TOXOID C

Horse	Weight	Treatment 9-11-27	Treatment 9-21-27	Toxin 9-28-27	Results
C	1100 Lbs.	30 cc Botulism Toxoid 1787 C subcutaneously	30 cc Botulism Toxoid 1787C subcutaneously	1 cc C. Toxin subcutaneously	10-7-27 Released Healthy
D	900 Lbs.	30 cc Botulism Toxoid 1674C subcutaneously	30 cc Botulism Toxoid 1674C subcutaneously		10-7-27 Released Healthy
B	1000 Lbs.	30 cc Botulism Toxoid 1774C subcutaneously	30 cc Botulism Toxoid 1674C subcutaneously		10-7-27 Released Healthy
E	950 Lbs.	Control			10-1-27 Died

OUR FRIENDS THE INSECTS.

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There is necessarily such a preponderance of emphasis on the losses man sustains through insects that a statement of the credit the hexapods are responsible for is occasionally desirable to maintain a correct mental perspective in regard to their relation with man's welfare. It is a common and logical principle in educational psychology that instead of setting up a long series of "don'ts" to regulate childrens' conduct we aim to substitute legitimate and desirable activities for those we would prohibit. In a somewhat parallel manner, much has been done, and much more may perhaps be accomplished in the future, toward subduing injurious insects by establishing beneficial forms among the undesirable species. Instead of creating a partial biological vacuum in nature by killing insects by artificial methods, we may plant a benefactor where a criminal rules, lest the house that is swept clean and vacated be eventually filled with seven times more devils than at first. Obviously this plan has limitations inasmuch as effective natural checks do not exist for all pests.

Biological Control.

The method of combatting insect pests by the utilization of natural agencies that hold the destructive forms in check, is perhaps the most fascinating chapter in the history of insect control and at once the least known by the people as a whole. The present attempt is only to prepare a brief, simple account of the growth, methods and accomplishments of this phase of warfare against insects. The subject stated comprehends other phases of entomology than this, but the present article will be limited to a consideration of our friends, the parasitic insects. The term "parasitic", as used here, is defined to include only such insects as live upon other insects, spending a whole stage or more on or in another individual which is designated the host.

Ever since man began supplying himself with food by tilling the soil, he has, no doubt, had to fight six-legged enemies of his crops. And when our agrarian ancestors made more or less intelligent observations on them, they probably perceived also, though more rarely, that certain kinds make their living by preying upon, or by eating, the bodies of their own relatives. And as observations in the field of natural history became more purposeful and systematic, the idea of pitting the latter against the former, the benefactor against the foe, probably grew, in a few minds, to a conviction and a personal experiment, and eventually to practice. Doctor Howard (1) tells us that the "gardeners and florists in England for very many years have recognized the value of the ladybirds and have transferred them from one plat to another." But a similar use of parasites is not likely to have been made at that time on account of their small size, and chiefly because of the general lack of knowledge even regarding the nature of their habits. It is not too much to say that no one knew that such a phenomenon as parasitism existed until certain naturalists (1, pp 16-17) discovered it in the seventeenth century. Aldrovandi, in 1602, is supposed (1, p. 16) to have been the "first to observe the exit of the larvae of *Apanteles glomeratus* L.", a common small wasp-like parasite of the imported cabbage worm. But it was probably not until more than a half century later that Vallisnieri (1661-1730) discovered (1, p. 17) "the existence of true, parasitic insects" and the real nature of insect parasitism. "Reaumur (1683-1757) and DeGeer (1720-1778) each studied the life histories of living insects with great care and, among them, worked out the biology of a number of parasites." Ratzeburg observed the bionomics of Hymenoptera parasitic on forest insects, but did not believe that their efficiency could be increased by man.

Hence, although several biologists had become familiar with the fact of parsitism, and apparently considered that man might utilize it in control, the artificial manipulation of parasites was not definitely suggested until after the middle of the nineteenth century. Earlier hints at the feasibility of biological factors for pest control applied to predaceous forms, chiefly the lady beetles and ground beetles, whose manner of checking their prey by direct feeding was more easily comprehended generally. Hence, the movement for the use of parasitic insects in what we now call biological control has been begun and carried forward in the past nine decades, and the outstanding ingenious accomplishments of an extensive and practical nature are the work of the past forty years, and fall mainly within the lifetime of that chief enthusiast for, and sponsorer of, the utilization of insect parasites, Doctor L. O. Howard, who began urging biological control in 1880 and is still engaged in his favorite field.

The Nature of Parasitic Insects.

A very small number of the present population of the world is aware of the true nature of the white oval bodies seen so commonly on the backs of certain caterpillars. Aldrovandi, in 1602, supposed them to be eggs which, he probably thought, gave rise to many more caterpillars to eat the rest of his crop. His supposition also implies that he was also unfamiliar with the phenomenon of metamorphosis of moths and butterflies. The nature of these so-called "eggs", their source, and their ultimate end, could not be appreciated then, as now, until the fact of metamorphosis among the parasites, and their hosts as well, is understood. Parasitic insects that attack other insects have a common mode of development from the egg to the parent, or adult stage. These friends of ours usually begin life as an egg which the parent places into, on, or near the host. Wasp-like parasites or Hymenoptera have hollow boring instruments, or ovipositors, by means of which the eggs are usually passed into the very bodies of their hosts, whereas two-winged flies or Diptera deposit their eggs on the surfaces of the host, and the responsibility of entering the body of the latter belongs to the young parasite or larva. Certain true wasps, the Tiphiidae and Scoliidae, are parasitic upon beetle grubs in the soil, and their larvae are ectoparasitic, clinging to and feeding only on the outside of their hosts. The Rhipiphoridae, a family of beetles, are also ectoparasites of white grubs, while the little-known minute twisted-winged parasites spend the larval stage in the bodies of wasps and leaf hoppers. When the parasite larvae become full-sized they do, or do not, leave the host, if they happen to be endoparasitic. Wasp-like parasite larvae often spin silken cocoons, either in the empty shell of the host, or near by outside: the "maggots" or larvae of flies retain their last skin instead of shedding it as before, and live in it as a covering or puparium. In the puparium or cocoon the larva transforms to the adult stage, the process of transformation being called pupation, and the insect during the transition period is referred to as being a pupa or in the pupa stage. Each of the four stages—egg, larva, pupa and adult—is remarkably different from each of the others, for which reason this mode of development is named complete metamorphosis. On the other hand, insects like the grasshoppers and true bugs have young resembling the adults in form and have only three stages, lacking the pupa. None of the insect parasites of other insects have this type of metamorphosis. Only the larval stage of parasitic insects feeds upon its host, which ordinarily lives only as long as necessary for the parasite to become mature. The parasites do not feed upon the vital organs of the host, but instead are nourished from the blood which flows about through the open spaces of the host's body, and from the fat body which represents the reserve food supply of the victim. While residing in the host's body the hymenopterous parasite larva retains in its alimentary canal, which is sac-like and closed behind, all the wastes from the digestive process. The waste materials are voided concurrently with the last moulting.

It is a significant fact that all parasitic insects attacking others of their class have complete metamorphosis. The larva is no doubt more adaptable to a multitude of circumstances of life than the nymph type of young, such as is present in grasshopper life cycles. While limited in locomotor capacity, the larva has a flexible body capable of entering the soil or boring into and out of a host, and by its tenacious hold on the host, or by virtue of its position in the host, ceases to use, and has long since lost, all the legs it ever had. The parasitic larvae have been engaged in the business of living at the expense of others a long time, as witness the reduction of the legs, antennae and mouthparts. That they once possessed these organs is suggested by the facts that some non-parasitic relatives still have them, and that some parasitic larvae, notably of the ichneumonoid flies, retain their large falcate mandibles in the first larval instar, but lose them when they moult the first time. While the nymphs of such external parasites as the sucking lice of mammals and the chewing lice of birds are parasitic, they do not exhibit the versatility in choice of, and fitness for, life in a considerable variety of host situations such as hymenopterous and dipterous parasitic larvae display. Among the many thousands of species of parasitic insects there is material for a very interesting study of the multiplicity of form and habit changes or adaptations,—such as the means by which the parent gets its progeny upon or into the host, how and in what stage the parasite emerges again, and the variety of hosts it may attack. In a single superfamily, the Ichneumonoids, we find one species an ectoparasite on caterpillars, another an internal parasite in a hard shelled, swift-running beetle, a third in a minute sluggish soft-bodied plant louse, and a fourth more than a hundred times larger than the former and carrying a set of drills much longer than itself for reaching into the burrow of a tree borer which is the larva of another member of its own order. In fact, one stage or more of some member or members of practically all the twenty-four orders of insects are probably subject to attack by one species or another of parasitic insects. Furthermore, some parasitic larvae have come to attack other parasite larvae, and the latter may be subjugated by a third parasite, which, better than anywhere else in the animal world, illustrates well the poem of the fleas that have lesser fleas, and so ad infinitum. We see, then, by these examples that parasitic insects are by no means limited to any particular place, host or host stage, and still they are so bound to their habits by heredity that they select their hosts within certain group limits and die without progeny if certain hosts, or sometimes a single species of host, are not available. It is this relative uniformity, and furthermore their limitation to a parasitic life, that makes them dependable for use in biological control.

Methods of Biological Control.

It is necessary to admit at once that the use of parasites to combat their injurious relatives has limitations. Where a native parasite of an indigenous pest already exists and fails to hold its host sufficiently in check, there is not much that has been done to increase the numbers of the benefactor, but new methods may possibly be originated in the future. Their rate of growth is much controlled by weather and the available numbers of the host, and men can scarcely hope to regulate these influences. However, even in the instance of native parasites various means of utilizing them are known or may be developed. It is a well known fact that winters reduce the numbers of parasites considerably below their status of the previous year. The host is likewise reduced, oftentimes, but the parasite can not reproduce extensively until its host is first plentiful. Consequently the host is free to do more or less damage in the first months of the growing season, whereas the parasite requires a month or two to "catch up" or reach effective numbers. At present, projects begun in California are under way in several states of this country to develop an abundance of the egg parasite *(Trichogramma minutum)* of certain moths in laboratories during the early spring. They are then released in orchards for the control of the codling moth, or in southern fields to hold the cane stalk borer or celery leaf tyer in check, while the outdoor parasites are building up a controlling number. The method of securing the parasite in plenty is to use the Angumois Grain Moth which reproduces in stored grains indoors under warm conditions during the early spring and whose eggs can, therefore, be secured in large numbers. These eggs are exposed to the adult parasites which deposit their eggs into those of the moth. The life cycle of the parasite is short, hence a good number of generations is produced annually and many thousand individuals are reared quickly with proper mechanism and management.

The variation in the beginning of the growth period from the north to the south extreme of the United States amounts to several weeks. For example, between southern Ohio and Illinois and the northern boundaries of these states there is, in the instance of some crops, a difference of three weeks. As an illustration, let me cite the instance of the imported cabbage worm and its *Apanteles* parasite in Ohio. In the Muskingum Valley of that state early cabbage harvest is begun by the fourth of July, whereas some cabbages are only being set into the field in the north part at the same time. The chief pest of cabbage there is the imported cabbage worm, whose very efficient parasite was intentionally introduced from Europe many years ago to check the worm. In the first two generations the worm gradually develops injurious numbers, but the parasites also multiply rapidly. By the time that the cabbage crop is removed the parasites dominate the situation, but must soon be weakened in numbers again because the host grows scarce due to parasitism, and many thousands of parasites die without reproducing. At this time, the worm is probably doing its worst damage two hundred miles north. Valuable cabbages grown in the vicinity of large cities like Cleveland and Toledo are probably being injured, or artificial control may be practiced. Inasmuch as many thousands of the parasite may be gathered in a few days at Marietta, it would seem feasible to ship or carry such for release in the north parts to greatly supplement the work of the individuals present there and perhaps prevent severe damage to the crop and possibly avoid the extensive use of insecticides.

Perhaps the most feasible mode of favoring parasites of insect pests is to modify slightly the application of certain other insect control measures. When a pest is known to possess one or more effective parasites, wholesale slaughter of the hosts should be avoided in order to permit the parasites to increase. For example, the large green injurious tomato and tobacco horn worms are freely parasitized by a small wasp-like species whose mature larvae issue through the back of the host and spin their white cocoons there. When such cocoons begin to appear, many caterpillars could easily be assembled and placed in a screened cage, from which the parasites can go forth but which retains any moth that might have escaped the parasite. Many other insects might be kept at a minimum in this manner or a modification of it without excessive costs, if their parasites were better known and this method of biological control were studied with reference to them. Probably no other plan for the use of parasites has been more frequently suggested in earlier times.

In spite of careful state and interstate inspection service to prevent the spread of insect pests, some of these inevitably penetrate into new territory. Trade within and between states has been instrumental in transporting or disseminating such insects. It occurs also that their parasites are not spread at the same time, permitting the host to multiply to unprecedented numbers and to greatly increase damage. The common asparagus beetle, a European species, is capable of causing severe loss under favorable conditions. In the east, it is in part checked by a chalcid egg parasite which, as far as known from several attempts to locate it in Ohio and Illinois, has not followed its host into all its present geographical range in America. On the other hand, the squash bug, a native species of general distribution, seems to be without its egg parasite in Illinois, whereas such a species is known to exist in the eastern states. Providing a more extended study of these, and other insects, should confirm such findings as the above, the artificial spread of the parasites of these pests might be undertaken, and the parasites could probably be established with little cost or difficulty. Deserts, mountain ranges or large bodies of water may act as deterrents or barriers to the spread of parasites into the areas which may be reached with relative ease by their hosts on account of their better equipment for long distance travel.

The most obvious as well as most productive use that can be made of parasites is based on the fact that some of our plant-eating insects are of foreign origin. These have usually come to our country without their natural enemies, hence multiply without limitations and constitute some of our "millionaire" insect pests. A few major examples are the European Corn Borer, the Gypsy and Browntail Moths, the Japanese Beetle, the Codling Moth and the Imported Cabbage Worm. It has been recognized for about forty years, since the Gypsy Moth problem became acute, that one of the fundamental steps to take in attempts to control such imported and liberated pests is to study them in their native situations. These studies soon revealed that the insects were usually of relatively small importance in their old homes and that this difference in their status was caused by the work of one or more parasites. Thus was suggested the idea of bringing these parasites to this country where it was hoped they would eventually perform the same good service as in their native lands. The result is that many species of parasitic insects have been introduced and successfully established here in the last four decades and with more or less of the desired effect.

The procedure in such introductions naturally varies much due to the difference in habits of the parasites and their hosts and the advantage taken of earlier experiences for development of better methods of handling them. But the general essentials are as follows. Specialists in parasitic insects are sent by the states or usually the Bureau of Entomology of the United States Department of Agriculture to the native abode of the pests and their parasites. These men go for a year, or several years, or more, and establish laboratories in a crucial area where the host and its enemies are carefully studied before shipments of parasites to this country are attempted. Such studies are in the nature of bringing out facts that will lead to the intelligent manipulation of the parasites when they are transported, and even more for the sake of ascertaining whether the beneficial primary parasite may have parasites of its own, or secondary parasites, which, if introduced, would more or less impair the efficiency of the primary species. By means of laboratory technique, the secondary parasites may be eliminated, and a quantity of free primaries obtained for shipment. Other species have no secondary enemies. Native men, women and children are employed to collect the parasitized insects desired and deliver them at the laboratories. After their habits and life histories are studied, numbers of them are packed for shipment. They may be in the egg, larva, pupa or adult stage when sent, the stage preferred being determined by the knowledge man has gained of the ways of the parasite and its host. Frequently the parasite is a larva in the egg or other stage of the host, or in a cocoon of its own, out of, or in, the hosts' body or cocoon. A convenient time to send some parasites is in a cold season, when they are naturally dormant due to low temperature, or if sent in a warm season they have frequently been stored in refrigerators at temperatures of 40 to 50 degrees Fahr. on ship to prevent further development before they reach their destination. Or food and hosts may be supplied in cages to enable the parasite to continue its growth in a normal way in transit. If the parasite larva be in the host when sent, it may reach the pupa or even the adult state by the time it arrives after a journey lasting from one to two weeks.

If the parasites make the trip successfully, they are next placed in a laboratory to study further their habits, to determine whether hyperparasites may be present, and to develop large numbers for liberation. The breeding is done in many ways, depending again on the species concerned, and a considerable variety of cages and technique are employed. The hosts are provided in these cages to allow the parasites to multiply upon them. Usually when thousands are developed, they are taken, at the most opportune time known, to selected spots where the host is abundant, and where the environment is otherwise favorable to the survival of the parasite. Thereafter the parasite is dependent entirely on its own persistence in finding its hosts and in resisting the climate and other untoward influences. Sometimes our own parasites attack it, even when its native enemies have been left behind. Probably less than half the species introduced from other countries are established, or, if established may be of minor importance as factors in host control. Success depends on so many influences that the entomologists concerned need have intimate knowedge of every phase that composes the parasite's environment as well as of its habits and development. However, in spite of failures due to inadequate facts, the specialists who are close to the work are optimistic for the future, and Dr. L. O. Howard (2, p. 282) says "work of this kind is in its infancy, and its possibilities are great." It is necessary to point out again, however, that this method of combatting insect pests is not advocated as a panacea for all insect troubles, and can not be regarded as a solitary substitute for any or all other methods now in use.

Instances of Parasite Transportation.

The transportations of parasitic insects have by no means been to the United States alone, although this country started this type of work on a large scale. Porto Rico imported experimentally in 1911-13 from our own state certain wasp parasites (*Tiphia* sp.) for the control of the sugar cane grubs which are related to the Illinois corn-root destroying white grubs.

The Mulberry Scale threatened the silk industry in Italy (3), but it was almost completely freed of this pest by a minute parasite (*Prospaltella berlesei*) established there from America and Japan.

Australia inadvertently received the woolly apple aphis, a notorious louse pest of the apple, because its covering of woolly secretion protects its body against ordinary contact sprays. The apple industry had prospered greatly in that favorable country, until the arrival of this aphis. Professor Tillyard of Australia, with the aid of our entomologists, received importations of a small wasp-like parasite from the United States where it holds this pest in check. The parasite is flourishing in Australia, and as a result, the apple industry is doing the same.

The larch forests of Canada have been severely injured by an imported sawfly, whose larva eats foliage. About fourteen years ago, one of its foreign parasites was established, and by gradually increasing has now practical control of the host, the last reports indicating over seventy per cent mortality due to the parasite.

The Hawaiian islands present a peculiar biological situation in that they originally harbored few native crop pests. By international commerce the sugar cane leaf hopper became established there, and created heavy losses amounting in 1903 to $3,000,000. By 1906 some species of egg parasites obtained in Australia were multiplying rapidly, and after ten years Dr. Howard (3, p. 7) found that the leaf hoppers had been reduced to practical insignificance. This is only an example of numerous other instances of complete success with imported parasites in Hawaii. But this case is not typical of most introductions into the United States and elsewhere, for the reason that parasites taken to Hawaii have no native secondary enemies awaiting them, hence multiply with extraordinary rapidity.

Extensive attempts have been made with varying success to establish foreign parasites of imported pests in the United States. California has always been a leading state in experiments with biological control, and (4) "because of the spectacular results of the introduction of *Vedalia* the Australian lady-bird, in the early days of California horticulture, the general public was inclined to favor this method of control to the exclusion of all others.'' The black scale ''is still the most important pest of citrus in the state'', and effective natural enemies are still being sought.

From 1911 to 1913 (5) the cocoons of the parasite of the alfalfa weevil were sent to Utah where alfalfa culture was damaged by this snoutbeetle. By 1922 the parasite ''was practically covering the weevil territory'', and parasitism sometimes reached 85 to 90 per cent or more.

Generally, the appearence of a new insect pest of importance in this country is a signal for the beginning of a search for its parasites. In the New England States thousands of acres of woodlands, and shade and forest trees have been defoliated at various times since 1889 by the caterpillars of the gypsy and brown-tail moths, both of which are of European origin. Than this there is no more extensive instance of damage by introduced pests and there is scarcely an example of a more far-reaching, attempt to control such pests by its introduced parasites. Since 1905 (6) ''over 60 species of parasites'' of these enemies of trees, ''including predacious beetles, have been imported from Europe and Japan.'' Mr. Burgess indicates that many attempts failed, for ''of this number 16 species have become established in New England. One-half of these have not become very abundant and are probably of slight importance.'' The damage, however, decreased ''with more or less regularity until 1924, when only a small number of localized areas were defoliated.'' Observations over many years indicate that the number of parasites fluctuates with the result that occasional injury of more or less extent may be expected in the future. The same consequences will normally result in the instance of any other pest for whose control parasites are chiefly employed. The ideal of parasite importation in this and other instances is perhaps to find and establish a series of parasites, one or more attacking each stage of the host, and thus developing a sequence that will strike the host at various seasons of the year and perchance effect an adequate control in spite of variations in factors governing host and parasite abundance. However, this point of view has been criticized, and certain other plans may be more effective.

While the gypsy and brown-tail moths were the occasions for the first large-scale biological control project of the United

States Bureau of Entomology, others of large dimensions have since been instituted. The Japanese beetle is a relative of our common May Beetles or white grubs. It was first seen in this country in New Jersey in 1916 and the grubs in the soil wrought havoc on lawns, meadows and golf courses since that date, while the adults have done likewise to foliage, flowers and fruits in general. In 1920, the study of its natural enemies, including parasites, was begun in Japan (7), and up to January 1927, nine species of parasites were found there and in Chosen (Korea). One of the three Tachinid flies parasitizing the adult beetle frequently destroys from 50 to 100 per cent of its host and this species, among other parasites, has been introduced into this country. Six other species attack the host in the larval stage.

Among other pests of primary importance are the Mexican Bean Beetle, the Oriental fruit moth, and the European corn borer, all of which have occasioned the investigation of their native parasites, but those of the corn borer, the worst threat we ever had on our corn crop, deserve special mention. Although six two-winged (Diptera) parasites and seventeen wasp-like species (Hymenoptera), all native, have been found attacking the eggs, larvae and pupae here, "the combined parasitism" by these species "has totaled less than one percent of the larvae and pupae collected each year" (8). The native parasites are therefore "practically negligible except in the case of the sporadic egg parasite, *Trichogramma minutum* Riley" (8). Eight species of Diptera and Hymenoptera that parasitize the corn borer in Europe had been liberated in the infested area of the United States up to February 1927. Two of these(*Microgaster tibialis* Nees and *Exeristes roborator*) had been recovered incidentally at that time. It can not be predicted what the status of the imported species will be in the future. Ten years or more are sometimes necessary for a normal adjustment of parasites to their new surroundings and to reach their maximum efficiency, providing they become established at all. It is generally believed that parasites of the corn borer can not be expected to become an adequate check alone on this pest, the chief factor operating against a high proportion of mortality seeming to be the habit of the host of feeding sheltered within the corn stalk most of the time during the stages susceptible to attack.

The amount of hope to be placed in the method of control by the use of entomogenous insect parasites is obviously various according to the species considered. But whether they are in themselves sufficient to keep to an insignificant minimum the economic loss occasioned by their host, or must be supplemented by other methods of control, our friends, the parasitic insects, constitute one significant ally of man. Their importance does not permit them to be omitted from any program of control for foreign introduced pests and furthermore, it may be truthfully said that the appreciation of the possibility of their use against native pests has probably only begun.

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NOTES ON THE FOOD OF THE PADDLEFISH AND THE PLANKTON OF ITS HABITAT.*

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The paddlefish or spoonbill cat, *Polyodon spathula* (Wal.) has long been recognized as a fish of very peculiar structure. It has a long, broad, paddle-like snout and an enormous mouth, almost toothless. Its alimentary canal is very short and consists chiefly of a very capacious stomach emptying into an intestine which is not much more than a spiral valve. Its gills also are large and are equipped with gill rakers or strainers nearly twice as long as the corresponding gill filaments.

A fish of such structure obviously cannot eat other fish but must depend for food on smaller organisms. Forbes (1878), in his pioneer studies of the food of fish, first recognized the paddlefish as feeding entirely on plankton. Other investigators, as Jordan and Evermann (1896), Imms (1904), and Stockard (1907), have regarded it as partly a bottom feeder. Fishermen have always confused the fine mass of plankton in its stomach with mud and consequently have considered this fish as being a mud feeder. An examination of the contents of a number of paddlefish stomachs shows an exclusive diet of microscopic organisms, most of which are normally found in the plankton.

Little is known of the life history or habits of the paddlefish. It is widely distributed in the larger streams and lakes of the Mississippi valley from Wisconsin to Louisiana, being quite abundant in the larger lakes and bayous of the lower Mississippi valley, but it does not occur in the Great Lakes drainage basin. Next to the sturgeon the paddlefish has the highest market value of any fish of this region. It is priced locally as high as 75c per pound under the name of "Boneless Cat."

Some paddlefish reach a very large size. Individuals have been reported by Jordan and Evermann (1896) from Manitou Lake, Indiana, as weighing 163 pounds. It is surprising that so large a fish can secure enough food of microscopic size to maintain itself. Its gills have to strain a prodigious volume of water in order to catch enough plankton for one square meal.

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* Contribution from the Zoölogical Laboratory of the University of Illinois, No. 335.

If we wish to understand the feeding habits of this fish in relation to the quantity of available plankton in the waters of its habitat, we must make quantitative collections of the plankton and compare the number and abundance of the constituent organisms with those found in the stomach of the fish.

The present paper is based on data obtained from a study of the stomach contents of 30 paddlefish which were taken from McIntyre Lake near Money, Mississippi, in the spring and summer of 1927. In addition to these, ten stomachs which were secured from the Illinois River at Meredosia in June, 1927, by Doctor D. H. Thompson of the Illinois State Natural History Survey, were also used for comparison.

McIntyre Lake is four miles long and one-fourth mile wide and has an average depth of thirty feet. Plankton collections were made from the lake at the same time that the fish were taken. Both the stomach contents and the plankton collections were carefully preserved and examined microscopically to determine the constituent organisms and their relative abundance. A striking uniformity was found to exist in the constituents of the stomach contents at any one period.

Of the 26 stomachs which were obtained from McIntyre Lake between the 18th and the 24th of August, some were full and others were apparently empty. Those that seemed empty were opened and scraped, yielding food and a considerable amount of detritus which appeared to be stomach lining. Several collections were also made of scrapings from the gill rakers. These collections were composed entirely of plankton organisms in a fine state of preservation.

The contents of the different regions of the intestinal tracts were saved separately and preserved in formalin for examination. In the cardiac region of the stomach the contents resembled freshly caught plankton, with a gray color depending on the nature of the constituent organisms. The collections from the Illinois River had a reddish color due to the presence of certain species of Entomostraca which formed the bulk of the stomach contents. In the pyloric region of the stomachs from McIntyre Lake, the contents were still in a fair state of preservation although somewhat broken. In the spiral valve a decided change had occurred, the contents having the appearance of brown mud and bearing a very disagreeable odor. In the material from this region only fragments of empty skins were recognizable, the bulk of the contents consisting of a mass of opaque detritus, apparently digested or disintegrated food.

Two organisms which formed the bulk of the food in the material collected in August at McIntyre Lake were *Cyclops leuckarti* Claus and the larvae of an undetermined species of Corethra. From eighty to ninety percent of the bulk of the contents was composed of these two organisms. A variable amount of detritus was always present and occurred most abundantly in those stomachs which seemed empty. This did not resemble mud but looked like particles of digested food or bits of stomach lining. A smaller and generally immature copepod, *Cyclops bicuspidatus* Claus was found in twelve of the twenty-six stomachs but was never abundant. Mosquito larvae occurred in nine of the stomachs but were common in only one where they composed about fifteen percent of the bulk. Larval copepods were scarce, occurring in very few numbers in seven stomachs. Rotifers were never abundant and occurred in only very small numbers in less than half of the stomachs examined. A very few *Anuraea cochlearis* Gosse occurred in eleven stomachs while a single *Brachionus calyciflorus* Pallas was found in one stomach. Another stomach contained a few specimens of *Conochiloides dossuaris* (Hudson) and *Diurella stylata* Eyferth. Cladocerans were more abundant than rotifers. *Moina micrura* Kurz occurred in ten stomachs and although never occupying much bulk, it was sometimes fairly abundant. Small numbers of *Diaphanasoma brachyurum* (Liéven) were found in seven stomachs. Protozoa were very scarce and were limited to two species. *Pleodorina californica* Shaw occurred in seven stomachs and was abundant only in one, but because of its small size occupied only about five tenths of one percent of the bulk. Two specimens of *Difflugia globulosa* Duj. were found in one stomach. The only algae found in the stomachs consisted of several *Scenedesmus quadricauda* (Turpin) Breb. in one stomach and a few cells of *Lysigonium* (*Melosira*) *granulata* (Ehr.) Ralfs in another.

The contents of two stomachs collected in the spring from McIntyre Lake were examined. One stomach taken March 7, 1927, contained the usual diet of plankton origin, *Cyclops bicuspidatus* (68%) constituting the bulk of the contents, and *Daphnia longispina* O. F. Muller occupying about 20% of the contents. The remainder consisted of an occasional *Bosmina* *longispina* Leydig, eggs of Cladocerans and a few *Chydorus sphaericus* O. F. Muller and Synedra.

A stomach taken April 15, 1927 contained a common assortment of plankton organisms although different from those previously described. Large specimens of *Cyclops bicuspidatus* formed most of the bulk (60%) of the contents. *Diaptomus stagnalis* Forbes composed 20 percent, and the remainder consisted of *Bosmina longispina*, 10 percent, and detritus 8 percent. A very few specimens of *Chydorus sphaericus, Pleodorina californica* Shaw, *Pediastrum simplex* (Bail..), and *Lysigonium* (*Melosira*) *varians* Agassiz were present but composed only about 2 percent of the bulk. The difference in the assortment of species indicated that a different plankton was present from that found later in August.

A collection of food made March 19, 1927 from the gills contained an assortment of organisms somewhat different from any found in the stomachs. Insect eggs constituted the bulk of the food (78%). Detritus was abundant (20%). Ostracods and a very few Bosmina and *Chydorus sphaericus* constituted the balance of the food. This collection showed the only evidence observed that the paddlefish fed in vegetation or on the bottom.

The contents of the stomachs obtained from the Illinois river were of the same nature as those from McIntyre Lake. Entomostraca formed the bulk of the food differing, however, in species from those found in the stomachs from Mississippi. *Cyclops bicuspidatus* composed nearly 90% of the contents of all the stomachs. Sometimes *Diaptomus sililoides* Lilljeborg was present. A few specimens of *Leptodora kindtii* (Focke), *Bosmina obtusirostris* Sars, and *Daphnia longispina* were common in six stomachs although they did not occupy much bulk. Cladoceran eggs occurred in most of the stomachs. A few specimens of Ostracods were present in three stomachs and a chironomid larva occurred in one. Both of these latter organisms normally live on the bottom although occasionally they form an adventitous element of the plankton. Only a single rotifer, *Brachionus angularis* Gosse occurred in one stomach. The smaller plankton forms were exceedingly rare just as in the stomachs from McIntyre lake. *Fragilaria virescens* Ralfs, *Scenedesmus quadricauda* (Turpin) Breb., Cyclotella, *Lysigonium* (*Melosira*) *granulata* (Ehr.) Ralfs, *Eudorina elegans* Ehr., Anabaena, and a few undetermined diatoms were present in several stomachs but formed such a slight proportion of the food as to be quite negligible.

Parasites often appeared in the stomach contents as well as in the collections from other regions of the intestinal tract. The pyloric region of the stomach usually contained a large number of nematodes, and these forms also occurred in smaller numbers in all parts of the digestive canal. The most common parasites were cestodes, both larvae and adult. These were found in practically every fish from McIntyre Lake, and at times numbered well over one thousand in a single individual host. Cestode parasites have been reported for this fish by Stockard (1907) and Beach (1902), but only the single species, *Marsipometra hastata* (Linton) has been described. This study shows that there are in reality three distinct species of this genus present; an undescribed species of moderate size occurring mostly in the pyloric caeca; a small species found most commonly in the spiral valve, also undescribed; and *M. hastata* which occurs throughout the posterior three quarters of the intestinal tract. Larval forms of these cestodes as small as 0.3 mm. and ranging to adult size were present in enormous quantities throughout the entire digestive canal. Trematodes were also found in this host but with the exception of a very common gill polystome occur only rarely.

Kofoid (1900), observing the feeding habits of a paddlefish in captivity, found that the fish apparently located the plankton or finely chopped meat which was fed to it and swam rapidly in circles occasionally opening and closing its mouth until all the food had disappeared. Weed (1925) made observations quite similar, and later suggested (Norris 1923) that the mode of swimming of the paddlefish may aid in jarring loose aquatic animals from the vegetation.. Stockard (1907), Jordan and Evermann (1896), Alexander (1914), and Imms (1904) have asserted that the paddle is used for stirring up the mud of the bottom through which the fish then swims backwards, straining out all food. If this were the case one would expect bottom organisms which do not occur normally in the plankton, to be found more often in the stomach contents. Beach (1902) thinks the paddlefish elevates the paddle above water and swims into water plants, manipulating and guiding the water plant into its mouth. He suggests that such procedure tends to cause a current of water containing food to pass out the gill openings and the gill rakers are thus enabled to catch a great deal of food. He adds further, that according to his observations, the fish is almost if not entirely vegetative in its habits. Norris (1923) states that one function of the long bill is to dislodge aquatic animals which form the chief food supply of this fish.

Our observations on the feeding habits of the paddlefish, both in its natural habitat and in confined areas, confirm those of Kofoid and Weed. Fish placed in a small shallow pool were seen to swim slowly around the borders with the mouth slightly open, and at times to close it as if swallowing. The movement of swimming always involved the lateral movement of the bill accompanied by a similar rythmic body motion. This characteristic movement, considered by many investigators as being an adaptation to secure food while swimming in vegetation, occurs even when the fish is in water free from vegetation or plant debris of any kind, and it appears to be the natural type of movement in fish of this type, rather than any special modification for securing of food. Beach (1902) and Stockard (1907) call attention to the fact that paddlefish in their natural habitat are often seen to leap out of the water, making a loud splash as they fall back to the surface. Beach explains this action as an attempt on the part of the fish to free itself of the lampreys which are said to be common ectoparasites. At Lake McIntyre, especially during the warm afternoons of the summer months, the spoonbills were seen to jump from the water quite frequently, and because of the great number present in this lake, they kept up a constant splashing at regular intervals. Although no explanation can be given at the present time for this peculiar habit, is it likely that the conclusions of Stockard, who attributed the action to lack of an adequate oxygen supply in the warm water, are more nearly correct than those of Beach, for in no case in over three hundred examinations of this fish did we observe lampreys attached to the body surface.

Only in one collection from the gills was there any definite evidence of bottom feeding as is commonly believed by fishermen and many investigators. This was the collection from the gills made in March from McIntyre Lake, and contained insect eggs and ostracods which were either bottom or vegetation forms. The presence of a few ostracods and chironomid larvae in several of the stomachs from the Illinois River may be indicative of bottom feeding, but is not conclusive evidence, as bottom organisms are often stirred up by river conditions and found in the plankton. The absence of mud and bottom diatoms and also the scarcity of these bottom forms in the Illinois River specimens seem more to indicate that the latter possibility offers a more plausible explanation of the occurrence of such forms. Forbes and Richardson (1908) stated that they found no evidence of mud or bottom fauna in the stomachs of the paddlefish. Most of the stomach contents examined in this study consisted of the same organisms as the plankton collected from the same waters at the same time as the fish. The bulk of the stomach contents consisted only of the larger plankton organisms, while the smaller forms were almost entirely absent. The animals which were most abundant in the plankton were not necessarily the most abundant species in the stomach contents. This was due to the selective action of the gill rakers which only retained the larger species which did not always form the greater part of the plankton. The smaller forms which were eliminated were often the most abundant and characteristic forms of the plankton. Insect larvae and copepods which formed the bulk of the diet of the paddlefish were only fairly common in the plankton of McIntyre Lake. The smaller cladocerans, rotifers, protozoans, and algae which formed a prominent part of the plankton constituted only a very small portion of the food of the paddlefish. This elimination of the smaller organisms, which included practically all the algal portion of the plankton, enabled the paddlefish to secure an entirely animal diet.

It is uncertain as to the level at which the paddlefish normally feeds. According to Forbes and Richardson, fishermen at Alton, Illinois state that the paddlefish feeds at the upper levels of the water. Others believe that it feeds from the lower levels. Our plankton records were largely based on surface collections although several were made from the bottom to the surface. There was no evidence in any of the data collected to show where the paddlefish fed, for the same plankton organisms were found in both the surface and bottom collections. All organisms found in the stomachs likewise occurred in both the surface and bottom plankton collections.

The paddlefish, because of the selective gill apparatus previously described, consumes only a small part of the plankton passing through its mouth. The waters bearing a heavy micro- or nanno-plankton and only a slight macro-plankton would hardly form a profitable feeding area for the paddlefish because only a certain type of plankton is available. As this fish can utilize only part of the plankton it must pass a much larger volume of water through its gills than it would if all the plankton were available. Accordingly, the amount of water bearing plankton and passing through the gills of the paddlefish must be enormous. It is of interest to estimate the amount of water required to supply enough food to fill the stomach of a moderately large paddlefish. The largest stomach examined had a capacity of about 700 cubic centimeters. This was almost entirely filled with Entomostraca and insect larvae; and first it was necessary to determine the number of these forms present in the stomach and then find the number of the same organisms normally present in a given volume of water at the place where the fish had fed. Assuming that the gills strained out all these forms, it is comparatively easy to compute the volume of water that must pass over them in order that enough food may be secured to fill the stomach. The contents of a well filled stomach from McIntyre Lake contained 80 Corethra larvae and 300 *Cyclops leuckarti* per cubic centimeter. At this rate, a stomach with a capacity of 700 cc. would contain 56,000 Corethra larvae, and 210,000 *Cyclops leuckarti.* The largest numbers of Corethra larvae found in a collection of plankton was 900 per cubic meter and the greatest number of Cyclops *leuckarti,* found in a collection of another date, was 1035 per cubic meter. Thus, it would require 62 cubic meters of water to supply enough Corethra larvae and about 203 cubic meters of water to furnish enough Cyclops to fill a stomach with a capacity of 700 cc. These figures are merely a rough estimate but they serve to demonstrate that the paddlefish strains an enormous amount of water to satisfy its appetite. The variation in plankton distribution from day to day and within similar areas of the same locality is well within the limits of the variation in the computed amount of water required for the two organisms. The plankton net is far from being 100% efficient but there is reason to believe that it is more efficient than the gill rakers of the paddlefish which do not secure many of the smaller organisms found in the silk net collections. Although the plankton data may not have been acquired at the exact spot or level at which the fish had fed, it is close enough to the vicinity to make it possible to form some idea of the volume of water utilized by this fish. Furthermore, from the many plankton collections taken at different parts of the lake, there was no evidence that the plankton organisms were unusually abundant in any one area. There seems rather to be a general distribution with some variation in regard to levels but not enough to greatly influence these figures.

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PLANKTON FROM McINTYRE LAKE, AUGUST, 1927.

Per cubic meter	Surface 8/17	Surface 8/18	Surface 8/19	Surface 8/24	Surface 8/24	Bottom, 25 ft. 8/24
Anabaena sp.	...	37000	9000	...	24000	rare
Lysigonium (Melosira) granulata (Ehr.)	42500	36000	...	36000	150000	common
Fragilaria virescens Ralfs.	...	...	...	...	200	...
Pediastrum duplex Meyen*	...	...	...	90	...	...
Difflugia globulosa Duj.	...	...	...	...	50	...
Pleodorina californica Shaw*	6800	190	...	1800	3150	common
Euglena sp.	...	...	180	90	200	...
Eudorina elegans Ehr.*	...	360	...	...	2070	...
Pandorina morum Bory de Saint Vincent*	30	...	...	...	100	...
Platydorina caudatum Kofoid*	3400	...	...	...	50	...
Peridinium tabulatum Ehr.	...	...	...	...	50	...
Strombidium sp.	...	...	...	...	500	...
Halteria grandinella O. F. M.	...	220	...	...	...	...
Codonella cratera (Leidy)	...	...	...	...	100	...
Synchaeta stylata Wierz.	850	...	1800	180	200	...
Polyarthra trigla Ehr.	175	...	180	3600	4000	rare
Diurella stylata Eyferth	...	...	...	...	100	...
Rattulus sp.	170	...	...	...	...	rare
Notholca longispina (Kellicott)	...	...	...	...	50	...
Brachionus angularis Gosse	1700	5400	5400	1350	950	occasional
Brachionus budapestinensis Daday	75	360	...	...	...	...
Brachionus patulus O. F. M.	...	1800	...	...	...	...
Schizocerca diversicornis Daday	400	650	...	45	400	...
Asplanchna priodonta	170	...	180	...	...	...
Conochiloides dossuaris (Hudson)	13600	720	1800	90	1035	...
Filina (Triarthra) longiseta (Ehr.)	...	...	...	40	1000	rare
Pedalia mira (Hudson)	...	...	900	...	1050	occasional
Keratella (Anuraea) cochlearis (Gosse)	1800	900	360	13500	9000	occasional
Pleosoma sp.	6800	3600	3600	7200	40000	common
Monostyla quadridentata Ehr.	...	...	...	...	100	...
Diaphanosoma brachyurum (Liéven)	...	...	...	5400	10300	common
Daphnia longispina O. F. M.	...	...	...	...	100	...
Moina micrura Kurz	...	...	180	8100	41000	abundant
Cyclops bicuspidatus Claus	...	180	...	5000	6210	abundant
Cyclops leuckarti Claus	...	...	...	450	1035	...
Young Copepods	...	200	...	9000	25000	...
Ergasilus sp.	...	...	...	...	207	...
Corethra Larvae	40	...	360	900	575	common

* Per colony.
Organisms shown in bold face type occurred also in the stomach contents.

THE NATIVE BEECHES IN THE CHICAGO REGION.

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A few extracts from a paper read before the National Conference on plant acclimation in New York City, in 1902, may still be of interest: Two groves of the native beech *(Fagus ferruginea)* are found in Illinois. One colony is on Pettybone Creek, south of the city of Waukegan; and the other at Highland Park, twenty-four miles north of Chicago. There are also a few scattered trees planted on estates or in private gardens along the Lake Shore north of the city of Chicago.

The late Robert Douglas, who settled in Waukegan in 1844 or thereabout, thought the beech trees at Waukegan and Highland Park had been planted by the Indians, or rather the seed had been scattered by them when in camp. It was known that the Indians frequented these places and were fond of the beech nuts. In Highland Park they held council. His son, the late Thomas Douglas, who was born in Waukegan, thought that the beech nuts had beeen scattered by the pigeons, which at the time were plentiful along the North Shore. One may doubt this last suggestion because the pigeons were plentiful in the woodlands all along the lake, consequently the beech nuts would have been scattered wherever the pigeons roosted.

Most of the trees in the two colonies are not very large—less than twelve inches in diameter, a few perhaps sixteen inches in diameter. Trees planted in the gardens are mostly small and scrubby, and after twenty or thirty years have not attained the height of more than twenty to twenty-five feet. They diminish in size towards the lower end of the lake whether they are found on the lake border Moraine or in alluvial soil.

Study for a minute the map of the lower end of Lake Michigan and consider that our prevailing wind from the west comes across the great plains. Whether it is the hot winds in summer or the cold winds in winter, it is evident that these winds coming across great land areas must be dry, and their influence on vegetation that demands moisture for a healthy growth must be more or less injurious. As we follow the Lake Shore north from Chicago the winds become more or less influenced by the water they have to cross. These influences seem to favor the beech, and especially is this so on the eastern side of Lake Michigan. That the lakes have a tempering and moistening influence on the west winds is evident and of great economic value on both the east and west side of the Lake. That the changes brought about by this influence are remarkable, we all know, and that part of southern Michigan would never be the fruit producing country it is if it were not for the effects as stated before. The beech on the west side of Lake Michigan is benefited in the same way as soon as the influence of Lake Superior and Wisconsin's thousands of lakes is preceptible, and this is where the beech extends into the so-called white pine belt.

The above notes were written after a study of fifteen years. Twenty-six years have now passed and little can be added to what was then recorded. I know of no record of our native beeches in Illinois that has shown or described any other groups than those mentioned, except those found in southern Illinois, and they are not to be considered here. No one knows the northern part of the Chicago region better than Charles Douglas of Waukegan, a brother of the late Robert Douglas, and Mr. Douglas states that he has never seen any other native beech trees, than those referred to, between Chicago and the State Line.

The Waukegan groups are found in a ravine, or rather on the drained slope of a ravine south of Waukegan, and are now on the grounds of the Great Lakes Naval Training Station. There are a few small groups and some scattered trees. One group of a half dozen trees or more have a few fine specimens between sixteen and eighteen inches in diameter. There are no seedlings, but one tree has produced two suckers. The other groups are younger in years; some of the trees not more than twenty-five to thirty years old, and all more or less struggling for existence. They may be off-shoots of seedlings of earlier trees, but there is no evidence of this. Of the scattered trees there are one or two large specimens that may be a hundred to one hundred fifty years old now in a state of decay. It is quite possible that seeds from these trees have been carried by animals or birds and produced the last group mentioned. Most of the trees have a western exposure. Some of them a northwestern.

The group at Highland Park is also on a ravine slope with a southerly exposure. When I first visited this grove, some thirty years ago, it was in a healthy condition. Today it is showing signs of decay. There are a few seedlings in this group. None of the trees seem to have grown much in the intervening time. The soil consists of a yellowish pebble clay, and is the same for both colonies. Of the trees found in private gardens very little change has taken place in growth. They are short and stunted. There are some purple beeches of the European variety, but they cannot compare in growth with those found in the gardens on the Atlantic Coast. The largest one is found at Highland Park, and although it is a fairly good size tree it is short and stunted.

Whether the Indians scattered the seeds or dropped them in their camps, or whether the pigeons or squirrels brought them, or they were carried by other natural agencies, matters little. The fact remains that when we reach a point where our prevailing west winds come across the great plains, the struggle for existence begins. Judging from soil conditions they should succeed equally as well on the lake border moraine all the way to its southern terminal if no other agencies interferred with its growth. As one follows the lake border moraine north, the beeches gain in size and normal growth. Let us consider that the moraines are better drained than the low alluvial lands about the City of Chicago. On the latter all attempts to grow beeches have been fruitless.

I have centered out the beech, but a great number of other plants from the east side of Lake Michigan and also plants from the humid regions of the Atlantic Coast or other Countries succumb after a shorter or longer time. Temperature cannot be at fault. There are many plants on the New England Coast, growing in a temperature a great deal lower than ours, that will not thrive here. We therefore must come back to the conclusion arrived at before: That the dry west winds hinder the beech on its march south toward the Chicago areas, and also that the lack of humidity in those, our most prevailing winds, creates a limitation in the growing of numerous plants that are found in the more humid regions of the temperate earth.

In conclusion, the Commandant at the Great Lakes Naval Training Station has expressed his desire to preserve the group of native beeches on the Station's grounds.

THE PROBLEM OF THE UNIT HEREDITARY FACTOR OR GENE.

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Genetic analysis has demonstrated that the hereditary differences between individuals are due to unit hereditary factors or genes which are segregated in the gametes and recombined in each generation. Cytological study has revealed the chromosomal mechanism by which these segregations and recombinations are accomplished. With these demonstrations the central problem of genetics has shifted to the genes themselves, just as in physics and chemistry it shifted from the recombinations of atoms to the internal structure of the atom.

The gene is being attacked from two sides, first through the study of the causes of gene change or mutation and second through the study of the somatic effects produced by the gene before and after mutation and the comparison of these effects with those produced by the direct effect of environmental agents upon the soma.

Most genes are remarkably stable, remaining unchanged for long periods. A gene undergoing change within a hundred years has an unusually rapid rate of mutation. In a few cases only, has it been possible to measure the rate in a particular gene. One of these is that of bar eye in the fruit fly Drosophila. About one individual in 1600 shows a change in this gene. Environmental agents such as temperature affect the rate only to the extent to which they affect the length of the individual life cycle. The number of mutations within normal environmental ranges is proportional to the number of individuals produced by any particular environmental condition and it seems therefore that mutations may be due to certain critical transformations such as the reduction in the number of chromosomes. These processes may go wrong occasionally and thereby alter the structural basis of a gene.

There is no indication of modification of the gene correlated with the somatic effect of an environmental factor. We have had the descendants of a single pair of flies of an inbred line in two groups one at 17 degrees centigrade and the other at 27 degrees for nearly six years. This length of time represents 141 generations at the higher and 57 at the lower temperature. The eyes of the flies raised at 17 degrees are over twice as large as those raised at 27 degrees. Yet when flies from both sources are raised at the same temperature they are indistinguishable. The gene for bar-eye is unchanged by the environment to which it has been subjected. There is no inheritance of the somatic temperature effect.

However when genes are subjected to the violent action of X-rays and the dosage is regulated so as to be just under the fatal amount, gene mutations may occur with startling frequency. In Muller's experiments the rate was increased 150 times. We seem to be on the verge of rapid production and control of gene changes and with such a control over the units of heredity we will be able to guide the course of evolution in any desired direction.

The other angle from which the problem of the gene is being approached is that of the comparison between the effect of environmental factors upon the nature of somatic characteristics and the effect produced by a change in a gene.

In bar-eye of Drosophila the temperature at which the larva is raised has a marked effect upon the eye. A change of about nine per cent is produced by a change of one degree centigrade and it has been shown that this effect is confined to a period of a few hours during the early larval period. When there is a mutation in the bar gene there is a change in the size of the eye and also a change in the temperature coefficient and in one case a reversal of the direction of the effect. In the presence of the bar gene the eye *decreases* in size with increase in temperature and in the mutant infrabar it *increases* with increase in temperature as shown by Luce. An analysis is being made of the developmental processes with a view to the determination of the chain of cause and effect from the gene to the somatic character. Such an attempt is being made through the cooperation of several investigators in our laboratory and it is hoped that the results will throw light not only on the nature of the gene and the method of gene mutation, but also on the central problem of embryology, the manner in which somatic differentiations arise from the original structure of the egg and spermatozoon.

SOME PHASES OF THE EUROPEAN CORN BORER CONTROL PROGRAM.

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The continued spread of the European Corn Borer into new territory makes it appear inevitable that the insect will within a few years become established in this State. In order to combat it at the least expense of money and labor it is necessary that we develop methods of control as far in advance of the actual establishment of the insect in this State as possible. The European Corn Borer has only been established in North America for approximately 20 years. Its presence has raised many questions which have been found impossible or very difficult to answer because of the lack of a sufficient amount of research data.

Studies of the European Corn Borer both in North America and Europe are bringing out more strongly the fact that this insect is much affected by different weather and climatic factors, and that it is not likely to be of equal importance in all parts of the corn belt, nor will it be of the same importance each year, even within areas where conditions generally are very favorable to it. We do not at present, however, have sufficient data to say under just what conditions or in what areas the insect will, or will not be destructive. At the present time we are greatly in need of further research to answer some of the following questions:

1. What is the best date for planting corn in different sections of Illinois?
2. What is the possible range of time over which corn can be planted and still produce a profitable crop?
3. What is the average wind movement and direction of the wind during the day and during the night in the corn belt counties of the State during June and July?
4. What are the average evening and night temperatures?
5. What is the average humidity during the day and night in Illinois corn fields and in the spring in Illinois stalk fields?
6. What parasitic insects are present within the corn belt which may adopt the corn borer as their host?

These and many other questions must be answered before we can tell with any degree of certainty just what the European Corn Borer may do to the corn crop of Illinois.

An attempt is now being made to answer some of these questions from the results of the research projects now under way by the Experiment Station and Natural History Survey. This paper is an attempt to briefly summarize some of the work that has already been done in Illinois on parasites of the European Corn Borer.

In 1919, studies of the parasites of native borers similar to the corn borer were started by some of the entomologists of the Natural History Survey. These studies were continued in 1920, 1921 and 1922. A special effort was made in 1920, to find the parasites of the native smartweed borer, *Pyrausta ainseli* Heinrich. Large collections of this insect were made at various points over the State, and in some areas it was found to be quite heavily parasitized. It was thought that possibly some of the native parasites of *Pyrausta ainseli* might parasitize the European Corn Borer, *Pyrausta nubilalis Hueb.*

In co-operation with the Federal Bureau of Entomology a number of these parasites were sent to the European Corn Borer parasite laboratory at Arlington, Massachusetts, where the European Corn Borer was exposed to them, but without favorable results. In 1921 and 1922 further attempts were made to find out to what extent these native parasites would attack the corn borer. A survey of a number of areas where the smartweed borer was abundant showed that in certain fields near Urbana this borer was quite heavily parasitized, in some cases parasitism reaching 20 to 25%. A number of barrels of heavily infested smartweeds containing both borers and parasites were shipped to the corn borer parasite laboratory at Arlington. Some several species of parasitic flies and a number of parasitic *Hymenoptera* were bred from this material and an attempt was made to get them to parasitize the European Corn Borer. While this work was carried on more or less intensively for two years, the results were rather discouraging. In a few cases the native parasites accepted the smartweed borer as their host, but did not thrive on the new host and the actual amount of parasitism achieved was very small. In fact, the results of this work were much the same as the results thus far obtained in all sections of the country. Studies to date have shown that we would expect less than 1 percent of the corn borer larvae to be killed by the native parasitic insects now occurring in our corn belt.

As the native parasites did not seem to take readily to the newly imported insect, an attempt was made to reverse the process, and establish imported parasites known to attack the corn borer on some of our native insects, and in this way establish them throughout the State in advance of the time when the corn borer might reach Illinois. One of the imported parasites of the corn borer, *Microbracon brevicornis* Wesm. was known to be a general feeder and to readily accept the native smartweed borer as its host. In August, 1922, several hundred of these parasites newly brought in from France were sent by the Federal Bureau of Entomology to the Laboratory of the Natural History Survey in Urbana, and partly grown smartweed borers were exposed to them. The imported parasites readily accepted the smartweed borer as its host, and during the years 1923 and 1924 large numbers of these parasites were reared in the Survey Laboratory in Urbana and liberated at four points in the State, Aurora, Jacksonville, Centralia and Urbana. At the latter point in 1924 more than 3600 mated females of this species were put out in fields heavily infested by the smartweed borer. During the last year several lots of this same parasite have been liberated in Illinois corn fields along the east side of the State. To date, this parasite has not been recovered in the native smartweed borers in the State, but this does not necessarily mean that it has not become established. During the present season an attempt will be made to establish several other parasites of the European Corn Borer, and also to increase within the State the population of one of our general egg parasites, *Trichogramma minutum*, which is on the whole, the most effective parasite of the corn borer now known either in this country or in Europe.

ECOLOGIC FOLIAR ANATOMY OF SOME PLANTS COMMON TO ILLINOIS AND NORTH CAROLINA.

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Botanical literature contains many reports of studies on leaf structure and the variations observed in different species of the same region or in the same species of two or more markedly different habitats. But very few studies have been made of the foliar anatomy of species common to widely separated regions. The purpose of this paper is to discuss the amount and kind of modification appearing in leaves of the same species collected from Illinois and North Carolina and to correlate so far as possible any variations found with the meteorological conditions existing during the growth and maturing of these leaves.

Collections of leaves were made at Pink Beds, Pisgah National Forest, North Carolina, during the month of August, 1926, and in the vicinity of Urbana, Champaign County, Illinois, in September, 1926. In all cases the specimens were taken as nearly as possible from the south periphery of the plants. The following species were included in the investigation. *Liriodendron tulipifera, Quercus alba, Acer rubrum, Robinia pseudoacacia, Sassafras variifolium, Solanum carolinense, Plantago lanceolata, Hamamelis virginiana, Cornus florida, Castanea dentata, Prunella vulgaris, Juglans nigra, Rumex acetosella, Pyrus malus,* and *Rhododendron maximum.* Pieces from several leaves of each species were imbedded, cut, and stained with Bismarck brown. The sections were studied microscopically and measurements of the parts were made by means of a filar micrometer and carefully checked on various days in order to eliminate personal error as far as possible.

The Pink Beds habitat in North Carolina is situated at an altitude of about 3200 feet in the chestnut-tulip tree climax association. Champaign County, Illinois, on the other hand, is only about 700 feet in altitude and is located in the transition zone between forest and prairie. The climax community in the vicinity of Urbana is a hard maple-red oak association. Table I gives the comparative meteorological conditions of the two habitats from July, 1925, to July, 1926, inclusive. It is readily seen from this table that for the year 1925-26 the North Carolina habitat exhibited the more xeric conditions.

TABLE I.[1]

		Mean temperature	Saturation Deficit	Total Precipitation
1925				
July	Ill.	77.6	.351	1.14
	N. C.	74.5	.302	0.77
Aug.	Ill.	74.8	.200	3.42
	N. C.	72.0	.301	0.22
Sept.	Ill.	73.0	.255	5.69
	N. C.	73.6	.255	1.92
Oct.	Ill.	45.6	.061	4.16
	N. C.	53.6	.125	2.74
Nov.	Ill.	38.6	.108	2.81
	N. C.	43.6	.082	2.43
Dec.	Ill.	26.6	.023	1.19
	N. C.	36.6	.068	1.10
1926				
Jan.	Ill.	28.1	.020	1.86
	N. C.	37.0	.069	3.39
Feb.	Ill.	33.5	.030	2.98
	N. C.	40.4	.090	2.50
Mar.	Ill.	33.5	.037	2.75
	N. C.	39.6	.080	3.04
Apr.	Ill.	45.4	.087	4.01
	N. C.	52.0	.177	1.68
May	Ill.	65.7	.256	2.34
	N. C.	63.0	.257	2.37
June	Ill.	69.4	.275	3.60
	N. C.	68.0	.219	1.85
July	Ill.	77.9	.351	4.38
	N. C.	72.8	.266	4.48

Mean for March, April and May, 1926

Ill.	48.2	.126	9.10
N. C.	51.5	.171	7.09

Table II presents the criteria selected for a comparative study of the leaves of the fifteen species from the two habitats. The figures represent the thickness in microns of the leaf parts indicated. These data, with the exception of those for the cuticles, are shown graphically in figures 1 and 2.

An examination of the data presented in Table II reveals that thirteen of the fifteen species show greater leaf thickness in North Carolina than in Illinois, the exceptions being *Acer rubrum* and *Robina pseudo-acacia.* One of these, *Acer rubrum,* has a thicker palisade layer in North Carolina but *Robinia pseu-*

[1] The authors are indebted to the U. S. Dept. Agr. Weather Bureau, Asheville, N. C., and the Weather Bureau at the University of Illinois for the data given in this table.

TABLE II.

		Leaf thickness	Palisade	Spongy parenchyma	Upper epidermis	Lower epidermis	Upper cuticle	Lower cuticle
1. **Liriodendron**	Ill........	93.3	25.5	42.5	8.5	8.0	4.2	2.7
tulipifera	N. C.....	180.2	59.5	68.0	12.7	11.6	4.8	3.9
2. **Quercus**	Ill........	136.0	59.5	51.0	14.7	12.75	3.62	2.72
alba	N. C.....	153.0	68.0	51.0	16.1	11.64	4.67	3.23
3. **Acer**	Ill........	128.0	51.0	42.5	15.72	12.75	4.62	2.97
rubrum	N. C.....	109.0	55.25	25.5	16.15	11.0	5.1	3.4
4. **Robinia**	Ill........	136.0	59.5	42.5	16.1	11.6	4.25	3.48
pseudo-acacia	N.C.....	119.0	40.0	46.75	17.0	12.3	5.52	3.9
5. **Sassafras**	Ill........	127.0	51.0	44.0	13.45	11.05	4.25	2.97
variifolium	N. C.....	144.0	68.0	34.0	15.72	12.75	5.35	3.4
6. **Solanum**	Ill........	127.0	51.0	51.0	12.75	11.05	4.33	3.0
carolinense	N. C.....	160.0	68.0	59.0	13.17	12.07	4.5	4.25
7. **Plantago**	Ill........	144.0	42.5	68.0	17.5	15.6	3.8	4.2
lanceolata	N. C.....	187.5	68.0	76.5	20.4	19.5	4.93	4.25
8. **Hamamelis**	Ill........	153.0	68.0	51.0	12.75	12.32	4.25	3.82
virginiana	N. C.....	178.5	85.0	68.0	13.17	12.58	4.93	4.25
9. **Cornus**	Ill........	110.5	34.0	51.0	11.9	10.2	3.48	2.97
florida	N. C.....	153.0	51.0	76.0	15.43	12.58	4.84	3.4
10. **Castanea**	Ill........	136.0	68.0	38.25	15.3	13.43	4.2	3.4
dentata	N. C.....	144.5	76.5	36.0	17.0	13.1	5.1	3.9
11. **Prunella**	Ill........	174.25	68.0	68.0	17.0	15.3	3.4	2.5
vulgaris	N. C.....	204.0	85.0	76.5	25.5	22.7	3.8	3.3
12. **Juglans**	Ill........	93.0	51.0	25.5	8.5	4.5	2.5	2.1
nigra	N. C.....	140.2	68.0	51.0	14.4	8.5	4.2	2.8
13. **Rumex**	Ill........	195.5	85.0	89.0	21.2	17.0	4.2	3.4
acetosella	N. C.....	229.0	76.5	93.5	25.5	21.2	5.5	4.0
14. **Pyrus**	Ill........	178.5	85.0	68.0	13.6	11.9	3.2	2.5
malus	N. C.....	182.7	76.0	68.0	14.4	12.3	5.1	4.4
15. **Rhododendron**	Ill........	314.5	140.2	136.0	16.57	12.75	5.52	2.55
maximum	N. C.....	365.0	170.0	153.0	27.0	17.0	8.0	5.0

do-acacia and also *Rumex acetosella* and *Pyrus malus* have more palisade in Illinois. The upper epidermis and the upper and lower cuticles of all fifteen species are constantly thicker in North Carolina, and this is true of the lower epidermis as well except that in *Quercus alba* and *Acer rubrum* this part is thicker in Illinois. The maximum amount of variation is found in the leaf of *Liriodendron tulipifera* which is nearly twice as thick in North Carolina as in Illinois. It is undoubtedly true that just as great differences could be found between sun and shade leaves on the same tree in either North Carolina or Illinois but that does not diminish the significance of the data here presented since, as previously stated, all leaves used in this study were collected from exposed positions on the south peripheries of the plants.

Table I presents the mean temperature, saturation deficits and precipitation for the thirteen months beginning with July, 1925, and ending with July, 1926. During this period the leaves used in the present investigation were formed and developed to maturity. The term "saturation deficit" expresses "the lack of vapor pressure, or the difference between the existing vapor pressure and that which the atmosphere would contain at the current temperature if the space were saturated with water vapor." The saturation deficit has been found to be far more accurate for ecological purposes than relative humidity since it gives a direct measure of the capacity of the atmosphere for more vapor and thus, to a certain degree, "a measure of the rate at which evaporation will take place."

The general outline and fundamental structure of most leaves are developed while the leaf is yet minute within the bud. Later growth consists in increase of cell size and the maturation of the mesophyll. If the leaves under study were fully developed in August and September of 1926, they were laid down as embryonic structures in 1925. The mean monthly temperatures were higher in North Carolina than in Illinois in eight of the thirteen months treated in Table I. In nine of the thirteen months the precipitation was less in North Carolina than in Illinois, while the saturation deficits show a drier atmosphere in North Carolina in eight of the thirteen months.

It may be concluded from such data that the leaves collected in North Carolina developed under more xeric conditions than those collected in Illinois. If we consider March, April and May of 1926 as the months of cell enlargement and maturation of the mesophyll after the swelling and bursting of the buds, we are again confronted with more xeric conditions in North Carolina. The differences between the habitats are in no case very great but they are great enough to be of significance in the development of plastic organs, and it is interesting to note that the amount of variation in thickness of the various leaf parts is proportional to the amount of difference in weather conditions in the two habitats.

In addition to the factors already discussed the differences in altitude between the two habitats is of some importance since the illumination at an altitude of 3200 feet would presumably be more intense than at 700 feet. Higher light values, by increasing assimilation, tend to cause an increase in assimilative parts such as chloroplasts and palisade cells. This in turn increases transpiration and necessitates adaptations in leaf structure to meet the more xeric conditions.

An increase in thickness of leaf parts is, of course, only an indication of xerism, the cuticle being the most conclusive indicator, while primary significance lies in the entire plant structure. Species are plastic in varying degrees and respond in different ways to the same stimulus, and the data presented in this paper would be of conclusive significance only after comparison with similar studies in several successive years.

Summary and Conclusions.

1. The present investigation is a detailed microscopical study of the foliar anatomy of fifteen species common to the widely separated habitats of Illinois and North Carolina.

2. Thirteen of the fifteen species studied show a greater leaf thickness in the North Carolina habitat.

3. *Liriodendron tulipifera* shows the maximum variation of thickness between the two habitats in mesophyll, palisade and sponge tissues.

4. The protective structures, as a whole, show a higher degree of development in the North Carolina specimens.

5. The weather conditions existing during the period of the formation and development of the leaf tissues characterize the eastern habitat as a more xeric region than the western habitat.

6. The amount of variation in leaf thickness is in agreement with the amount of difference in weather conditions in North Carolina and Illinois.

7. Of all the leaf parts, the cuticle is the most conclusive indicator of xeric conditions.

8. Environmental conditions vary from year to year, and plants respond according to the plasticity of the species.

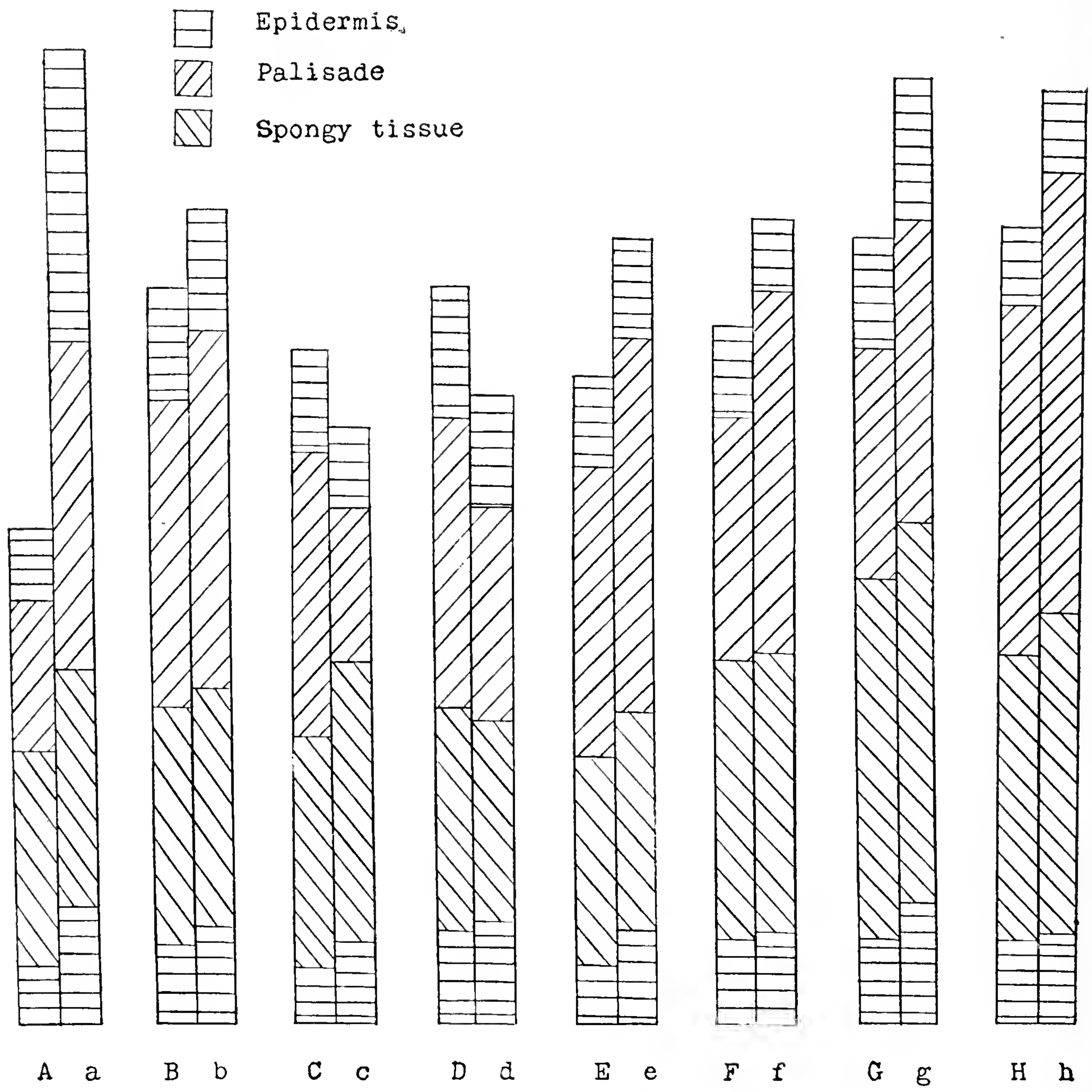

Fig. 1. Schematic representation of cross sections of leaves showing relative proportions of tissues. The large letters indicate Illinois specimens, the small letters North Carolina specimens. A, a=**Liriodendron tulipifera**; B, b=**Quercus alba**; C, c=**Acer rubrum**; D, d=**Robinia pseudo-acacia**; E, e=**Sassafras variifolium**; F, f=**Solanum carolinense**; G, g=**Plantago lanceolata**; H, h=**Hamamelis virginiana**. Scale: 1 inch=30 microns.

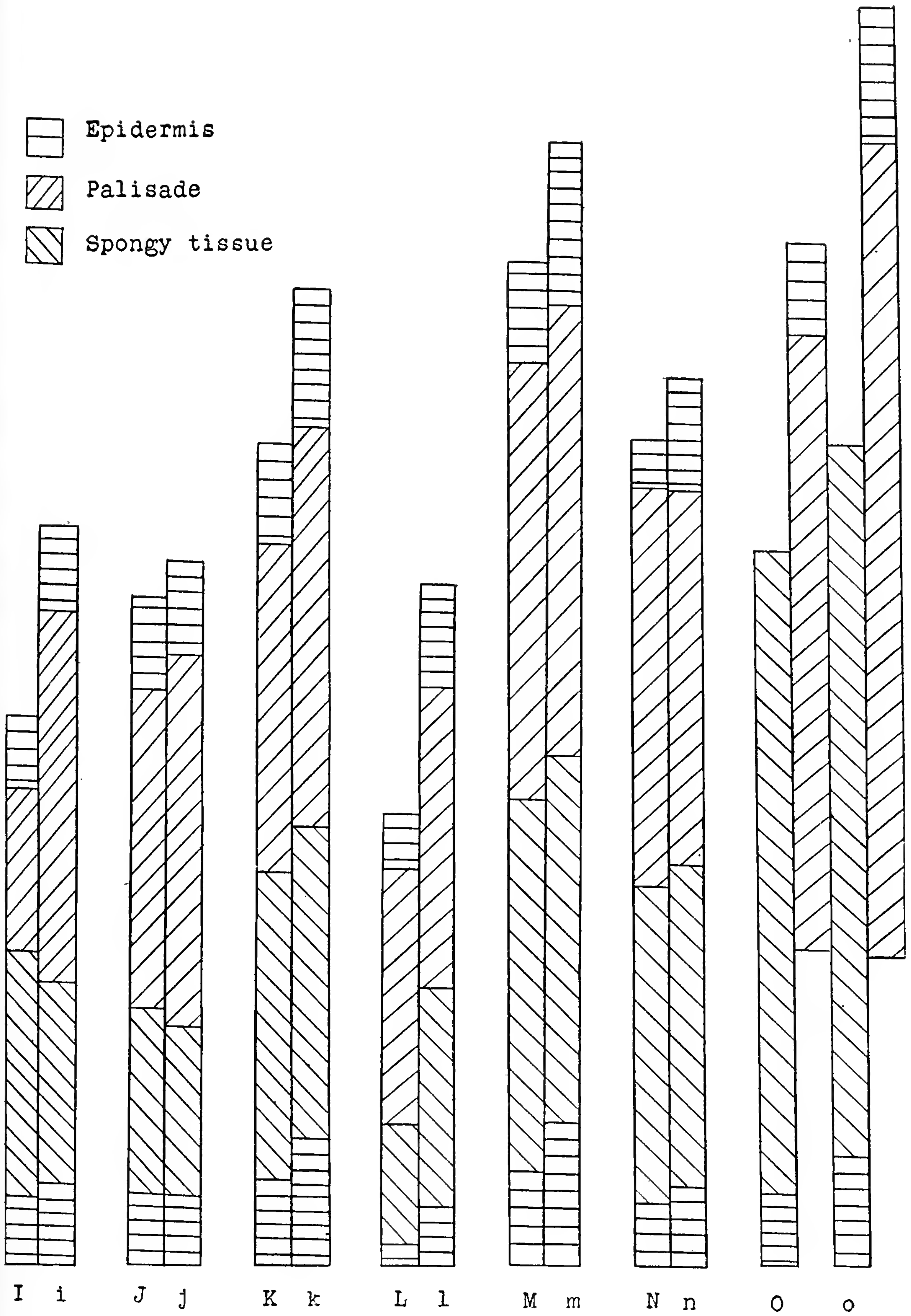

Fig. 2. Schematic representation of cross sections of leaves showing relative proportions of tissues. The large letters indicate Illinois specimens, the small letters North Carolina specimens. I, i=**Cornus florida**; J, j=**Castanea dentata**; K. k=**Prunella vulgaris**; L, l=**Juglans nigra**; M, m=**Rumex acetosella**; N, n=**Pyrus malus**; O, o=**Rhododendron maximum**. Scale: I inch=30 microns.

THE LIFE HISTORY OF THE GERMAN COCKROACH.*

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Although it is such a common insect, relatively little work has been done on the life history of the German cockroach, *Blattella germanica* (L.). With a view to filling a few vacancies in our knowledge of these interesting creatures the experiments and observations set forth in the following paper were made by the author during the winter of 1926-27 in the laboratories of the Department of Zoology of the University of British Columbia at Vancouver, B. C.

Methods of Rearing.

Material for study was obtained in various heating plants and eating establishments, and kept in a large box cage in the laboratory for future use.

Throughout the larval instars the rearing experiments were kept in pint fruit jars with the regular glass top clamped on, but without rubber rings. These jars were kept in an electric incubator with a constant temperature of 35° C. maintained throughout the experiment. Although it was not measured, the humidity must have been close to 90 or 95% saturation, since free water was present in the jars at all times. The interior of the incubator was dark. These conditions were interrupted a few minutes each day when the jars were removed into the light room for examination. The insects were fed exclusively on fairly thin flour paste and brown bread soaked in water, the food being changed every second day. Water was squirted into the jars every three or four days. A mass of loosely crumpled paper was put into each jar for the insects to run over. In the main experiment forty newly hatched nymphs were started at the rate of ten in each of four jars, but owing to deaths at moulting, escapes and accidental deaths, only 50% of these reached maturity.

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* This paper constitutes part of a thesis submitted to the Department of Zoology in partial fulfillment of the requirements for the degree of B. S. A. at the University of British Columbia. The writer wishes to acknowledge his appreciation to Mr. G. J. Spencer of the University of British Columbia, under whom the work was done, for his valuable assistance, encouragement and criticism, and to the Department of Zoology for permission to present this paper.

The Life Cycle.

B. germanica thrives and multiplies wherever there is plenty of warmth, food and water, regardless of season. Under the conditions as outlined above, the complete life cycle took place in about three months. The egg stage took about fourteen days, followed by seven nymphal instars together taking about sixty days in the case of the males and about sixty-five days in the case of the females. The females each produced one or two oöthecae, with a total of about fifty eggs. At this rate there would be produced four generations per year. Haber[2] found the life cycle to be from two and one-half to five months, or that from two and one-half to four generations might be produced in a year. Thus the presence of these roaches in great numbers in favored localities is easily understood.

The Eggs.

This species, as is characteristic of the family to which it belongs, does not lay its eggs singly, but produces them in a capsule-like structure, the oötheca. The production of the oötheca takes place in two days, and it is then carried for some time attached to the genital chamber of the mother at the posterior end of the body.

Two or three days before the formation of the oötheca the abdomen of the female distends and swells noticeably. At the beginning of its formation the external opening of the genital pouch becomes enlarged and shows, just within, the tip of the oötheca, which appears white and translucent. Within the day, the oötheca protrudes from the genital pouch, and by the end of the second day is fully developed. It may then seem to be nearly as big as the insect itself and might be considered an encumbrance to the latter. But in spite of the clumsy oötheca dragging behind, the females are quite active and do not show any signs of being impeded by their burden. While it is being formed the oötheca is translucent white in color, changing in a few hours to pinkish, then to light brown, and finally in two or three days reaches the ultimate dark chestnut brown color. It is roughly rectangular in shape, twice as thick as wide, and three times as long as wide. Very large oöthecae are nearly as long as the adult. Usually the sides are not straight, but curve, rapier-like, a trifle. Along the middle of the convex side is a seam which splits at hatching, liberating the young. The oötheca is usually carried in a flat position, in which case the seam is on the right side, but sometimes the oötheca is carried on edge, when the seam is on the dorsal side. The oötheca cannot be dislodged from the abdomen of the adult by agitation such as shaking, dropping, prodding, etc., before its natural time. By careful manipulation, however, the oötheca can be removed, using padded forceps or some such tool. When they are more than a week old this can be done quite successfully, but when they are younger than this the pressure required to free them is liable to break the wall of the oötheca. The oötheca seems to be held in place by the pressure of the parts of the genital armature and the genital pouch, rather than by any special hooks or teeth.

Internally the oötheca is divided into two rows of compartments, dorsal and ventral, staggered in formation, each compartment housing an egg. These are marked externally by transverse sutures and furrows, and give the oötheca a slightly scalloped appearance. These markings form an accurate guide to the number of eggs in the oötheca. This number varies greatly. An examination of forty capsules showed a continuous gradation from eighteen to fifty eggs each. The greater number, however, held from thirty-two to forty-two eggs each, including 75% of the oöthecae. The average of the total number was thirty-seven eggs.

The oötheca is either deposited by the female the day before hatching, or hatches while still attached to the female, the empty capsule being deposited afterwards. Of the twelve cases observed none deposited the oötheca earlier than this, while three oöthecae hatched *in situ*, the females carrying the empty capsule for one or two days. One oötheca was seen actually hatching, literally bristling with young roaches, while the female was on the run.

The chief requirement of the eggs for development is moisture. This is amply borne out in the experiments to be cited. The question of the origin of this needed moisture is an interesting one, and in an attempt to throw some light upon it the following experiments were conducted:

Twelve oöthecae were put in a petri-dish, and as many females carrying oöthecae were put in a fruit jar. Each was covered to allow the same evaporation and put in the incubator at a temperature of 35°C. Daily a teaspoonful of thin flour paste was put in each container, keeping the humidity nearly the same. In three or four days the detached capsules completely shrivelled, but the capsules on the females hatched normally. The same experiment was set up again, but this time the two subjects were both deprived of water. The females were given dry flour for food, and occasionally enough water to keep them alive. In this case the detached capsules snrivelled a day sooner than before. In each case (as also happened before) the shrinking started at the *proximal,* or attached, end. After several days the capsules which the females were carrying started to shrivel, but they all shrivelled first at the *distal* end. Again, in general practice it was found that oöthecae removed from the adult when more than nine days old will hatch successfully if kept under cool, humid conditions. If, however, they are removed when younger than this, it was found impossible to bring them to hatching under any conditions tried.

It is evident, then, that the eggs cannot develop without ample moisture; and it seems extremely probable from these experiments that they get a considerable amount of it from the parent, and are unable to get sufficient for their needs from the atmosphere. To make this practical, the wall of the oötheca within the genital pouch must be more permeable than the remainder. Various writers[4] have supposed that the roaches carried their eggs with them to keep each other from eating them, or to keep enemies from molesting them. It seems much more probable and natural to the writer to suppose that the adults carry their eggs, whether instinctively or from some mechanical necessity, to keep them supplied with the moisture necessary for their growth, in order that the race may be propogated.

The heat requirements for hatching are not stringent. In the laboratory the hatching process took place at all temperatures from 15 to 35°C. Capsules hatched successfully both in the incubator, kept at 35°C., and in various cages kept at about 23°C. during the day, and cooling to about 15°C. at night. The latter were frequently subjected to nearly zero temperatures for one or two hours when the cages were being cleaned. The variation of the incubation period at different temperatures was not determined. With a constant temperature of 35°C., when the eggs were carried normally by the female, and ample moisture was supplied, the incubation period was fourteen or fifteen days, rarely sixteen, with an average of 14.6 days.

Hatching

Three or four days before hatching a green band appears down each flat face of the oötheca. At first it is faint, but gradually increases in intensity until hatching takes place. Then it is dark green, stretching longitudinally down the capsule, occupying the third quarter of its width from the seam. At hatching the entire capsule splits down the seam, starting at the middle. All the eggs hatch at the same time, the whole process taking place in about five minutes. The nymphs emerge in two regular rows, facing each other, with the dorsum to the outside of the capsule. They come out head first, with the antennae and all the appendages pointing caudad. They work their way out of the oötheca with alternate swelling and contraction. Spines and joints slide out easily but flare when pushed back, so that the nymph can go only outwards. During emergence the head is tucked into the "chest," gradually working its antennae and palpi free. While emerging, the thorax is cylindrical, but its dorsal plates spring into place before the abdomen is fully out. The abdomen at this time is one and one-third times as long as the thorax, and as wide as the thoracic sterna. Appressed hairs and spines spring upright a few seconds after emergence. While emerging, the color is translucent, but in less than a minute after exposure to the air the outer edges of the sclerites whiten and become chalky and opaque. The eyes, spines and tips of the mandibles are ferruginous, and the abdomen has a green band in the body cavity, as wide as the body, and occupying segments six, seven and eight.

After working free from the oötheca the nymphs are very active, running freely. The abdomen gradually shortens and widens until in one-half an hour it is almost circular, and only one-half as long as when emerging. The eyes soon become black, and the cuticle, starting at the edges, turns grey. In six hours the entire body is a dark brown. When other foods are present, the young do not eat the oötheca.

Hummel, according to Herrick,[3] states that the mother sometimes assists the young to escape from the egg-case by tearing it open with her jaws, thus providing a means of egress for the young. Watch was kept in these experiments for manifestations of this maternal care, but no case of it was seen. It was found, however, that if the adults were kept without water for a lengthy period, and only given dry food, if eggs were present, whether loose on the floor or carried by the female, the parched adults attacked them, eating the eggs and most of the oötheca wall. It is doubtful if they ever show maternal care, but cannibalism instead.

The Nymphal Instars.

Blachley,[1] and Miall and Denny[4] both state that the first moult occurs a few hours after hatching. This moult has not been observed in these studies.

The second moult occurred eight days after the first. Two or three days before moulting the abdomen of the nymph elongates, becoming almost cylindrical, with the white coria showing between the abdominal sclerites. The nymph then bursts the old skin down the median line of the thorax, pulls out its head, then its legs and abdomen simultaneously, and emerges in its new epidermis. This is at first a translucent white but darkens through gray to dark brown in the course of a day. The exuvia appears compressed, not elongate, as did the individual before moulting. The newly moulted nymph has a flat, broad abdomen, and is the same length as the lengthened individual from which it came, but much wider.

The exuviae are eaten very quickly either by the nymphs which came from them, or other individuals who happen to be nearby. Older nymphs were observed to drive away newly emerged individuals from their cast skins, and commence to eat the latter with great gusto, in preference to fresh flour paste. If this does not happen, the moulting nymphs usually eat their exuviae before leaving them. After the first meal only a few legs and odd bits are left of them, and these soon disappear also. Never are exuviae found lying about the cages of the younger instars.

The third moult occurred nine days after the first in all four cages. The habits of the nymphs are the same as in the earlier instar. The fourth moult took place nine days after the third in three of the cages, and ten days after in the fourth. Although all hatched from the same capsule at the same time, one or two nymphs moulted in eight days and some in ten. The large majority, however, moulted in nine days. The fifth moult occurred in from nine to eleven days, with an average of ten days. The sixth instar lasted sixteen days. As in the previous two instars the moulting in each cage was spread over three days, but in this instar practically the same number moulted on each of these days, and not the greater number on the middle day. In this instar the caudolateral angles of the meso- and metanotum are produced slightly caudad, but not conspicuously so. This is the first external evidence of the wings. In this instar also the two sexes can be distinguished. The males appear smaller and more slender than the females, and are a lighter color. They began moulting for the most part before the females.

The seventh is the last nymphal instar. The caudo-lateral angles of the meso- and metanotum are conspicuously produced caudad, hence it has often been referred to as the "pupal" stage. While the duration of the other instars was quite constant, the duration of this stage was extremely variable. The average length of the instar was ten days, but it varied from seven to seventeen days. This variation was present in all four cages. Again, in the previous moults there had been a very small mortality, less than 5%. The mortality in the last moult, however, was much greater, about 40%. The greater number of the deaths occurred when the insect had burst the dorsum of the thorax and was in the midst of the emerging process. The rest of the deaths occurred when the insect was unable to pull out its head or free its appendages from the old skin after it was almost entirely out.

The Adult.

Of the forty individuals started, nineteen were reared to maturity, the rest dying from natural causes, or being killed when attempting to escape.

The average time required to go from hatching to adult was sixty-two days, varying from fifty-five to sixty-eight. The males, eleven in number, took an average of 59.9 days, varying from fifty-five to sixty-two. With the exception of one female that matured in fifty-seven days, the males all matured in less time than the females. These took an average of sixty-four days, between four and five days longer than the males. The males, then, seem to develop a little more rapidly than the females. The two sexes are both developed from the same egg capsule. Considering large numbers they are usually present in about equal proportions. Of two hundred individuals examined, 45.5% were males and 54.5% females.

The two sexes can readily be distinguished by the following differences (see Fig. 1, A and B):

Male	Female
1. Body thin, slender; sternum light brown, markedly convex.	1. Body stout, robust; sternum dark brown, flattened.
2. Pygidium conspicuous, long, not covered by tegmina.	2. Pygidium inconspicuous, short, entirely covered by tegmina.
3. Seventh and eighth abdominal tergites with conspicuous depressions.	3. These tergites regular, without depressions.
4. Cerci eleven jointed.	4. Cerci twelve jointed.

The females, as previously stated, produce their first oötheca eleven or twelve days after becoming adult. According to Haber[2] this is two to four days after copulation. The number of oöthecae one female can produce has not been definitely determined for this species. From present observations, however, it would appear that some produce one oötheca while others produce two. Of sixteen females observed, five produced only one, and the remainder produced two. All died without producing more. While the average number of eggs contained in the first oötheca was thirty-six, the average number for the second was only twelve, ranging from ten, the usual number, to an occasional one with as many as eighteen. These were produced at varying intervals after the first ones, from fourteen to twenty-five days, as compared with the constant time of eleven or twelve days as the maturing period for the first oöthecae.

The longevity of the adults of this species seems to be over two months. Of thirty individuals which were recorded 30% had died after living from forty-two to fifty-six days, and the remaining 70% were still vigorous and apparently healthy sixty-five days after becoming adults. The body, which darkens with age, had by this time become almost black in the case of the females, and the individuals themselves had become relatively quiet and docile. It is curious to note that the younger females, even when carrying an oötheca, can walk upside down on dry glass with the utmost ease; but shortly after the first oötheca has been dropped, the females lose this power and can not walk up even a vertical surface of glass.

Further experiments in the life history were not pursued. Our knowledge of the biology of these insects, however, is very fragmentary. A great deal remains to be found out in this field and much interesting and valuable work must be done before this species and its allies are thoroughly understood. The short survey given in this paper does little more than touch upon the subject, but it is hoped that it will serve as a basis or suggestion for further research work.

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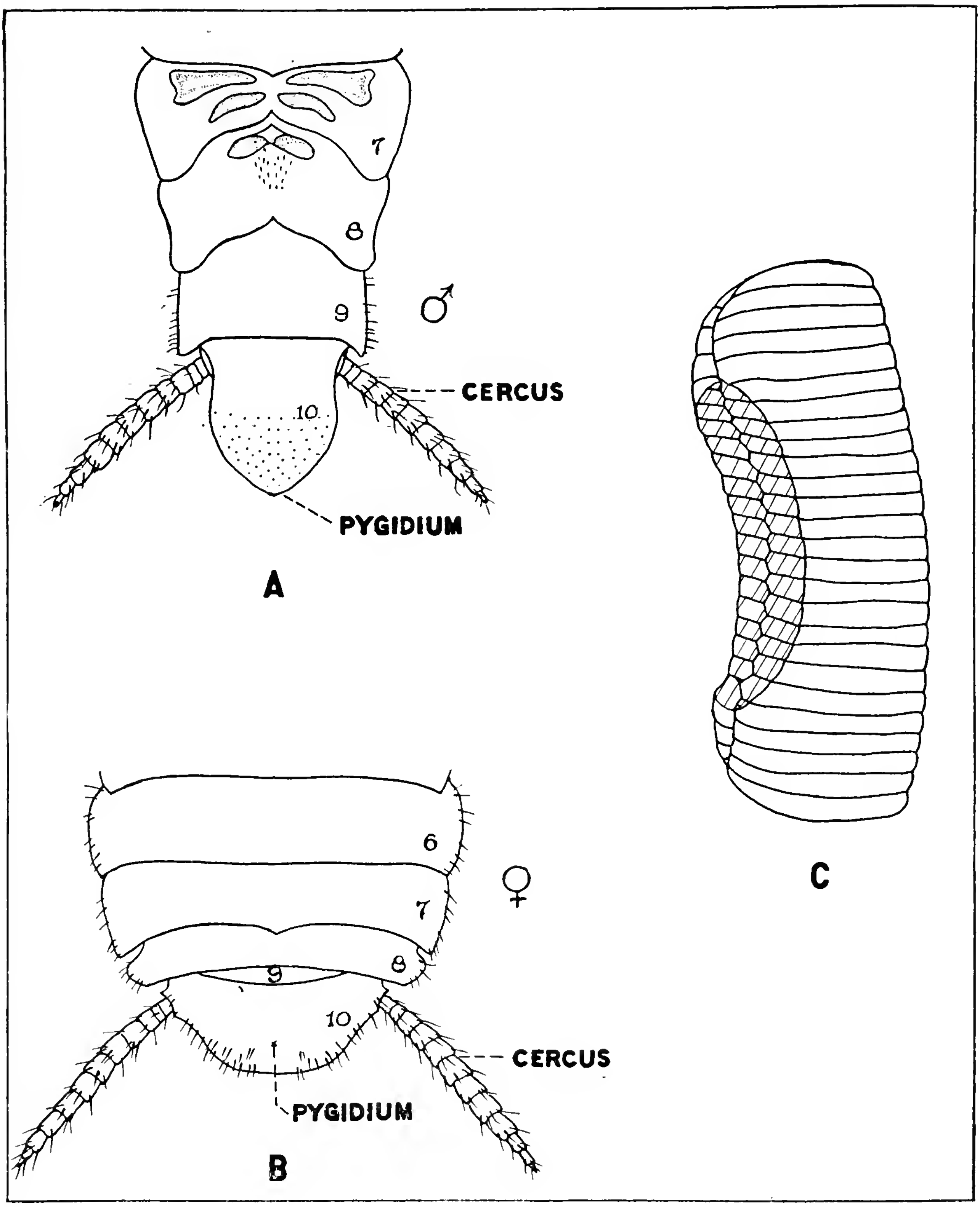

FIG. 1.

GERMAN COCKROACH. (Blattella germanica)

A. Apical abdominal tergites of male.
B. Apical abdominal tergites of female.
C. Oötheca with lateral portion cut away to show internal structure.

REVEGETATION AFTER LOGGING AND BURNING IN THE DOUGLAS FIR REGION OF WESTERN WASHINGTON.[1]

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During the summer of 1926 some 80 plots were established on logged and burned areas in the Douglas fir region of Western Washington. These plots were established primarily to study germination, survival and establishment of the Douglas fir and other coniferous seedlings. At the time they were laid out, however, full data were also taken on the density and specific makeup of their vegetative cover as well as slope, exposure, soil and time and degree of burn.

These plots were located on the cutting areas of several logging companies (see Table 1 and Fig. 1) operating chiefly on private land. They were laid out only on those areas whose cutting and fire history was accurately known (not later than the spring of 1924) and were permanently staked for future observation. All of them were 8¼ x 33 feet in size giving an area of 1/160 of an acre. The time of burning of these plots varied from the spring of 1924 to the spring of 1926 and was usually done in April (spring), July (summer) or October (fall). Burning occurred immediately or shortly after cutting. The author's judgment served as the basis for the designations, severely, moderately and lightly burned. This is an admittedly unsatisfactory method but so far no quantitative method of determining the severity of a slash fire has been devised. The reliability of the conclusions drawn varies with the number of plots observed under each burning date and the number of areas on which these plots were observed (Table 1).

Density of Vegetative Cover.

The density of the vegetation covering each plot was estimated according to the method used in grazing reconnaissance in the Forest Service, a fully vegetated area being considered

[1] This work was done while the writer was in the employ of the Pacific Northwest Forest Experiment Station, U. S. Forest Service. The study was not, however, a regular project of that Station but was carried along with other duties. The writer alone is responsible for the facts here recorded and the conclusions reached. Thanks are due the Director of the Pacific Northwest Forest Experiment Station for permission to publish.

100 per cent cover. There are many difficulties inherent in the method but none better is available for field work. "Foliage cover" was used rather than "basal cover,"[2] as very few of the species were bunch forming grasses or sedges.

The average density of vegetation increased with time: Spring 1926, 4%; Fall 1925, 15%; Summer 1925, 18%; Spring 1925, 43%; Fall 1924, 57%; Spring 1924, 70% (see Fig. 2). Whether the flattening of the curve at the Summer 1925 burning was due to local causes (all of the plots in this burn were located on one area) or whether in mid-summer the extremely dry slash caused an unusually complete burn, cannot be decided from the data in hand.

TABLE I.

SUMMARY OF PLOTS LAID OUT ON LOGGING AREAS—SUMMER OF 1928.

Logging Company	Time of Burning						Total Plots
	1926	1925			1924		
	Spring	Fall	Summer	Spring	Fall	Spring	
Mud Bay Logging Co.	4	1		4			9
Phoenix Logging Co.	4	7		4			14
Hama Hama Logging Co.				7		3	10
Webb Logging & Timber Co.		16					16
Elbe Lumber & Shingle Co.			10				10
Pacific National Lumber Co.		10					10
St. Paul & Tacoma Co.		5			6		11
Total number of Areas	2	5	1	3	1	1	13
Total number of Plots	8	39	10	14	6	3	80

When the percentages of total vegetative cover on all the plots of different degrees of burning (severe, moderate, light and unburned) are averaged, we get a very interesting result which may be summarized as follows: severe burn (9 plots) 37.3 per cent density; moderate burn (33 plots) 46.6 per cent; light burn (23 plots) 35.7 per cent; unburned (8 plots) 20.8 per cent. One would expect, contrary to the above, that unburned and lightly burned plots would have a greater amount of vegetation than the moderately and severely burned plots. On looking over the plot descriptions, however, it is noted that most of the unburned and lightly burned plots were laid out on areas

[2] Sarvis, J. T. Composition and density of the native vegetation in the vicinity of the Northern Great Plains Field Station. Jour. Agr. Res. 19:63-72. 1920.

where there was (1) considerable exposed mineral soil (skidways), (2) much disturbed soil mixed with duff and debris, or (3) a heavy cover of duff, debris, etc. None of such areas are

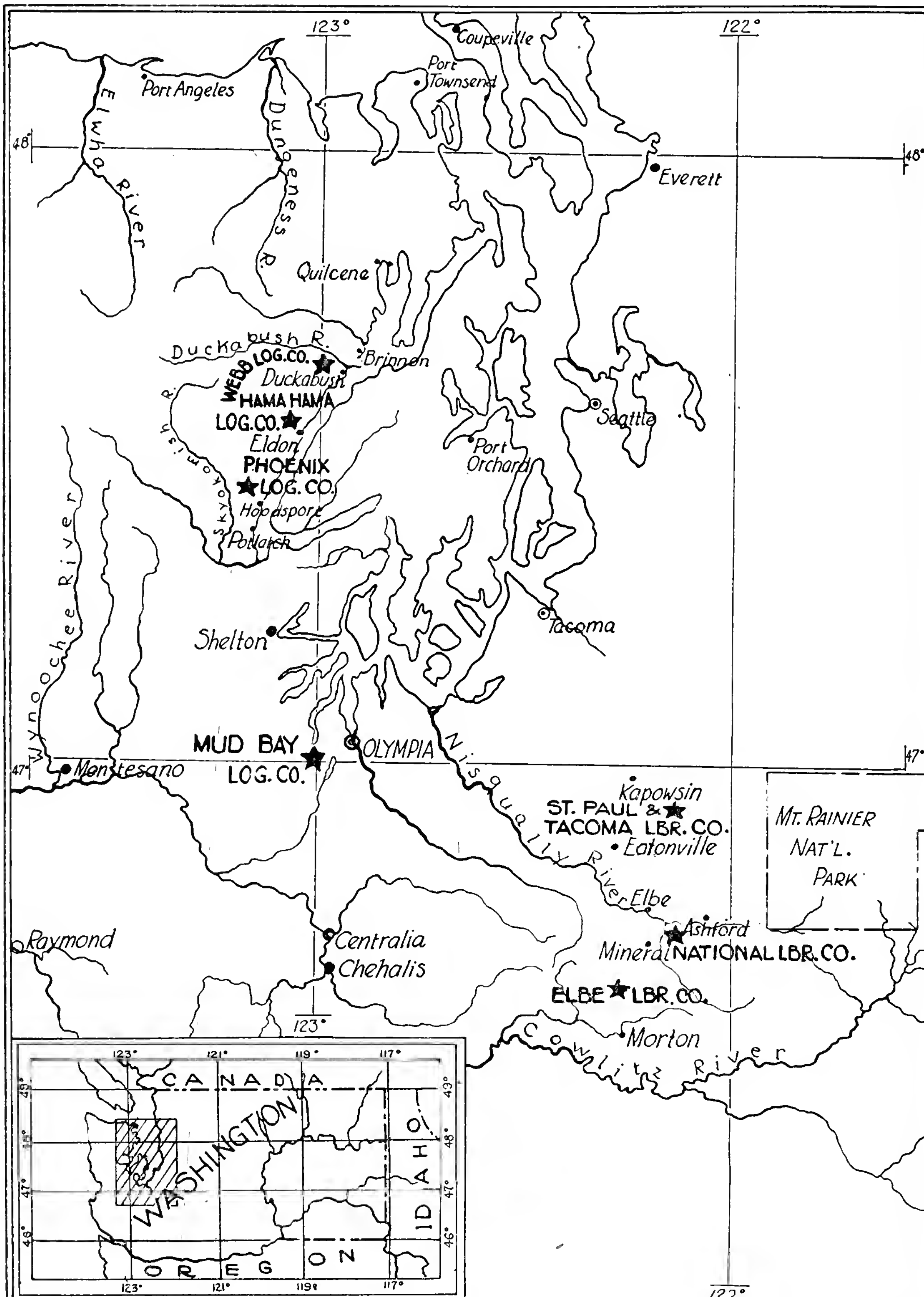

FIG. I.—Map of the Puget Sound region, Washington, showing the location of the logging companies on whose cuttings plots were laid out. The cross-hatched area in the inset is shown on the large scale map.

favorable for the early establishment of an abundance of vegetation. The bare mineral soil of a skidway or the disturbed soil mixed with duff and debris usually means that the species present on that area in the virgin timber have been destroyed by logging; hence there is little chance for an early reappearance of the original species, though weeds may seed in later in abundance. An area covered by duff and debris is also disturbed and the original species may be destroyed or covered up. Moreover, much debris prevents the seeding in of outside species for many years and such areas remain unvegetated the longest of any. It is difficult to get plots of all degrees of severity of burn and unburned on the same area. The above conditions (1, 2 and 3) are almost never found on moderately burned plots while severely burned plots are usually areas of heavy slash burned quite clean, the effect of which is accurately indicated, I believe, in the lesser amount of vegetation on the severely burned plots (37.3%) as compared to the moderately burned plots (46.6%). It must be remembered, however, that severe burning lessens the amount of shrubby and herbaceous vegetation which may live through the fire but may even favor the coming in of the seeds of wind distributed weedy species by clearing the ground of duff and debris and exposing the mineral soil in a favorable seed bed. Time very soon obliterates any differences in the amount of vegetation on burns of different degrees of severity.

Specific Makeup of the Vegetation on the Plots.

The species found on the plots after burning consist of those which are present in the virgin timber before cutting and burning and those which are not present in the virgin timber but are seeded in from the outside. The degree to which the different virgin timber species are able to withstand injury or killing by the fire varies greatly and determines the abundance with which such species are present immediately after fires of different degrees of severity. The woody species may be only partially killed, the larger stems and crowns sprouting out again after the fire. Usually the aerial part is killed and sprouting takes place from the roots and crown. The herbaceous species invariably have their aerial parts destroyed by a fire of any severity but their underground roots or stems as well as their seeds often survive a fire which is not too severe. The ability of those species not in the virgin timber to revegetate a burned area is dependent chiefly upon their nearness to the burned area; the mobility of their seeds or fruits and the number and viability of such seeds or fruits. These facts make it necessary to group the plants found on plots into several groups.

Group I, called the *virgin timber herbaceous species,* is made up of a group of herbs found in varying numbers in the virgin timber and surviving the fire chiefly through underground parts. The ferns are particularly prominent on recently burned plots. This group as a whole, however, is unable to withstand the much more xeric conditions of the burned plot as compared with the virgin timber and is most abundant shortly after the fire, gradually becoming less and less abundant.

Group II, called the *virgin timber shrubby species,* is made up of small trees, shrubs and creepers present in the virgin timber which survive the fire with varying degrees of success and sprout again from unkilled stems, crowns and roots. As a group they are much more able to thrive under the changed conditions of the burned areas and often grow in much greater profusion after the fire than in the virgin timber. This is particularly true of the blackberry.

Group III includes the *weedy species,* most of which are not found at all in the virgin timber but which seed in abundantly and often dominate the area, particularly on mineral soil exposed by disturbance or by severe fire. All are characterized by tufted fruits or seeds except *Carex* and the grasses.

A small but difficult miscellaneous group of three species consists of bracken fern, *Viola* and *Trientalis.* Bracken fern is an herbaceous plant found in the virgin timber but after burning it frequently dominates the area completely and is usually abundant wherever present at all. Because of this and because of its prevalence on waste lands it is classed with the weeds. *Viola* and *Trientalis* are found in the virgin timber but they persist after burning on most of the plots though never in any great abundance. They are classed with the virgin timber herbaceous species. The specimens of *Trientalis* found growing on the burned plots are dwarfed with small, curled, thickened leaves crowded on short, thick stems not at all the delicate, thin-leaved plant of the virgin timber.

The principal species in each of the above groups are listed below in the order of their frequency of occurrence on the plots. The number following each name indicates the number of plots (out of a total of 80) on which the species was found.

I. Virgin Timber Herbaceous Species.

Polystichum munitum (38), sword fern
Trientalis latifolia (32)
Viola spp. (22)
Oxalis spp. (10)
Bikukulla formosa (9), bleeding heart
Disporum oregonum (8)
Achlys triphylla (7), vanilla leaf
Montia asarifolia (7), miner's lettuce

II. Virgin Timber Shrubby Species.

Berberis spp. (56), Oregon grape
Rubus macropetalus (52), blackberry
Gaultheria shallon (43), salal
Sambucus spp. (25), elderberry
Vaccinium spp. (18), huckleberry
Vaccinium ovatum (8), evergreen huckleberry
Acer circinatum (7), vine maple

III. Weeds.

Senecio vulgaris (67)
Epilobium angustifolium (52), perennial fireweed
Epilobium (annuals) (41)
Crepis spp. (13)
Cirsium spp. (10), thistle
Hieracium albiflorum (9), hawkweed.

Evaluating the Density and Frequency of These Groups.

From field notes the density of the different species found on the plots was determined. These notes consisted of the per cent density of the total vegetation and also the density of the principal species on the basis of 100 per cent for the plot, while

TABLE II.

Density of the Vegetation on Plots Burned at Different Times.

Groups of Species	Time of Burning					
	Spring 1926	Fall 1925	Summer 1925	Spring 1925	Fall 1924	Spring 1924
Virgin timber (herbaceous)..	3.0	2.3	3.4	4.6	0.3	1.7
Virgin timber (shrubby).....	1.0	4.0	4.2	19.0	1.0	15.0
Weeds	0.3	7.8	11.4	20.9	56.0	52.0

the less important species were listed as being present. From these notes the density of each species has since been calculated. Thus if the density of the total vegetative cover on a plot was 75% and this was made up of 75% *Epilobium angustifolium*, 10% *Rubus macropetalus*, 5% *Gaultheria shallon* and 10% of

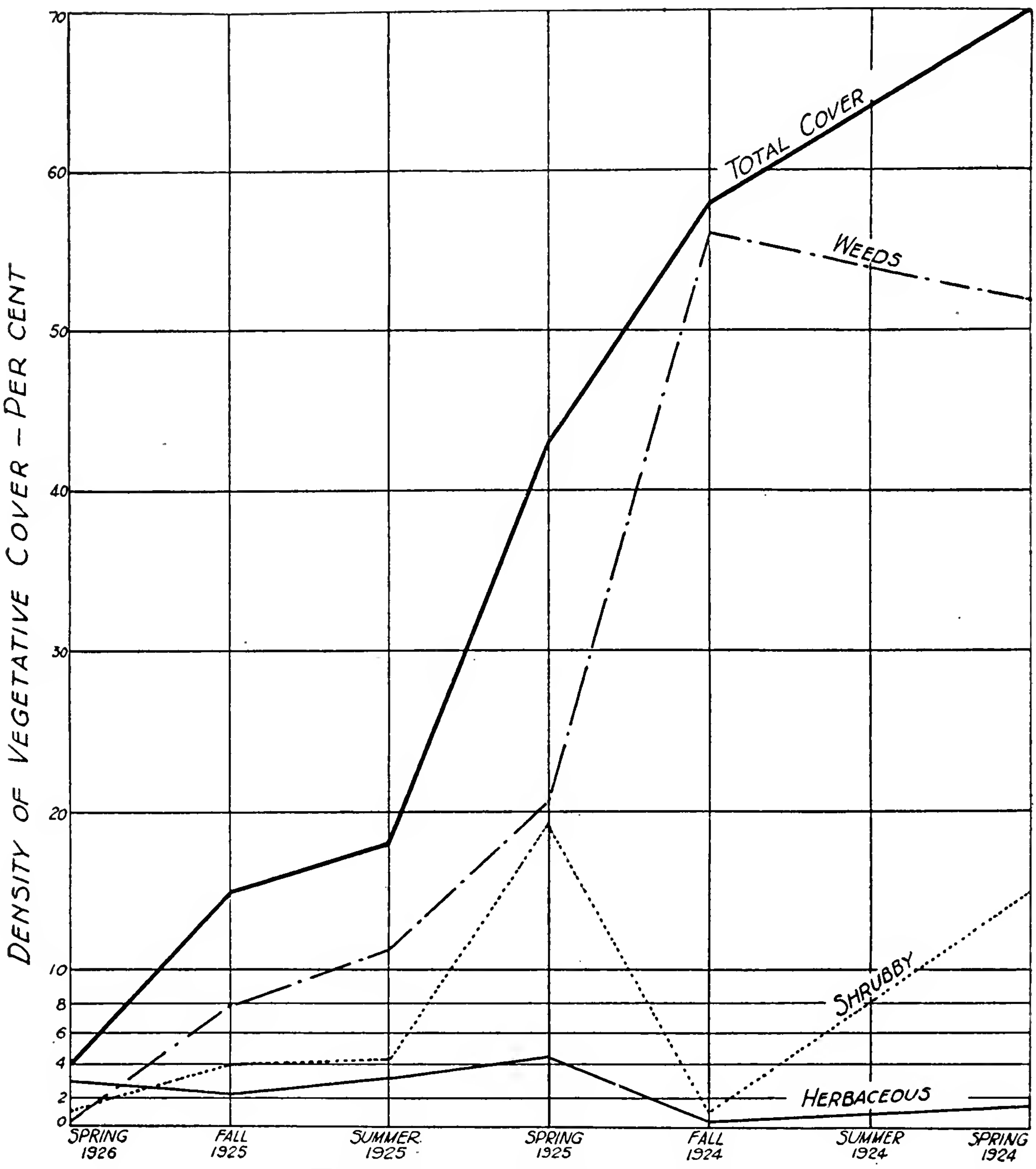

FIG. 2.—Average density of the total vegetative cover and the density of the three groups of species on the plots burned at different times.

other species consisting of *Berberis spp.*, *Senecio vulgaris*, *Vaccinium spp.* and *Oxalis spp.* (total 100%) the actual density was calculated as follows:

Epilobium angustifolium (75% of 75%)	=	56.25%
Rubus macropetalus (10 of 75%)	=	7.50%
Gaultheria shallon (5% of 75%)	=	3.75%

The remaining 10% was arbitrarily divided among the other species:

Berberis spp.	=	2.00%
Senecio vulgaris	=	2.00%
Vaccinium spp.	=	2.00%
Oxalis spp.	=	1.50%
Total	=	75.00%

Because of the difficulty of estimating accurately the per cent of density of the less important species without resorting to the extremely laborious method of cutting all of the vegetation on a plot, sorting it according to species and determining the dry weight, the above method was used because much greater areas could be sampled even though the method was less accurate. The figures obtained are a quantitative measure of the actual amount of each species present and when grouped into the three groups discussed above and averaged for all the plots of a certain burning date we get the results given in Table II and shown graphically in Fig. 2.

In order to determine how consistently the various species and groups of species were in their appearance on all of the plots observed the number of times they occurred was counted and this figure divided by the number of plots on which observations were made. This frequency figure indicates how consistently certain species or groups appeared but does not indicate the density of those species or groups on the burns of different dates. (See Table III and Fig. 3).

TABLE III.

FREQUENCY OF APPEARANCE OF THE DIFFERENT GROUPS OF SPECIES ON PLOTS BURNED AT DIFFERENT TIMES.

Groups of Species	Time of Burning					
	Spring 1926	Fall 1925	Summer 1925	Spring 1925	Fall 1924	Spring 1924
Virgin timber (herbaceous)..	1.9	2.3	3.3	1.3	.33	1.0
Virgin timber (shrubby).....	2.0	2.9	3.0	3.0	1.0	3.3
Weeds	0.6	2.5	4.0	3.3	3.7	4.0

The data presented in Table II and III and represented graphically in Figure 2 and Figure 3 when examined in relation to each other bring out certain facts which point the way toward a better understanding of the revegetation of areas after logging and burning. The limited number and distribution of the plots and the short period over which the observations extend make

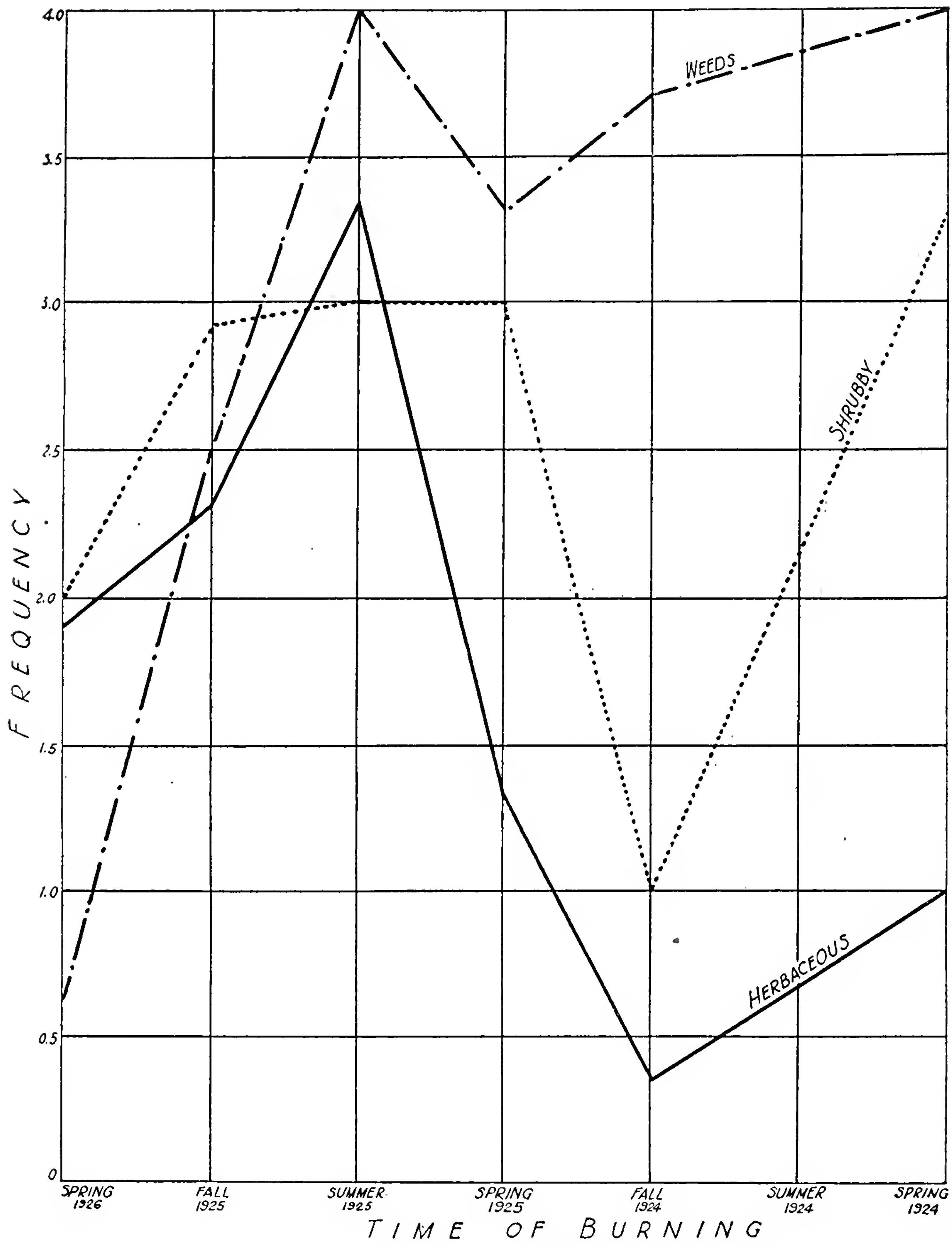

FIG. 3.—Frequency of occurrence of the three groups of species on the plots burned at different times.

the conclusions reached tentative in nature, subject to later modification and verification. The author believes, however, that in the light of observation made on other areas that the conclusions reached are essentially correct.

These conclusions may be summarized as follows:

(1) The density of all of the groups of species as well as the total vegetative cover is low on the plots burned recently. The total vegetative cover rises steadily and rapidly as the plots become older.

(2) The herbaceous group starts high in both density and frequency due chiefly to the high fire survival of the sword fern *(Polystichum munitum)* (Fig. 4). It starts higher on the whole than either the shrub or weed groups but shows a gradual downward trend, becoming consistently less in density and also less in frequency of appearance with increasing age of the plots. It will undoubtedly continue to become less and less in amount because of its inability to withstand the intense heat, bright light and consequent low humidity of the air and low moisture content of the soil of the burned areas as compared to the shady, moist virgin timber. It will probably increase later on as the shrubs shade the ground to a greater extent. The unusually high frequency of this group on the Summer 1925 plots is due to the limited number of plots (all located on the Mud Bay Logging Company holdings) which were on very wet seepage areas high in miner's lettuce (*Montia asarifolia*).

(3) The shrubby species present in the virgin timber start somewhat lower in density than do the herbs (Fig. 2) due to a slower start than the sword fern immediately after the fire. They are fairly high in frequency, however, due largely to Oregon grape *(Berberis spp.)*, blackberry *(Rubus macropetalus)* and salal *(Gaultheria shallon)*, being present on practically all of the plots soon after the fire. They put up only a few sprouts the first year after the fire but as a group they gradually become more and more abundant until they shade the ground but are in turn crowded out by the conifers. The unusual rise in the density curve in the Spring 1925 is due to the unusually large amount of salal surviving under the rather open stand of second growth so characteristic of the gravelly soils of the Phoenix Logging Company holdings. The low drop in the Fall 1924 is due to a severe burn which was very thickly populated by Epilobium and *Senecio vulgaris* as is shown by the rise in the curve for weeds (Fig. 2). The general upward trend of the curve representing the shrubs is evident despite these two cases.

(4) The weeds start very low in both frequency and density due to the fact that they must seed in from the outside but

the curve rises rapidly to a dominant position both as to frequency and density. The abundance of tufted seeds produced by Epilobium and tufted fruits by Senecio soon seed in these areas particularly where the mineral soil is exposed by disturbance or by severe fires. Observations on older areas indicate the gradual decrease in the weed population as the shrubs and conifers grow up and shade them out.

The most important members of each group of species are fairly consistent in their density on the various plots when compared with that of the group as a whole. We may choose therefore the most abundant species in each of the groups as representative of that group.

TABLE IV.

Density of Four of the Principal Species Found on the Plots Burned at Different Times.

Species	Time of Burning					
	Spring 1926	Fall 1925	Summer 1925	Spring 1925	Fall 1924	Spring 1924
Sword fern	2.5	0.77	0.5	0.21	0.33	0.0
Oregon grape................	0.25	0.69	1.6	2.3	0.17	2.33
Senecio	0.13	5.26	4.8	11.58	9.0	17.66
Perennial fireweed...........	0.0	1.29	3.9	1.0	45.66	15.33

Thus in Figure 4 the sword fern gradually becomes less as the plots become older while Oregon grape gradually rises and Senecio starts low but rises very rapidly. If we compare the density of perennial fireweed (*Epilobium angustifolium*) we notice a strikingly interesting fact, namely the reciprocal relationship that exists between Epilobium and Senecio, the two most important members of the weed group. When there is a high relative density of Epilobium there is a low relative density of Senecio. This is borne out by many observations of areas some of which are almost pure Epilobium with practically no Senecio and others pure Senecio with practically no Epilobium. These areas have been observed within a half mile of each other on areas cut and burned at different times on the St. Paul and Tacoma Lumber Company holdings. Some, as yet unknown factor, allows one species to get started before the other and thus gain complete dominance. Seeding in is probably not a factor as the two species are widely distributed throughout the region under observation and the tufted seeds or fruits of both are so light as to be blown everywhere in such abundance as to seem almost like a snowstorm during the height of the fruiting season. It does not seem probable that one area is seeded in with one species and not the other and another area the reverse.

Often a species may be present on a large number of plots but not be very abundant on those plots, that is have a high

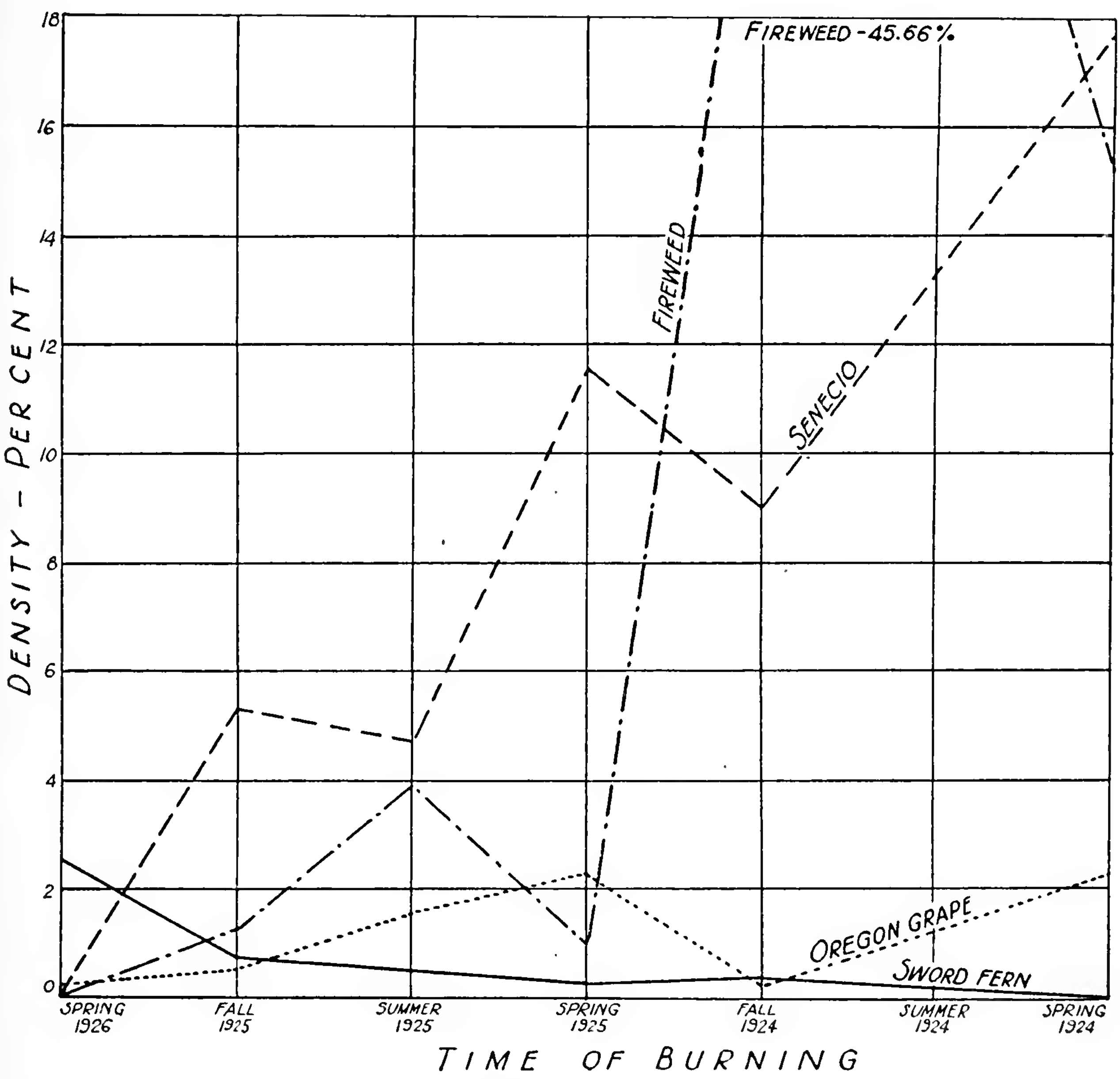

FIG. 4.—Average density of four important species chosen from the three groups of species on the plots burned at different times. The species are: sword fern (**Polystichum munitum**), Oregon grape (**Berberis spp.**), fireweed (**Epilobium angustifolium**), **Senecio vulgaris.**

frequency but a low density. This is more clearly shown by a comparison of the seven most important species found on the plots: sword fern (*Polystichum munitum*), Oregon grape (*Berberis spp.)*, blackberry *(Rubus macropetalus)*, salal *(Gaultheria shallon)*, *Senecio vulgaris*, perennial fireweed (*Epilobium angustifolium*) and bracken fern (*Pteridium aquilinum pubescens*).

TABLE V.

AVERAGE DENSITY AND FREQUENCY ON ALL PLOTS OF THE SEVEN MOST IMPORTANT SPECIES.

DESIGNATION	SPECIES						
	Sword fern	Oregon grape	Black-berry	Salal	Senecio	Fire-weed	Bracken fern
Density	0.72	1.22	1.23	4.05	8.07	11.2	4.0
Frequency	0.42	0.61	0.66	0.53	0.82	0.69	0.23

Sword fern is present on a considerable number of plots but usually as scattering individuals whose vegetative bulk (density) is not very great (Fig. 5). The same is true of Oregon grape and blackberry. Salal is present on fewer plots but usually forms a greater amount of vegetation on those plots on which it is present. This applies also to Senecio while fireweed is less consistent in its occurrence but whenever it does occur it occurs in such abundance as to form a great bulk of vegetation, hence a high density.

The data in hand does not show any significant difference in the density of the total vegetative cover on northerly slopes as compared with southerly slopes. A close analysis of a large amount of data would undoubtedly show a difference in the species inhabiting the two slopes but probably no difference in the amount of cover. The same is true of degree of slope, except extremely steep slopes which are apt to be rocky or badly washed and with less vegetation than gentle slopes or flats. Clay soil as contrasted with gravelly soil gave no consistent difference though there is an indication of more vegetation on the clays than on the gravels.

Raunkiaer's Law of Frequency.

When Raunkiaer's law of frequency as discussed by Kenoyer[3] is applied to the plots burned on various dates it is found that most of the frequency figures fail to fit the formula. Raunkiaer groups the species found on an area which has been adequately sampled, into five groups with frequencies of 1-20 percent, 21-40 percent, 41-60 percent, 61-80 percent, 81-100 percent respectively. These may be designated at A, B, C, D, and E. From thousands of frequencies Raunkiaer obtains the following

[3]Kenoyer, L. A. A study of Raunkiaer's law of frequency. Ecology 8:341-349. 1927.

ratio: 53, 14, 9, 8, 16 or simplified, about 7, 2, 1, 1, 2. That is, the species which are present on only a few plots (1-20 percent) are many in number (53) while those with a higher frequency are less numerous 14, 9 and 8, while those species that are present on all or nearly all of the plots (81-100 percent) are relatively greater in number (16). There are therefore many sporadic species and a few species which dominate the area to such an extent as to hinder other plants from competing with them.

The lack of fit in the frequency figures from the plots under observation may be due to inadequate sampling, or lack of homogeneity of the vegetation on the areas sampled but is most likely

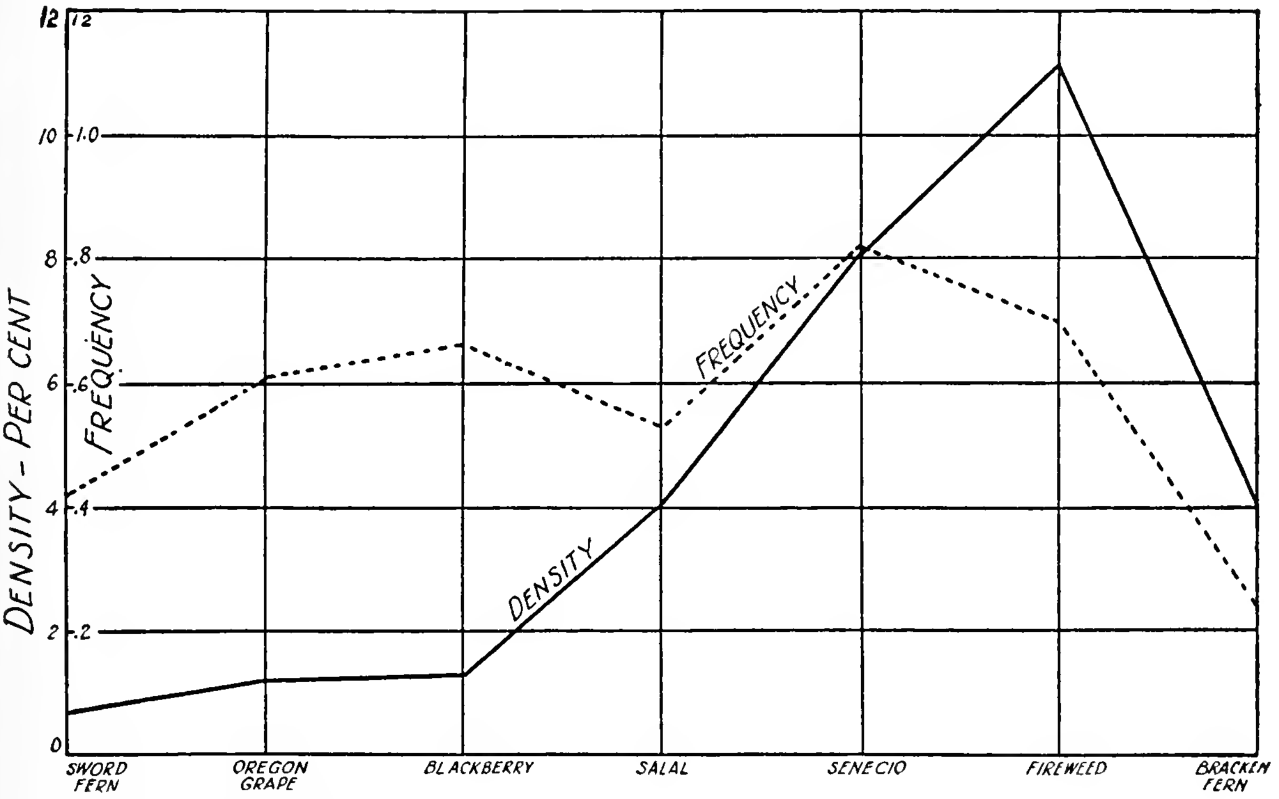

FIG. 5.—Comparison of the density and frequency of occurrence of seven of the most important species found on the plots: sword fern (**Polystichum munitum**), Oregon grape (**Berberis spp.**), blackberry (**Rubus macropetalus**), salal (**Gaultheria shallon**), **Senecio vulgaris**, fireweed (**Epilobium angustifolium**), bracken fern (**Pteridium aquilinum pubescens**).

due to the fact that the vegetation on these areas has not reached anything like stability and the ratios which were obtained such as: 31, 3, 5, 2, 1 and 11, 7, 2, 4, 1 and 14, 3, 0, 6, 2, and 15, 4, 3, 3, 3, indicate there is a great mixture of species and few or none dominate the areas sufficiently to hinder the development of all except sporadic species. The best fit was obtained on an area burned in the fall of 1924 covered by an almost pure stand of fireweed which dominated the area. The ratio here obtained was 5, 3, 1, 1, 2.

Summary.

1. The vegetation on 80 plots located on seven different areas and representing six different dates of burning (Spring 1926—Spring 1924) was judged as to density, specific makeup and frequency in the summer of 1926.

2. The density of the total vegetative cover varied directly with the length of time after burning.

3. The plots severely burned show less vegetation than those moderately burned. The plots lightly burned and unburned show less vegetation than those moderately burned. This result is undoubtedly a discrepancy caused by the difficulty of getting comparable plots on the same area which show all degrees of burning.

4. The species found on the plots are divided into three groups and the principal ones listed:

Group I.—Herbaceous species present in the original stand of timber,

Group II.—Shrubby species present in the original stand of timber,

Group III.—Weedy species not usually present in the original timber.

5. The herbaceous group starts high on plots recently burned but gradually becomes less and less. The shrubby group starts slightly lower and become more and more abundant as the plots become older. The weeds start very low but moved up to a dominant position on the older plots with amazing rapidity. They will probably in time give way to the shrubs.

6. No consistent differences in amount of vegetation were noted between north and south slopes, steep or gentle slopes and clay or gravel soils.

7. The species frequency ratios on most of the areas do not fit Raunkiaer's law, thus indicating that the vegetation is in an unstable condition with seldom any species completely dominant over an area.

THE MOUTHPARTS OF INSECTS.

C. L. METCALF, UNIVERSITY OF ILLINOIS[1].

The mouthparts of insects are derived from the original paired appendages of the fourth, fifth and sixth somities, with certain adventitious median processes that develop at an early embryonic stage, as unpaired lobes in close conjunction with the mouth opening (Figure 1).

In the modern insects there are eight, separate, and more or less independent parts, that go to make up the trophi (Table I). The paired appendages of the fourth somite are distinct in the majority of insects as the *mandibles,* and their homologues on the fifth segment as the *maxillae.* The pair on the sixth segment in all insects has fused to form a single organ, the lower lip, called the *labium.* An unpaired median sclerite (Fig. 1, Lm)

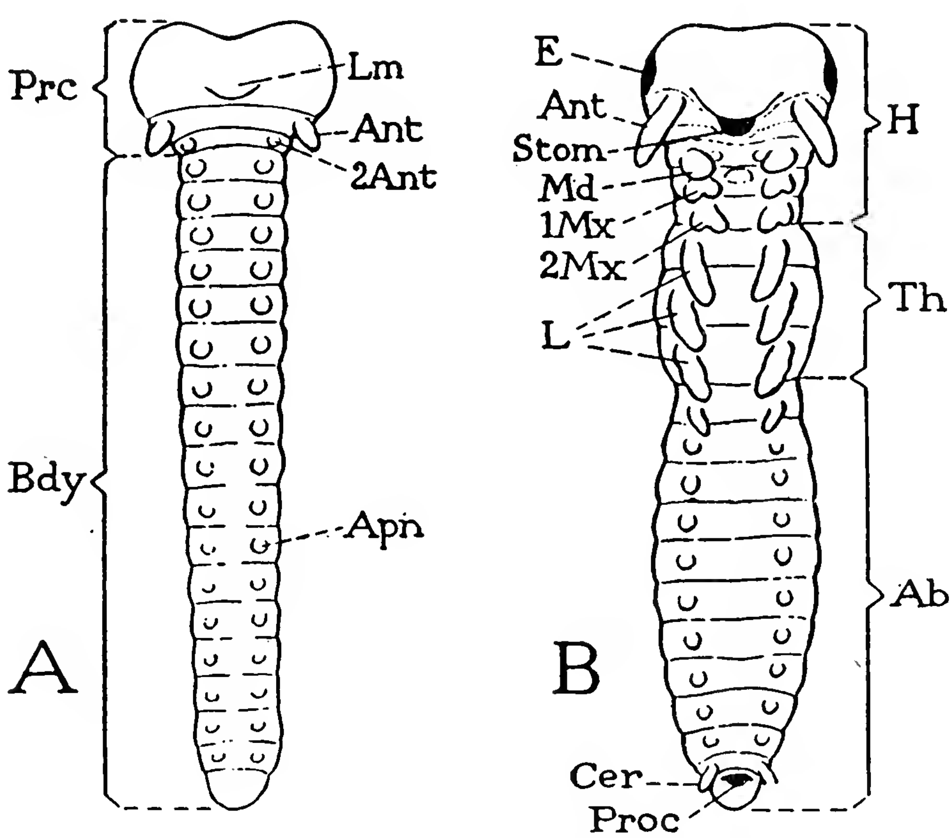

FIG. 1.—Insect embryos at two different stages, to show the origin of the mouthparts, in part as paired appendages of the head segment (**Md, 1 Mx, 2Mx**), homologous with antennae (**Ant.**) and legs (**L.**); and in parts as unpaired, median lobes above and below the mouth opening.

Ab, abdomen; **Ant**, antennae; **2 Ant**, rudimentary second antennae; **Apn**, ventral paired appendages of early embryo, common to head, thoracic and abdominal segments; **Bdy**, body of early embryo embracing three head segments, three thoracic segments and twelve abdominal segments; **Cer**, cercus; **E**, compound eye; **H**, head as constituted in adult; **L**, appendages which form the legs; **Lm**, median appendage of first segment which forms the labrum; **Md**, appendages which form the maxillae; **2Mx**, appendages which unite to form the labium or lower lip; **Prc**, procephalon or embryonic head of three segments; **Proc**, the anus; **Stom**, the mouth; **Th**, thorax. Between the **Md.** and **1Mx** are shown the three appendages which unite to form the hypopharynx with its superlinguae. **(From Snodgrass in Smithsonian Report for 1925.)**

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[1] Contribution from the Entomological Laboratories of the University of Illinois, No. 126.

arises on the embryonic insect head just in front of the mouth and develops into the upper lip, called the labrum. In many insects the prolongation and differentiation of a part of the roof of the mouth forms the *epipharynx* and a similar prolongation from the floor of the mouth is called the *hypopharynx*. According to Snodgrass the latter organ arises from three embryonic lobes, (Fig. 1), which grow together; thus accounting for the trilobed condition sometimes found in the Thysanura, Collembola, Orthoptera, Coleoptera, Dermaptera and Corrodentia. The lateral lobes are called superlinguae and are said by Crampton to be homologous with the paragnaths of the Crustacea.

The arrangement of the mouthparts of an insect, with reference to the mouth opening and other head structures, is indicated in Table I, which is plotted to show the position of the parts as the insect would face the reader.

TABLE I.

ARRANGEMENT OF THE SCLERITES AND APPENDAGES OF A TYPICAL INSECT HEAD.

The parts written in parentheses constitute the mouthparts.

The parts printed in italics are believed to be homologous to the legs of the thoracic segments.

Right Compound Eye		Vertex		Left Compound Eye
	Right Ocellus		Left Ocellus	
Right Antenna				*Left Antenna*
		Median Ocellus		
		Frons		
Right Gena		Clypeus		Left Gena
		(Labrum)		
		(Epipharynx)		
(Right Mandible)		MOUTH		*(Left Mandible)*
	(Superlingua)	(Hypopharynx)	(Superlingua)	
(Right Maxilla)				*(Left Maxilla)*
		(Labium)		

Probably no group of structures in the animal kingdom exhibits a better example of the adaptive modification of originally similar, serially arranged organs to very different-looking structures and to diverse functions. Of the appendages shown in figure 1, A, (*Apn* and *Ant*) the latter develop into the antennae and the remainder diversify to form the mouthparts, the legs, the cerci and genitalia, while many of those on the basal segments of the abdomen disappear during ontogenetic development.

In this paper attention is directed only to the modification of the eight parts which constitute the trophi. It will be seen that these structures diversify to such an extent that their homologies would never be suspected; and can be recognized, if at all, only by the most judicious study of their embryonic and postembryonic development. Their structures and uses become so varied in the different orders of insects as to constitute at least twelve different functional types and subtypes, which are discussed below.

The usual classification of mouthparts has been into "biting" and "sucking". This is so totally inadequate that one is surprised that it sufficed so long. Herms[1] advanced a classification that reveals the fundamental differences between many of the so-called "sucking mouthparts." Patton and Cragg[2] have given an excellent exposition of the structure and function of the blood-sucking species. On the work of these and many other authors in this particular phase of insect morphology, the following scheme of classification is founded. The known mouthparts of insects are here grouped into eight functional types. One of these types is subdivided into five sub-types, which are allied chiefly by function, being very diverse in structure. The two series, mandibulate and haustellate, merge into each other.

TABLE II.

TYPES OF INSECT MOUTHPARTS ARRANGED ACCORDING TO FUNCTION.

I. Mandibulate Series

A. The Chewing Type.
B. The Predator Type.
C. The Acuminate Type.

II. Haustellate Series

D. The Chewing-lapping Type.
E. The Rasping-sucking Type.
F. The Piercing-sucking Type.
   (a) The Bug or Hemipterous Sub-type.
   (b) The Common Biting-fly or Dipterous Sub-type.
   (c) The Special Biting-fly or Muscid Sub-type.
   (d) The Flea or Siphonapterous Sub-type.
   (e) The Louse or Anoplurous Sub-type.
G. The Sponging Type.
H. The Siphoning Type.

[1] Herms, W. B., Medical and Veterinary Entomology, The MacMillan Company, 1915.

[2] Patton, W. S., and F. W. Cragg, A Textbook of Medical Entomology, Christian Literature Society for India, London, 1913.

I. Mandibulate Series.

A. The Chewing Type. This type of mouthparts, which is the only form adequately described in most text books of zoology and entomology, is too well known to require detailed description here. The nature and arrangement of the parts is well illustrated by figure 2, which shows the parts *in situ* in the central drawing and more fully exposed in the surrounding figures. The characteristics of this type are two pairs of tooth-like or jaw-like structures, adapted to work together transversely; two pairs of jointed palpi; and two, more or less lip-like structures, one above the mouth and one beneath it.

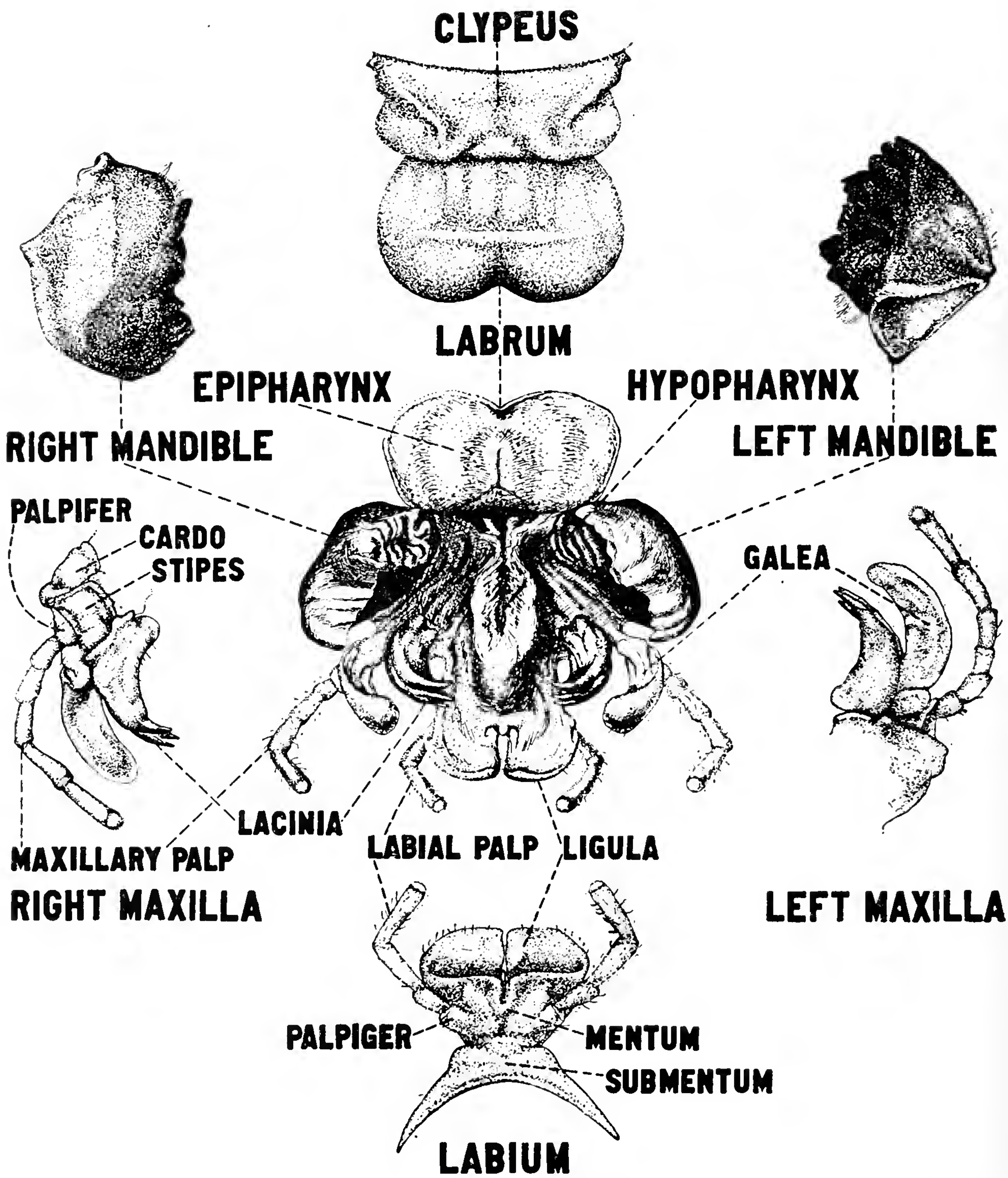

FIG. 2.—Mouthparts of the chewing type, as found in the grasshopper. The eight fundamental parts are widespread, in situ, in the central figure, and fully exposed to show the separate parts, in the surrounding figures.

(Drawings by Antonio M. Paterno.)

This is believed to be the primitive, fundamental and generalized type from which all the other types have been derived. It is found in the nymphs and adults of the orders Thysanura, Orthoptera, Dermaptera, Isoptera and Mallophaga; in the larvae and adults of Coleoptera, Neuroptera, Trichoptera, and some Hymenoptera; and in the larvae of Lepidoptera and some Diptera, besides many other insects that are less well known. There are many modifications from the fundamental type figured, some of which are indicated by the footnotes to Table III. In-

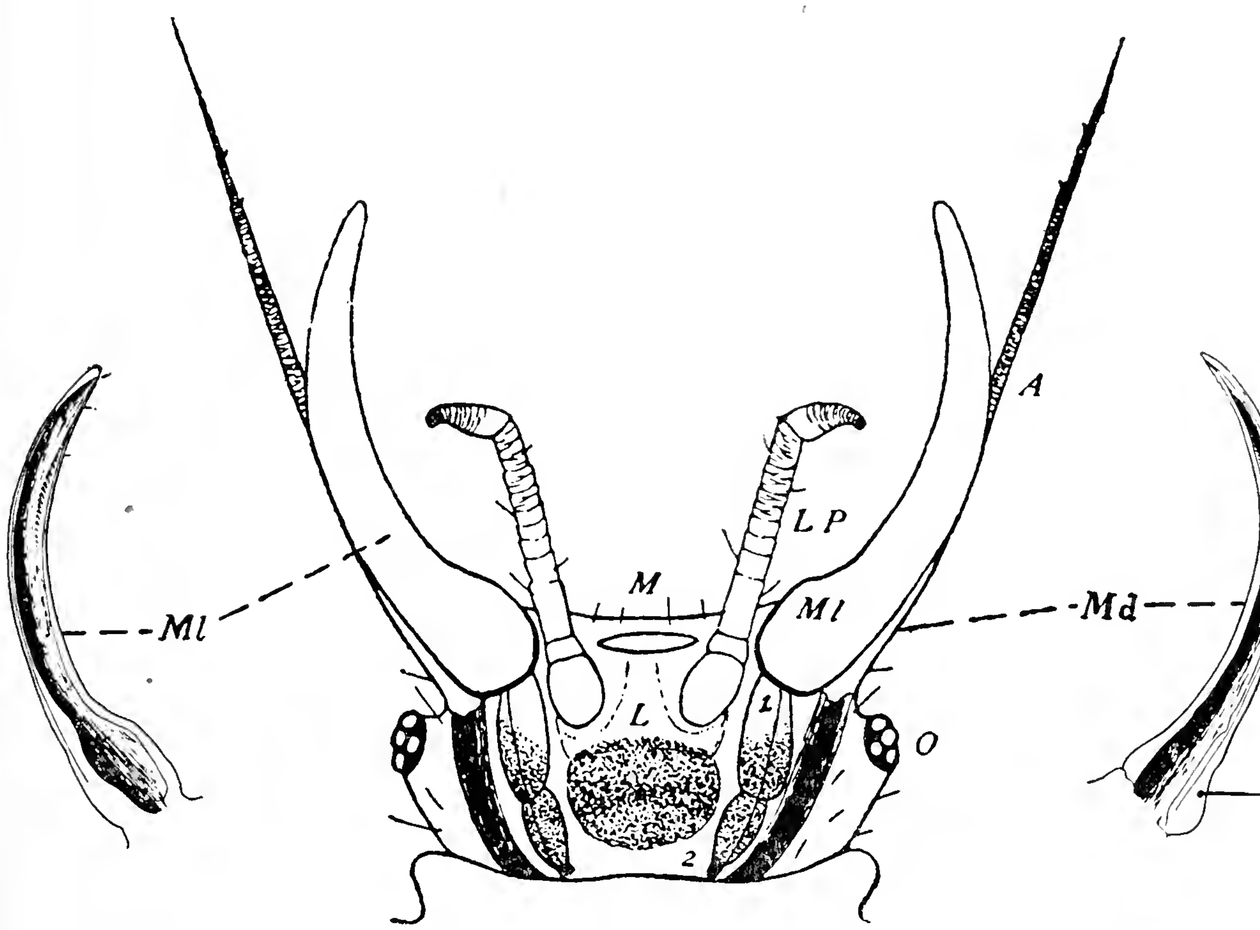

FIG. 3.—Mouthparts of the predatory type, as found in the larva of an aphid lion, **Chrysopa oculata**. At center a ventral view of the head, showing: **A**, the antenna, **L**, the labium, **LP**, the labial palpus, **M**, the true mouth opened by dissection, **Md**, the mandible, lying above, **Ml**, the maxilla, **O**, the compound eye. 1 and 2 are probably basal segments of the maxilla. At the right is shown the left mandible, ventral view, exposed to show the groove which, fitted against a similar groove in the maxilla, forms the food channel. At the left is shown the left maxilla, dorsal view, showing groove which complements that of the mandible.

(Modified from Smith, Cornell University Memoir 58.)

stead of serving for chewing plant tissues, they may be specialized for catching and devouring small animals, for fighting or clasping, for carrying or molding wax, for sifting food, or for brushing off pollen grains. All of these modifications are placed in this type, provided they readily conform to the characteristics given above.

B. *The Predatory Type.*—Some of the predaceous insects have departed so far from the chewing form of mouthparts as to be referable there no longer. The condition in the larvae of the Chrysopidae and some other Neuropteroid larvae constitutes a distinct type. In these insects (Fig. 3) the true mouth opening has become closed. Two adventitous mouths open, one at the base of each mandible. The mandibles (Fig. 3, Md.) are greatly elongated, sickle-shaped, grooved full length along the under side. Over this groove fits the maxilla (Ml) of the same side, which conforms to the shape of the mandible and bears a flange, interlocking it to the mandible. In this way a tube is

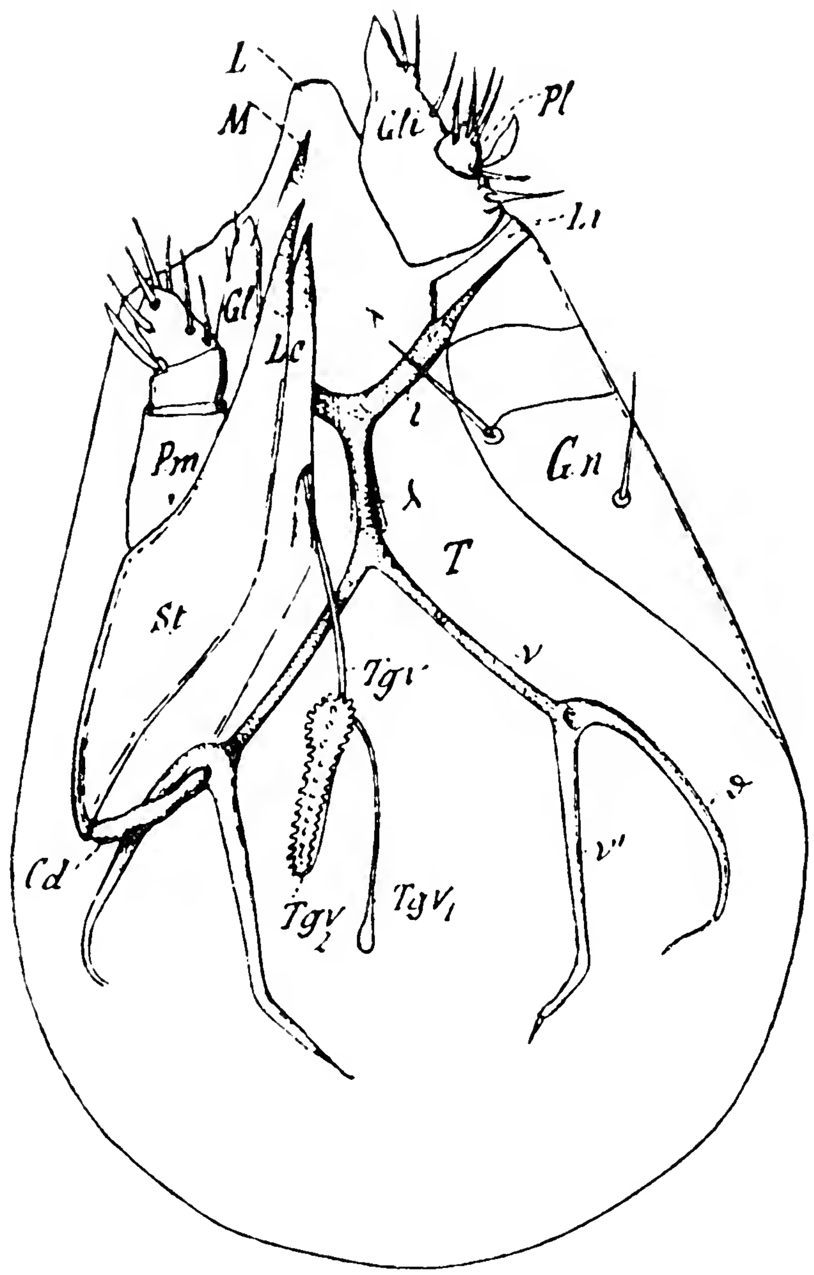

FIG. 4.—Mandibulate mouthparts of the acuminate type, as found in the Proturan, **Acerentulus tiarneus.** Note the elongation of the mandible **(M)**, the galea **(Gl)**, and lacinia **(Lc)**.

Cd, cardo; **Gn**, gena; **L**, labrum; **Li**, basal sclerite of labium; **Pl**, labial palp; **Pm**, maxillary palp; **St**, stipes. **(After Imms, from Berlese, Redia, 1909)**

formed leading from the sharp tip of this compound organ into the provisional mouth of that side. Small, soft-bodied animals are speared with one or both of these organs and their fluid contents sucked into the stomach.

C. *The Acuminate Type.* The mandibulate series also exhibits certain forms specialized for imbiding plant juices. The *Protura* (Fig. 4) may serve as an example. Here the parts are elongated and very sharp, the mandibles, galeae, and laciniae all being styliform and withdrawn into the head. This type together with the Chewing-lapping Type and the Rasping-sucking Type, placed arbitrarily in the haustellate series, make a fair gradation from the Chewing Type to the Piercing-sucking Type.

D. *The Chewing-Lapping Type.* This type is significant as connecting the mandibulate and haustellate series. The labrum, epipharynx, and mandibles have retained the form found in chewing insects altho the latter are modified to the industrial demands of the bee-community life and used for portage and for molding the wax cells.

The maxillae and labium on the other hand (Fig. 5) are elongated and highly specialized for lapping up nectar. Both pairs of palpi are present, the labial pair (Lb Plp) long and conspicuous, but the maxillary palpi (Mx Plp) very small. Between the labial palpi are the short paraglossae(*Pgl*) and a long, slender, hairy, grooved tongue, the fused glossae (*Gls*) with a specialized, spoon-shaped labellum *(Lbl)* at the end. The galeae (*Ga*) of the maxillae are also elongate and lie parallel to the tongue. According to Snodgrass a temporary *food channel* is formed by the concave inner surfaces of the galeae, roofing over the glossae and fitting snugly lengthwise against the labial palpi which in turn lie tightly against the sides of the glossae. Through such a complexly formed tube ("held, like a straw in one's mouth, by the mandibles grasping the bases of the galeae while the epipharynx plugs the gap where the ends of the galeae diverge toward the head") a drop of honey may be sucked up.

According to George E. King, in securing nectar from the open nectaries of flowers the bee thrusts out the glossa or tongue and licks the nectar with the tip of it. The glossa, thus smeared with nectar, is retracted between the labial palpi and galeae, and the nectar is squeezed off the tongue by the galeae and deposited so as to accumulate in the small cavity formed by the paraglossa at the base of the glossa. Then by bending the labium upward near mid-length the base of the glossa is brought into close apposition to the mouth opening and its accumulated nectar passes into the pharynx. The nectar thus gathered serves as food for the bees and the surplus is stored as honey. The inner channel (*l*) or the ventral channel (*Lum*) of the glossa, or both, may serve as a salivary groove to conduct saliva to the tip of the tongue where it may be used to dissolve solids such as sugar, preparatory to swallowing. The mandibles are used for carrying things and, in the honeybee, for molding wax into cells.

The parts when not in use are folded up, out of the way by means of a hinge or joint between the mentum and submentum and cardo and stipes.

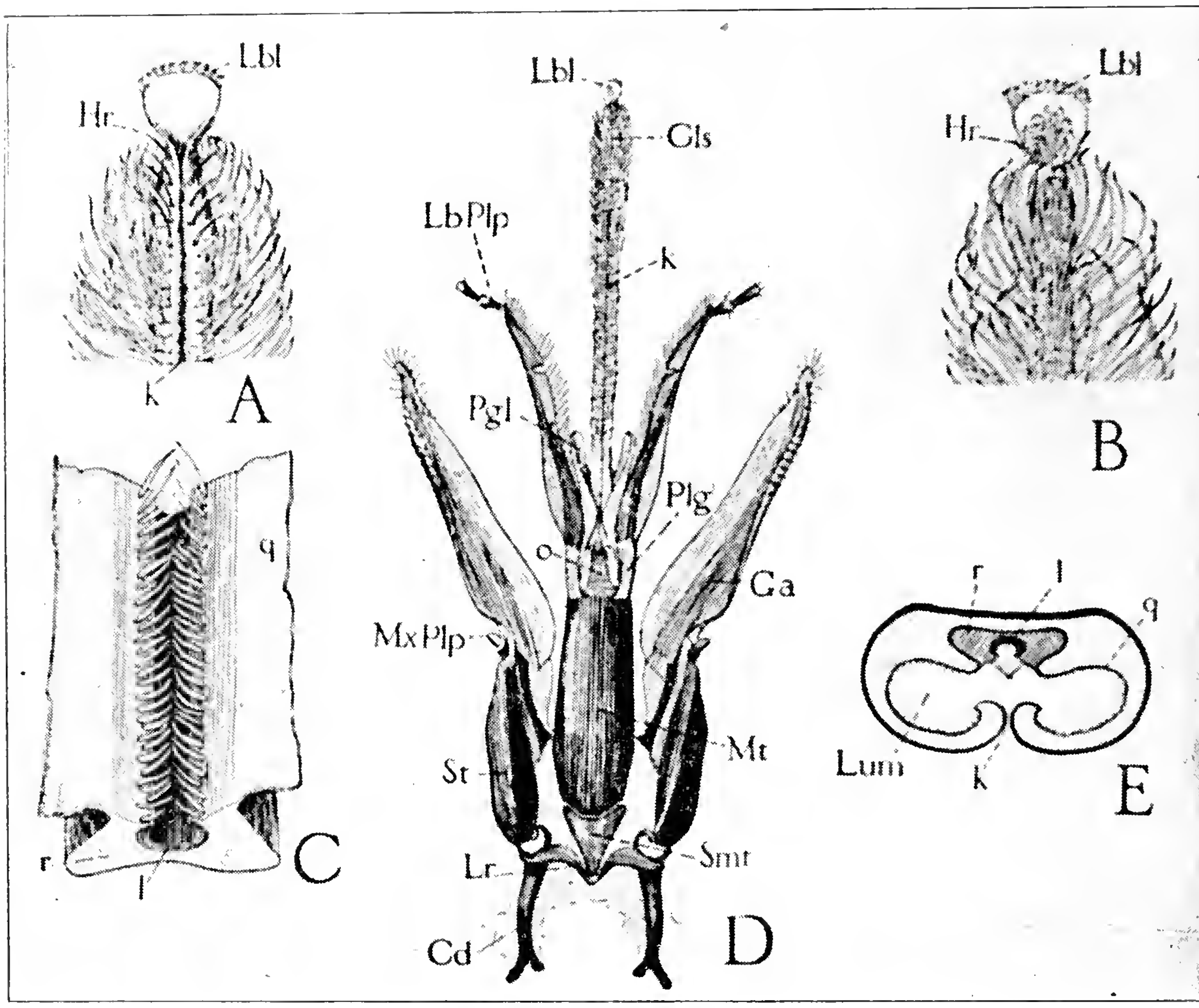

FIG. 5.—Chewing-lapping type of mouthparts, from the honeybee. The mandibles, labrum and epipharynx, which are not figured, are much as in Figure 2. The labium and maxillae, shown here are elongated to form a lapping tongue.

A, tip of glossa or tongue, from beneath, showing labellum (Lbl), the ventral groove to inner cavity (**k**), and the guard hairs (**Hr**) at its end. **B**, the same from above.

C, a small piece of glossal rod (**r**) dissected out of the glossal canal (**E, Lum**) with adjoining walls (**q**) attached and showing inner channel of the rod (**l**) guarded by rows of hairs.

D, ventral view of the maxillae and labium with parts spread: The following are parts of the maxilla: **Cd**, cardo; **Ga**, galea; **MxPlp**, maxillary palp; **St**, stipes. The following are parts of the labium: **Gls**, glossa; **k**, ventral groove of glossa; **Lbl**, labellum; **LbPlp**, labial palp; **Mt**, mentum; **Smt**, submentum; **Pgl**, paraglossae; **Plg**, palpiger; **Smt**, submentum.

E, cross section of glossa, showing its principal canal (**Lum**) opening through the ventral groove (**k**), with its lining walls (**q**) and the glossal rod (**r**) with its inner channel (**l**). **(After Snodgrass, Anatomy of the Honeybee.)**

II. Haustellate Series.

E. *The Rasping-Sucking Type.* In some respects this type is transitional between the chewing type and the piercing-sucking type. The mouthparts, including the lower part of the head, are asymmetrical (Fig. 6). The labrum (*l*) and parts of the maxillae (*g*) and labium (*j*) form a mouth-cone with the mouth

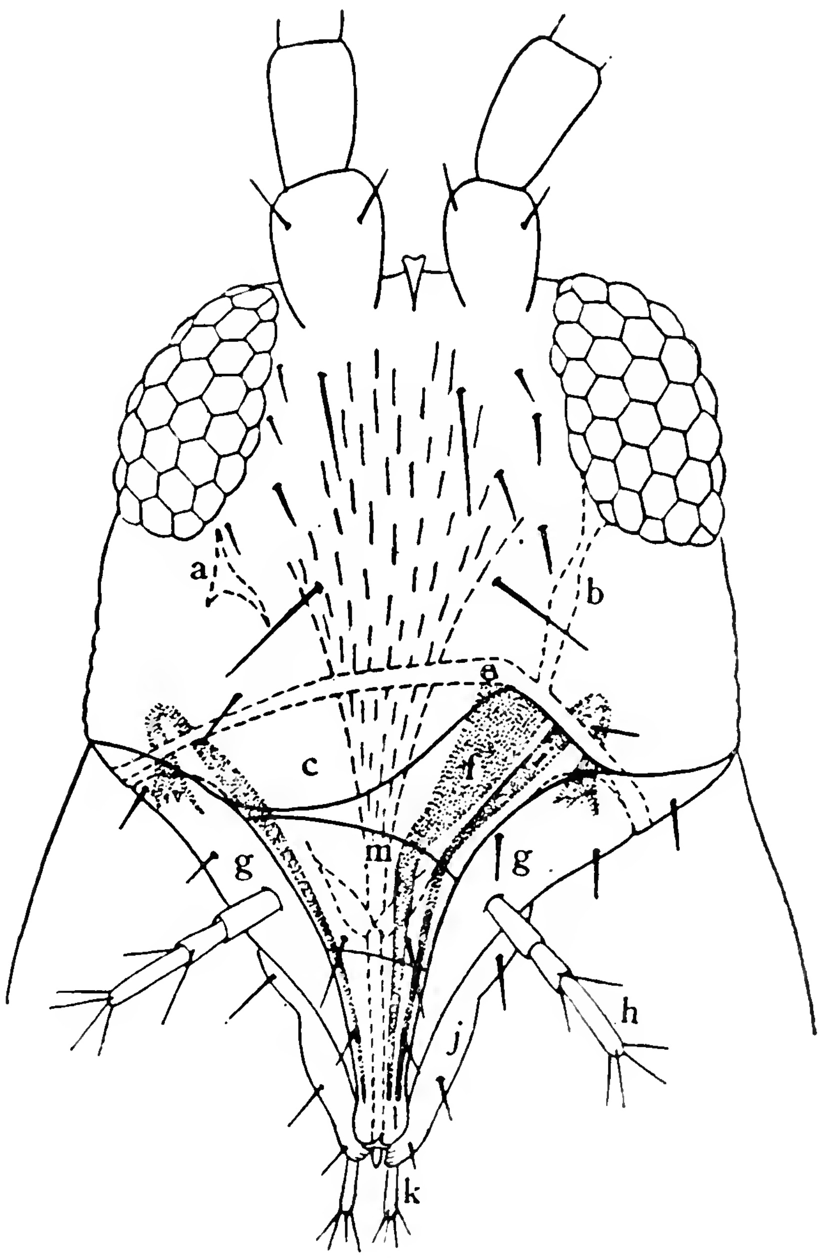

FIG. 6.—Rasping-sucking type of mouthparts, from the thrips, **Euthrips tritici.** Note the asymmentry of the parts especially **a, b, e,** and **f.**

a, b, e, chitinous band on wall of head; **c,** clypeus; **f,** mandible; **g,** maxilla; **h,** maxillary palp; **i,** maxillary stylet of left side; **j,** labium; **l,** labrum; **m,** hypopharynx. **(After Borden, Journal Econ. Entomo., 1915.)**

at its apex. The right mandible is reduced. The left mandible (*f*) the two maxillae (*i*) and the hypopharynx (*m*) are elongate, styliform, and completely retracted within the cavity of the head or mouth-cone. In operation they are protruded thru the mouth-cone and, by movements of the head, used to lacerate the epidermis of plants, when the juices are sucked up by the mouth-cone. This type is well characterized and distinguished from both the chewing type and the piercing-sucking type by the following characteristics: (a) The labium is not prolongated as a beak beyond the rest of the mouthparts; (b) there are two pairs of palpi; (c) the stylets are completely withdrawn into the head; and (d) the asymmetrical condition.

Such mouthparts are found in nymphal and adult thrips, Order Thysanoptera.

F. *The Piercing-Sucking Type.* This type includes a variety of very diverse structures, considered together because of functional similarity. They are used to imbide liquid foods from the interior of plant or animal tissues, thus requiring piercing or penetration of the epidermis. The only characteristic common

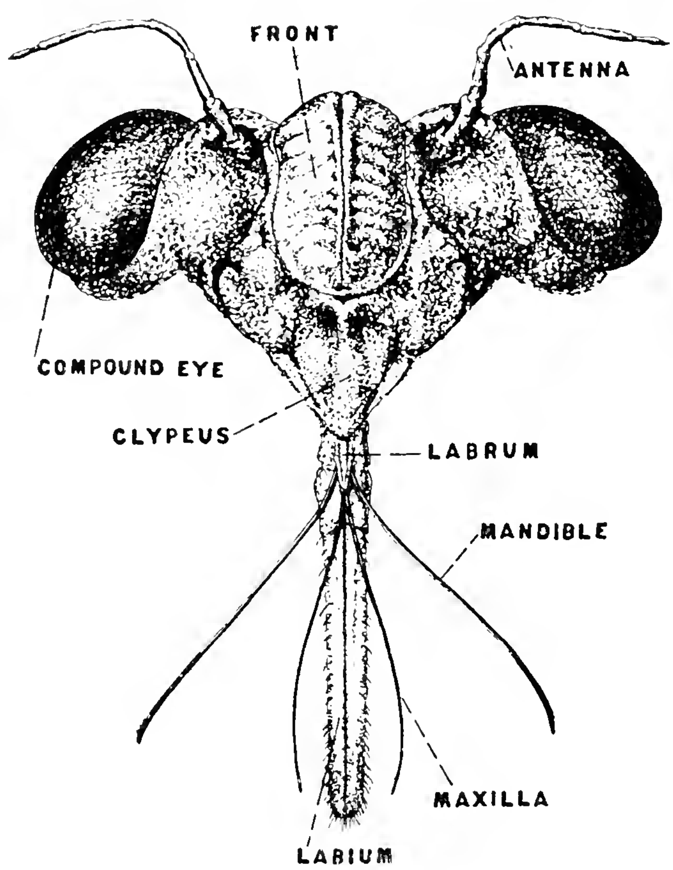

FIG. 7.—Piercing-sucking type of mouthparts, hemipterous sub-type, as found in the dog-day cicada. The piercing stylets, mandibles and maxillae, have been separated and spread out of the groove in the labium. See also figure 8. (Drawing by Antonio M. Paterno.)

to all of the subtypes placed in this division is the presence of a group of slender stylets apposed or interlocked to form a food channel. Usually the stylets serve as piercing organs and they are usually protected when not in use by the prolongated, subcylindrical labium. It should be emphasized that the conspicuous outer tube or labium is, with the exception of the special dipterous subtype, simply a protective, ensheathing structure that has nothing to do with piercing the tissues or drawing up the liquid food. Except in the fleas there is a single pair of palpi.

(a) *The Bug or Hemipterous Sub-type.* The simplest of the piercing-sucking forms to understand is that found in the squash bug, cicada, aphids, scale insects and all other Hemiptera and Homoptera (Figs. 7 *and* 8). The labium is long, nearly cylindri-

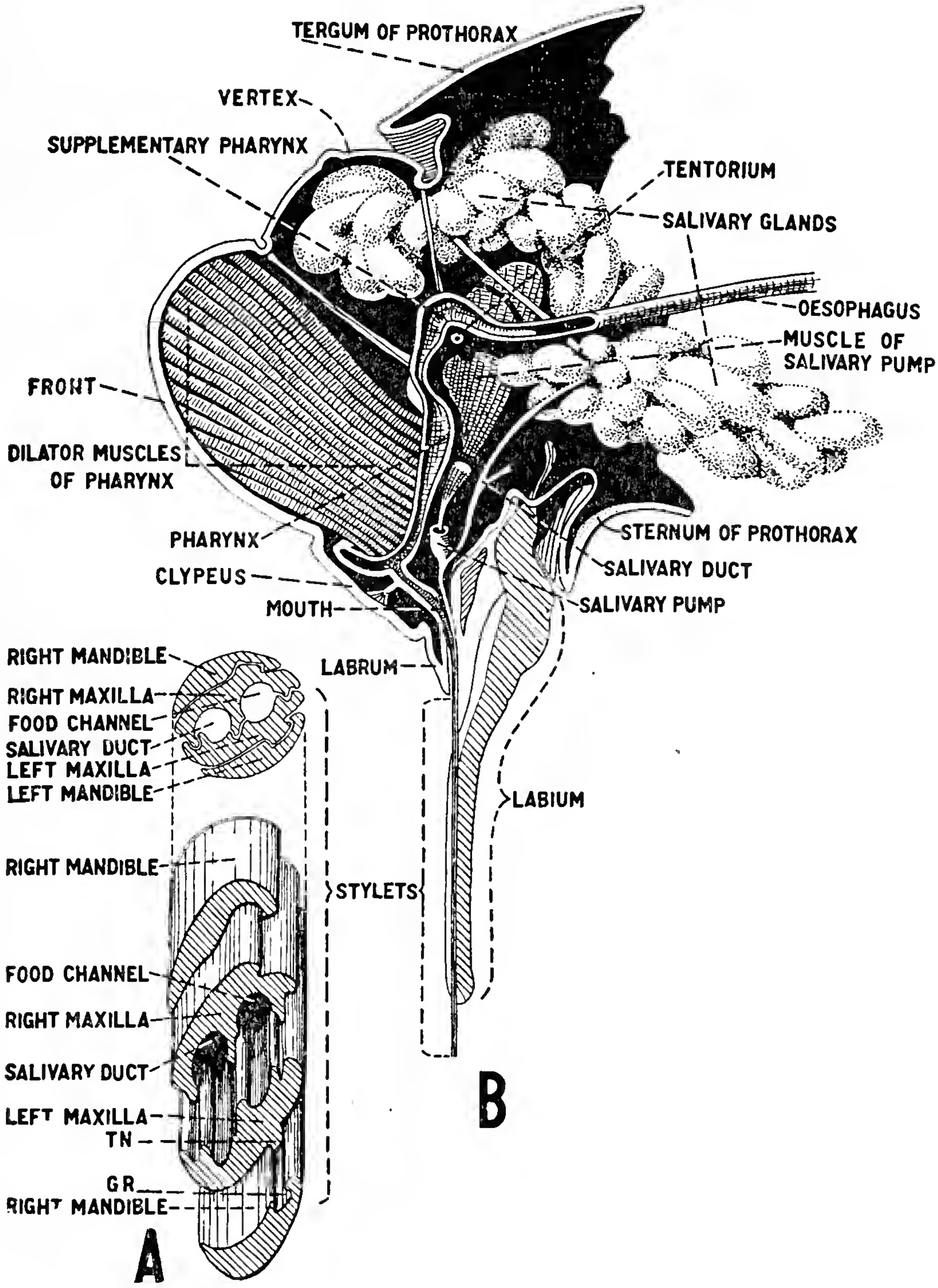

FIG. 8.—Piercing-sucking mouthparts of the periodical cicada, hemipterous sub-type. A, cross-section and isometric projection of a short piece of the stylets, greatly magnified to show how the maxillae and the mandibles are locked together, and how the food channel and salivary duct are formed by grooves in the mesal face of the latter. B, sagittal section of the head and mouthparts of the cicada showing how the liquid food is drawn from the stylets into the mouth and oesophagus by the action of the dilator muscles of the pharynx; also the salivary glands, ducts and pump and the ensheathing labium. See also figure 7.

(B, modified after Snodgrass, Proc. Ent. Soc. Wash., 1921.)
Figure 8. (Drawings by Antonio M. Paterno.)

cal, jointed, without apical labella, and deeply grooved along its dorsal surface for the reception and protection of the delicate stylets. The stylets are four in number, two mandibles and two maxillae. The latter (Fig. 8, A) are doubly channeled on mesal faces to form, by apposition, a dorsal food channel and a ventral salivary duct. All four stylets are closely interlocked by tongues and grooves to form a single, hair-like structure, which alone enters the wound. This is the only piercing type that has a beak and no palpi.

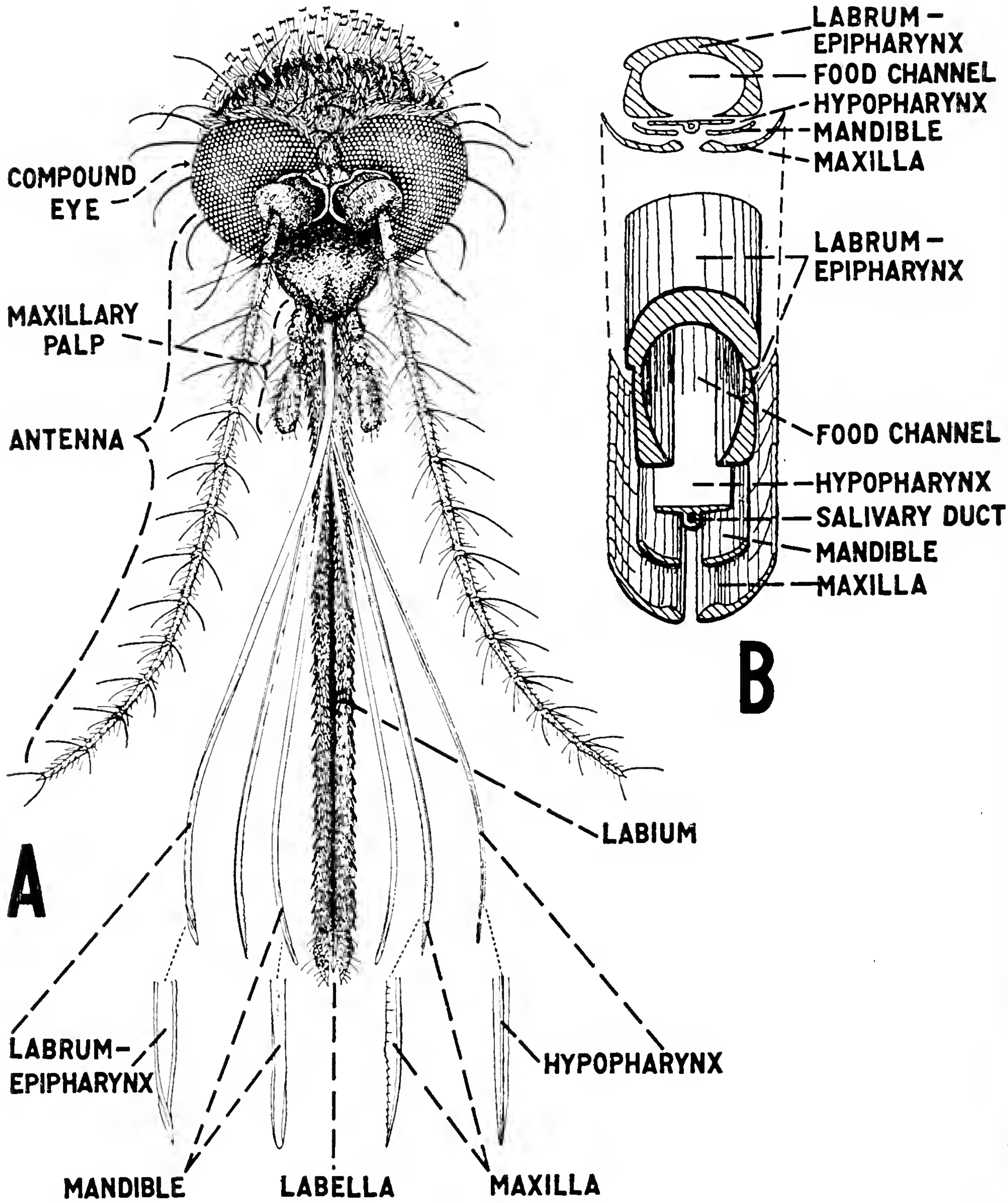

FIG. 9.—Piercing-sucking mouthparts of a mosquito, common biting-fly subtype. A, dorsal view with the stylets separated and their apices greatly magnified; B, cross-section and isometric projection of the six stylets showing how the food channel and salivary duct are formed. (Drawings by Antonio M. Paterno.)

Morphologists are not in agreement as to the homology of the parts labeled labrum, clypeus and front.

(b) *The Common Biting-fly or Dipterous Sub-type.* This form (Fig. 9) is found, with minor variances, in several families of flies such as mosquitoes, black flies and horse flies, that suck the blood of man and other animals. The labium is cylindrical and grooved dorsally, but unjointed except for the differentiation of a pair of labella at its apex. These are probably only sensory pads in the mosquitoes but in the horse flies are en-

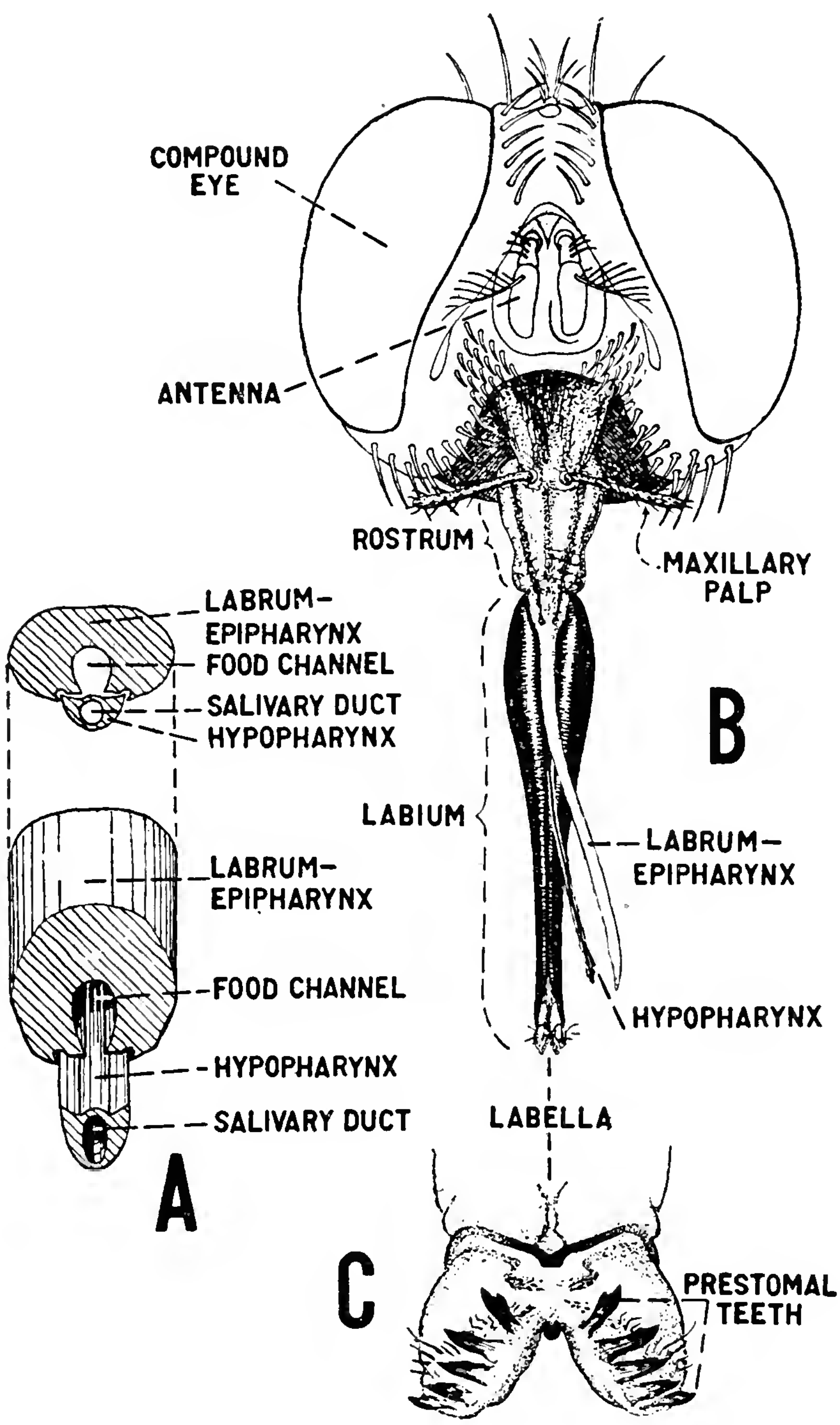

FIG. 10.—Piercing-sucking mouthparts of the stable fly, special biting-fly subtype. **A**, cross-section and isometric projection of the two stylets showing composition of food-channel and salivary duct. **B**, dorsal view of head and mouthparts with stylets separated from labial groove. **C**, the labella greatly magnified to show the prestomal teeth with which piercing is accomplished. **(Drawings in part by Antonio M. Paterno.)**

larged and provided with nearly closed channels (*pseudotracheae*), radiating over their surface, that serve to sponge up exposed liquids by capillary attraction, in the manner further explained under the sponging type, below. This type differs from the hemipterous subtype in three other significant respects.

There is a single pair of palpi, the maxillary. There are six stylets: in addition to the two mandibles and two maxillae the labrum-epipharynx and the hypopharynx are elongate, slender, styliform. The mandibles and maxillae are not interlocked (Fig. 9, B) but the food channel is formed by a deep groove in the ventral side of the labrum-epipharynx which is closed, for sucking, by apposition of the flattened hypopharynx. The hypopharynx also bears the saliva to the apex of the stylets. It is a curious fact that in this subtype only individuals of the female

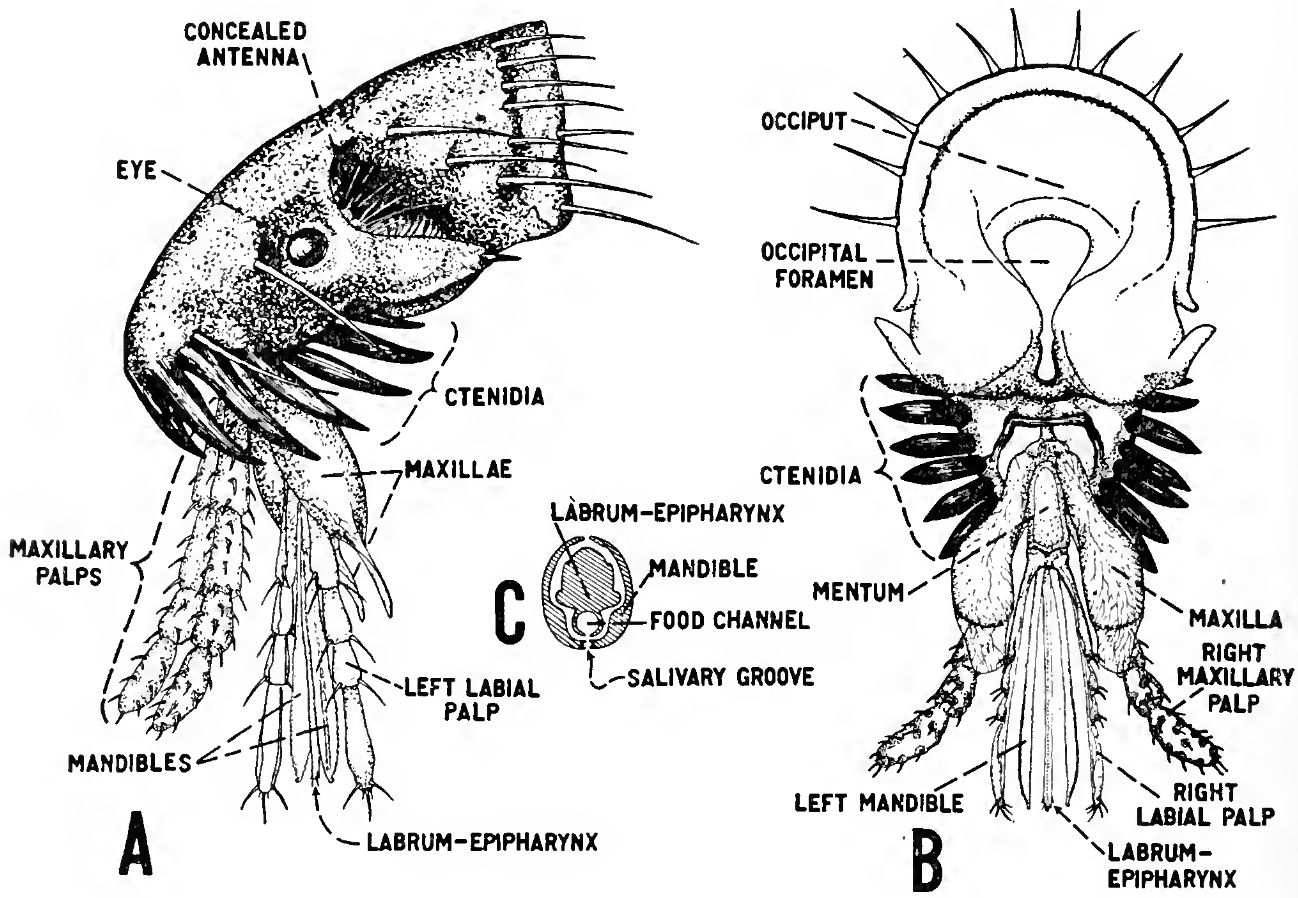

FIG. 11.—Piercing-sucking mouthparts of a flea, siphonapterous subtype. A, side view of head and mouthparts, showing the concealed antennae, the broad maxillae, the three stylets and the two pairs of palpi. B, ventro-caudal view of head and mouthparts with the stylets separated. Note the ensheathing nature of the labial palpi. C, cross-section of the three stylets showing how the food channel and salivary channel are formed by grooves in labrum-epipharynx and ventral edge of mandibles. (Drawings in part by Antonio M. Paterno.)

sex are adapted to suck blood, the males having the mouthparts reduced and impotent.

(c) *The Special Biting-fly or Muscid Sub-type.* This type (Fig. 10) is known only in such Muscidae as suck the blood of animals: the stable fly, horn fly, tsetse flies and others. Its derivation has been traced by Patton and Cragg (l. c.) through certain intermediate forms from the sponging type described below. Structurally it is closely allied to the sponging type, but differs in having the labella reduced in size, without pseudotracheal channels, and provided with sharp prestomal teeth (Fig. 10, C). According to Patton and Cragg, the skin of the host animal is punctured by the rapid protraction and retraction of the membrane bearing these teeth; and the attenuated labium follows the cutting labella into the wound. The food channel and salivary duct (Fig. 10, A) are formed in the same way as in the common biting-fly type by the labrum-epipharynx and the hypopharynx and there is a pair of maxillary palpi.

It is interesting to note that the only stylets developed here are the ones lacking in the hemipterous subtype; the labrum-epipharynx and hypopharynx being styliform, the mandibles and maxillae wanting.

(d) *The Flea or Siphonapterous Sub-type.* Still another combination of these homologous units is made (Fig. 11) in the adults of the order Siphonaptera or fleas, to serve the same functions of piercing the skin and sucking the blood. This is the only piercing-sucking type in which both pairs of palpi are clearly represented. The labium is not prolongated as a grooved beak, but the labial palpi are each flattened on the mesal surface and serve to ensheath the stylets loosely. The maxillae are not developed as piercing stylets but are broad plates much flattened apically and said to serve as fulcra to steady the head and mouthparts in the act of feeding. There are three stylets: a pair of blade-like serrated mandibles and an unpaired structure believed to be the labrum-epipharynx. It is grooved ventrally somewhat as in subtypes (b) and (c) but, in the absence of the hypopharynx, this groove is closed by apposition to the ventral edge of the mandibles (Fig. 11, C). A unique method of conveying saliva into the wound beyond the short hypopharynx is through a minute channel formed by the apposed, grooved, ventral edges of the mandibles (Fig. 11, C).

(e) *The Louse or Anoplurous Sub-type.* Allied to the others of the piercing-sucking type, functionally, this form is, structurally, very different and. superficially, more nearly analogous to the rasping-sucking type. There is no prolonged beak. A very short haustellum (Fig. 12, *h*) bears a circlet of denticles (*d*) probably of use in anchoring the head in place in the act of feeding. There are no palpi. The piercing structures are a complicated set of chitinous stylets which are, when at rest, with-

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* Peacock, A. D., The Structure of the Mouthparts and Mechanism of Feeding in Pediculus humanus, Parasitology, Vol. XI, pp. 98-117, 1919.

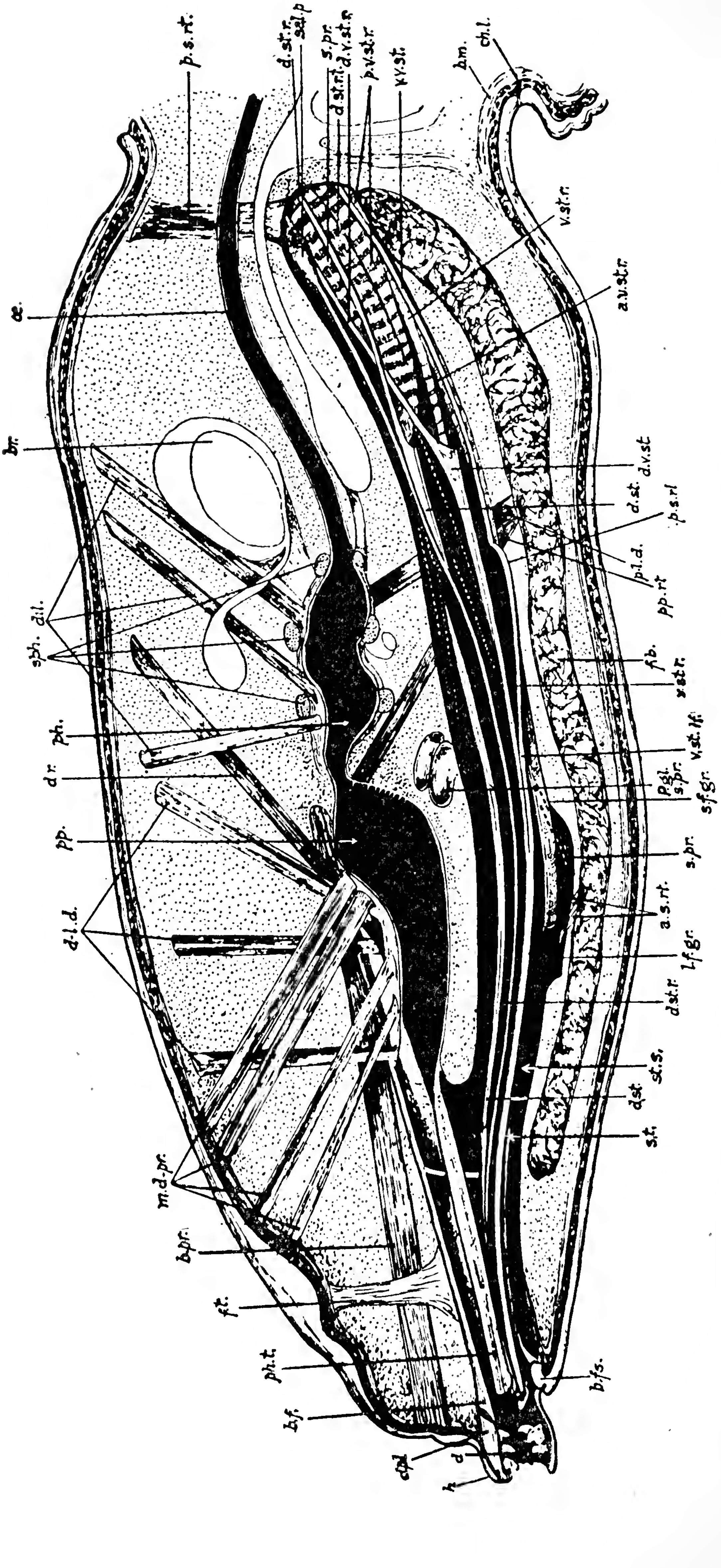

FIG. 12.—Piercing-sucking mouthparts of the human louse, anoplurous subtype; sagittal section, showing structures of the right half of the head. **p. f.**, buccal funnel; **br.**, brain; **d**, denticles; **d. st.**, dorsal stabber or stylet; **h**, haustellum or rostrum; **ph**, pharynx; **ph. t.**, pharyngeal tube; **pp.**, pumping pharynx; **st.**, sac tube; **st. s.**, stylet sac; **v. st. r.** and **v. st. lf.**, ventral stabber or stylet. Compare Figure 13. **(From Peacock, in Parasitology, Vol. XI.)**

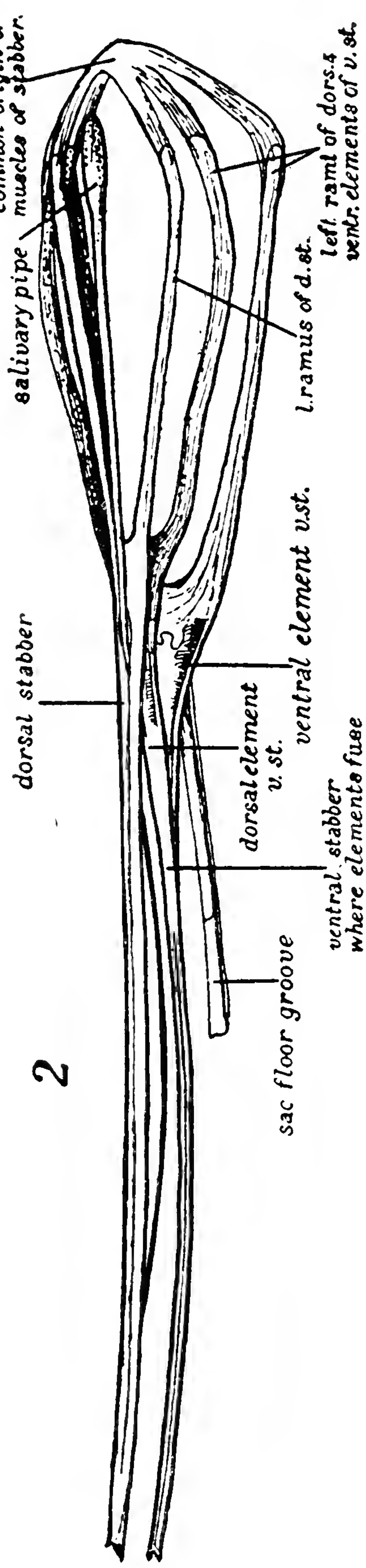

FIG. 13.—The stylets or tabbers of the human louse, exposed from the stylet sac in which they lie when not in use. Compare figure 12. **(From Peacock, in Parasitology, Vol. XI.)**

drawn into a blind diverticulum of the pharynx (*st. s*) lying in the head beneath the pharynx and oesophagus. As described and figured by Peacock,* they may be resolved into a dorsal and ventral stylet or stabber, (Fig. 12, *d. st., v. st.* and Fig. 13) which Tillyard says are derived from the hypopharynx. The parts are very complicated and the homologies exceedingly difficult to understand. The head cone probably serves to suck up the blood as it oozes from the wound and it is there transferred

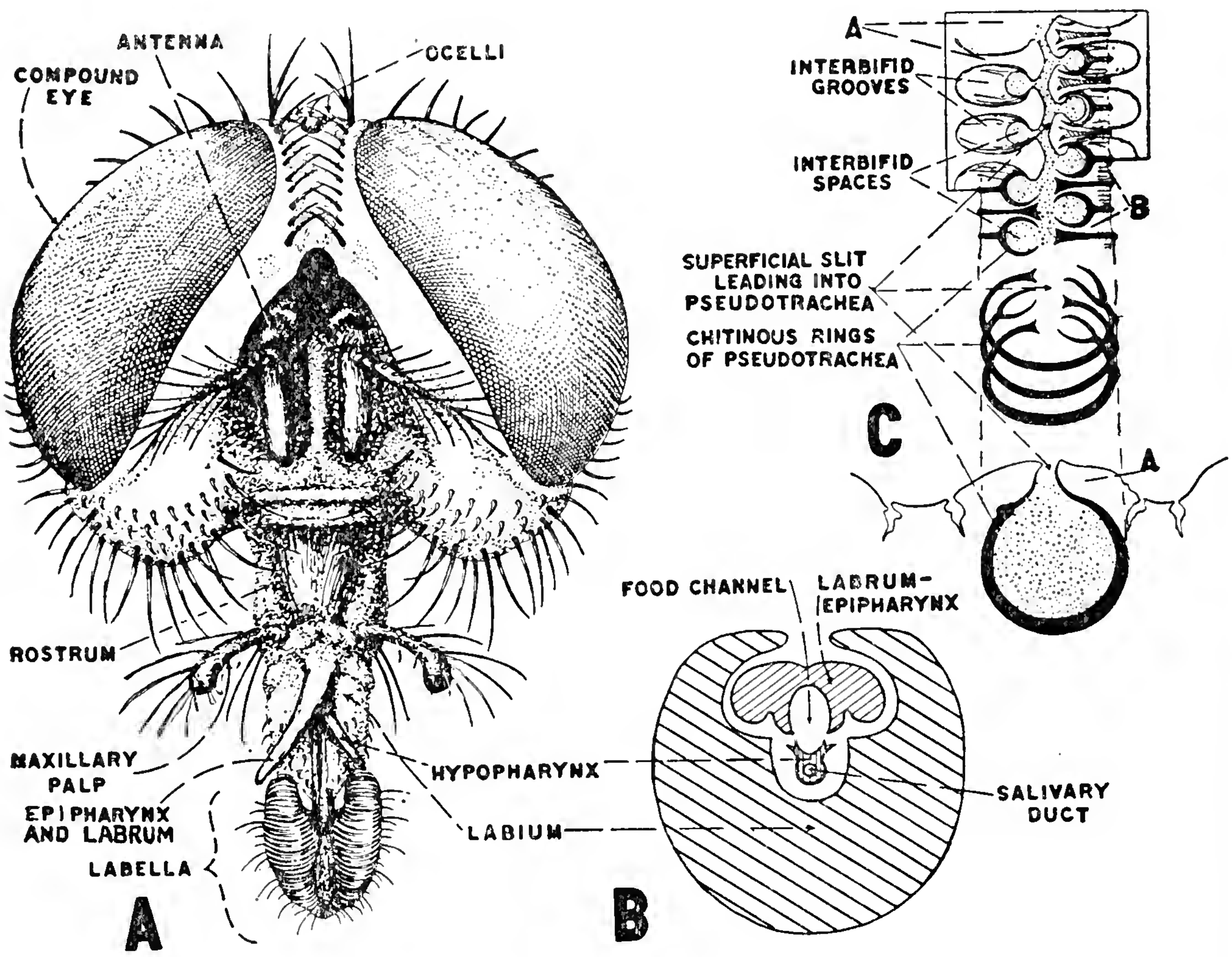

FIG. 14.—Mouthparts of the sponging type as found in the common house fly. A, antero-dorsal view of head and mouthparts with the proboscis extended and the stylets separated from the labial groove. Note the radiating channels (pseudotracheae) on the surface of the labella. B, a cross-section of the labium, hypopharynx and labrum-epipharynx showing how the latter are sheltered in the labial groove and how the food channel and salivary duct are formed. C, details of the pseudotracheae showing the nature of the slit by which liquids enter the pseudotrachea, the chitinous rings which keep its walls distended and, below, a pseudotrachea in cross-section. (Drawings in part by Antonio M. Paterno.)

to the pumping pharynx *(pp)* through an incomplete pharyngeal tube (*ph. t.*) which is apposed to a buccal funnel lying dorsal to it.

G. *The Sponging Type.* This type of mouthparts is well illustrated by the condition in the common house fly (Fig. 14) and many other Diptera of the sub-order Cyclorrhapha. The structures are very complicated and have been described in detail by Graham-Smith,* and Hewitt.† There is a prominent, elbowed proboscis. The proximal portion, known as the rostrum (Fig. 14, A), is formed in part by the head capsule. It is retractile and bears near its apex the maxillary palpi. The labial palpi are wanting, unless, as some writers contend, they are rep-

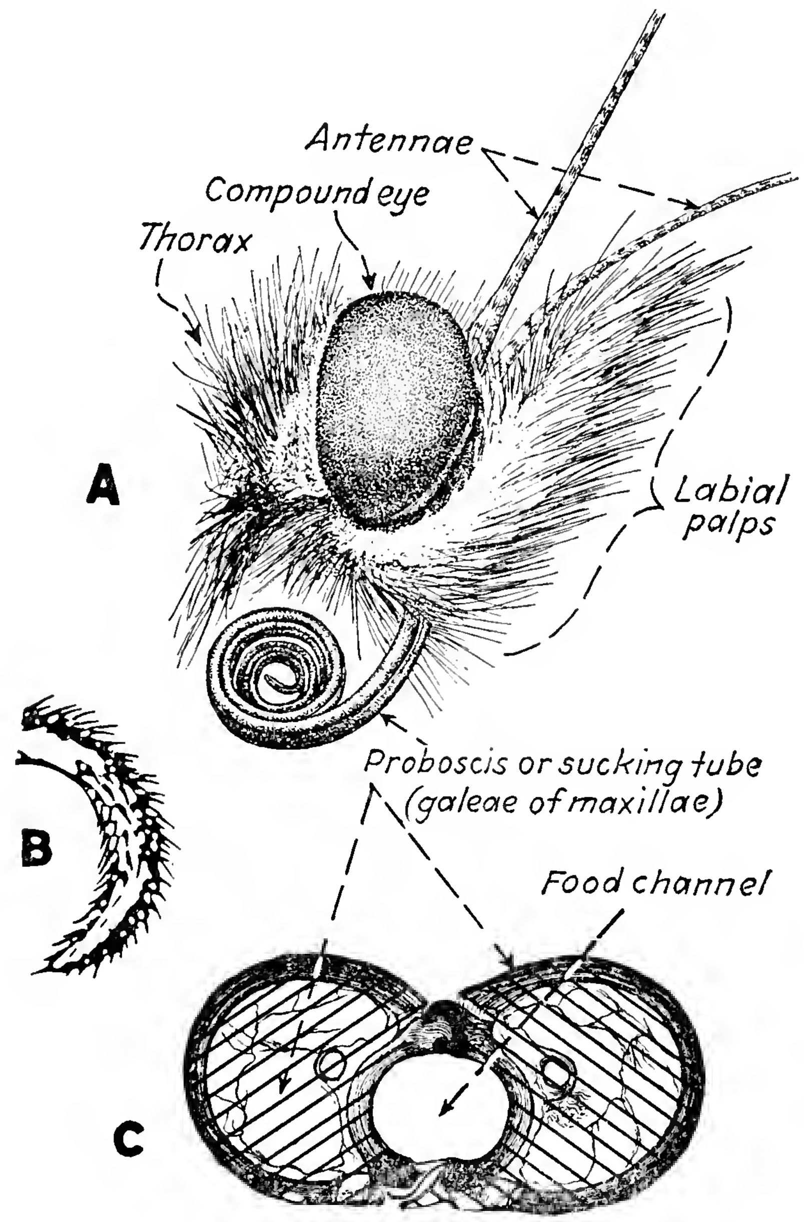

FIG. 15.—Siphoning mouthparts of a moth or butterfly.

A. side view of the head with the galeae of the maxillae, constituting the proboscis, partially uncoiled, below the head; the hair-covered labial palps, in front; and the bases of the antennae, above.

B. the tip of the proboscis of the cotton moth, a very exceptional condition in which the proboscis is provided with spines and capable of lacerating ripe fruits to get the sap (after Comstock.)

C. a cross-section of the proboscis (after Comstock) showing how right and left galea interlock to form the food channel.

resented by the labella. The distal portion of the proboscis, called the haustellum, is formed largely of the labium. It is grooved on its dorsal aspect as in the piercing-sucking forms. In this groove are sheltered two, short, non-piercing stylets, the

* Graham-Smith, Flies and Disease: Non-blood-sucking Flies. Cambridge, 1913.

† Hewitt, C. G., The House Fly. Cambridge, 1914.

labrum-epipharynx and the hypopharynx. They form a food channel exactly as in the common and special biting-fly sub-types described above (Fig. 14, B). Mandibular and maxillary stylets are wanting.

The most significant structures in this type are the labella which form a large, complicated, sponge-like organ for imbiding exposed liquids. Solid foods may be taken only by dissolving them in the saliva.

The labella are traversed by a series of deep cylindrical furrows or channels in the oral surface of the membranes (called *pseudotracheae*) which are nearly complete tubes but are narrowly open along the exposed surface (Fig. 14, C.) The lumen of these channels is kept open by chitinized loops or rings, which give the tubes a superficial resemblance to respiratory tracheae. The ends of these rings are alternately single and bifid and grooves in the membrane lead to the superficial, longitudinal slit of the channel. When the labella, bearing these pseudotracheal channels, are appressed to liquids, the channels fill by capillary attraction. All the channels converge at one point near the apex of the food channel formed by labrum-epipharynx and hypopharynx. The liquid is thence sucked up into the stomach by the action of a pharyngeal pump. The significance of the complicated collecting tubes is partly to serve as a screen or filter to keep out large particles. Some have attributed to the pseudotracheae a rasping function of use in bringing solid substances like sugar into solution.

H. The Siphoning Type. A very highly specialized condition of the mouthparts is found in adult moths and butterflies. The specialization is largely by reduction; but parts of the maxillae, believed to be the galeae, are greatly elongated, grooved mesally, and interlocked to form a slender, hollow, sucking tube used chiefly to draw up the nectar from flowers with long tubular corollas (Fig. 15, A and C). These stylets are not capable of piercing plant or animal tissues except in rare instances. Sometimes stiff spines at its apex (Fig. 15, B) are used to lacerate the ripe skins of fruits and so tap the sap-wells of plants. The proboscis which may reach a length several times that of the body is protected by coiling it up like a watch spring under the head, where it does not impede flight. The labial palpi are well developed. All the other parts are small, inconspicuous or wanting.

Tables III, IV, and V show the nature of the several mouthparts in the mandibulate and haustellate series and Tables VI and VII the division of labor in the several haustellate types.

TABLE III.—MANDIBULATE SERIES.

TYPE OF MOUTHPARTS AND INSECT REPRESENTATIVES	LABRUM	EPIPHARYNX	MANDIBLES	MAXILLAE			HYPO-PHARYNX	LABIUM		
				Galea	Lacinia	Palpi		Glossae	Para-glossae	Palpi
Typical Chewing Mouthparts of Thysanura, Orthoptera Dermaptera, Odonata, Isoptera, Corrodentia Mallophaga, Coleoptera, larval Lepidoptera, some Hymenoptera, and other orders. (1)	Typical, hinged, upper lip; apical margin sometimes incised at middle. (2)	Soft, sensory, (tactile and gustatory). Covers ventral surface of labrum.	Strongly chitinized; pyrimidal; variously denticulated. Usually a single sclerite. Work transversely. (3)	Typically helmet-like; often two-segmented.	Typically tooth-like; sometimes with a claw-like terminal digitus. (4)	Usually 5-segmented; hairy; bear taste-buds; homologue of crustacean endopodite.	A tongue-like swelling from floor of mouth cavity; bears the opening of salivary duct. (5)	Median pair of lobes; homologous with the laciniae. Often variously united to form a ligula. (6)	Submedian pair of lobes; homologous with the galeae.	Usually 3-segmented; hairy; gustatory and tactile.
Predatory Type Mouthparts of Chrysopidae larvae and other Neuroptera. (7)	Reduced	Reduced	Elongate, sickle-shaped. Grooved on ventral surface to tip.	Elongate, conform to shape of the mandibles; flange locks with groove of mandibles to make a pair of sucking tubes.		Generally absent.	Reduced	Reduced.	Reduced.	Variable, often large.
Acuminate Type Mouthparts of Protura and certain Collembola	Elongate; forms upper part of sucking beak.		Styliform, sharp, withdrawn into the head.	Slender	Slender, styliform, sharp.	Variously segmented.		Elongate; form the lower part of the sucking beak.		Variously segmented.

NOTES:
(1) Parts similar but greatly elongated in the order Mecoptera.
(2) Sometimes wanting as in the Rhyncophora and Strepsiptera.
(3) Sometimes greatly enlarged and specialized, as in soldier termites and male Lucanidae; may be specialized for grinding, cutting, crushing, grasping, sifting or carrying.
(4) Specialized as elongate, chisel-like rods in the Corrodentia; ensheathed by the galeae, but not articulated to the rest of the maxillae.
(5) Side pieces, called superlinguae, homologous to the paragnaths of the Crustacea, are developed in Thysanura, Collembola, Orthoptera, Dermaptera, Corrodentia, Coleoptera, etc.
(6) Wanting in the Strepsiptera.
(7) The true mouth opening is closed and non-functional. An adventitious mouth at the base of each mandible.

TABLE IV—HAUSTELLATE SERIES.

TYPE OF MOUTHPARTS AND INSECT REPRESENTATIVES	LABRUM	EPIPHARYNX	MANDIBLES	MAXILLAE			HYPO-PHARYNX	LABIUM		
				Galea	Lacinia	Palpi		Ligula: Glossa	Ligula: Paraglossa	Palpi
PIERCING-SUCKING TYPE: Hemipterous Sub-type. Homoptera and Hemiptera, Nymphs and Adults.	Very small and narrow.		Elongate, slender stylets, barbed distally. Interlocked by tongue and groove to sides of maxillae.	Elongate, slender stylets and plates on the sides of the head. Right and left stylets doubly grooved mesally and fused to form a dorsal food-channel and a ventral salivary channel.		Wanting	Small, chitinized organ between bases of the maxillae.	Elongate, usually 4- or 3-segmented. Deeply grooved on dorsal surface to form a protective sheathe for stylets.		Wanting.
PIERCING-SUCKING TYPE: Common Dipterous Sub-type. Mosquitoes, Horseflies, and Black Flies. Adult females only.	Well-chitinized; fused with dorsum of epipharynx.	Well-chitinized; fused with venter of labrum.	Piercing, needle-like or blade-like stylets.	Form a pair of piercing stylets.		1 to 4 segments.	Lanceolate, flattened. Is apposed to labrum-epipharynx to form the food channel. Traversed by salivary duct.	Elongate, cylindrical, grooved dorsally to form a sheath for stylets.		Wanting or modified into the labella.
	Grooved ventrally, U-shaped in cross-section. Apposed to hypopharynx to form the food channel.							Labella may be fleshy and provided with microscopic food channels called pseudotracheae.		
SPONGING TYPE: House Fly and many other Cyclorrhaphous Diptera. Adult males and females.	A portion of the head capsule is prolongated ventrally as the truncated, cone-shaped, proximal segment of the proboscis, called the rostrum. The distal segment of the proboscis, called the haustellum, is formed chiefly of the mouthparts. Labella with pseudotracheal channels, forming a very complex sponging organ.									
	Stylet-like, fused; borne on the dorsal face of the haustellum; non-piercing.		Wanting	Wanting.		Usually one-segmented.	Stylet-like, borne on the dorsal face of the haustellum; non-piercing.	Form a 1-segmented haustellum which ensheaths the stylets.		Wanting or modified into labella.

TABLE IV—HAUSTELLATE SERIES—*Continued.*

TYPE OF MOUTHPARTS AND INSECT REPRESENTATIVES	LABRUM	EPIPHARYNX	MANDIBLES	MAXILLAE			HYPO-PHARYNX	LABIUM		
				Galea	Lacinia	Palpi		Ligula: Glossa	Ligula: Paraglossa	Palpi
PIERCING-SUCKING TYPE: Special Dipterous Sub-type. Stable Fly, Horn Fly, Tse-tse Flies and others. Adult males and females.	Rostrum reduced in size. Haustellum elongate, slender, rigid and horny. Labella provided on their antero-dorsal membrane with chitinous prestomal teeth used for cutting. No pseudotracheal channels.									
	Stylet-like, fused; too short for piercing.	Stylet-like, fused; too short for piercing.	Wanting	Wanting.	Wanting.	One-segmented.	Stylet-like, but too short for piercing.	Form a 1-segmented haustellum which ensheaths the stylets.	Form a 1-segmented haustellum which ensheaths the stylets.	Wanting or modified into labella.
PIERCING-SUCKING TYPE: Siphonapterous Sub-type. Fleas. Adult males and females.	Elongate, grooved ventrally to form the food channel by apposition to the ventral edge of the mandibles.	Elongate, grooved ventrally to form the food channel by apposition to the ventral edge of the mandibles.	Elongate, blade-like, serrated stylets. Ventral edges grooved to form salivary channel.	Broad blades, much flattened dorso-ventrally; said to serve as fulcra for other parts while feeding.	Broad blades, much flattened dorso-ventrally; said to serve as fulcra for other parts while feeding.	Large, four-segmented.	Short, concave ventrally; extends distad a short way between labrum-epipharynx and mandibles.	Not recognizable.	Not recognizable.	Elongate, concave mesally; ensheathing stylets. Usually 5-segmented (2 to 17)
PIERCING-SUCKING TYPE: Anoplurous Sub-type. Blood-sucking Lice. Adults and Nymphs.	Not recognizable.	Not recognizable.	Not recognizable.	Not recognizable.	Not recognizable.	Wanting.	Forms two, unpaired stylets for piercing.	Not recognizable.	Not recognizable.	Wanting.
RASPING-SUCKING TYPE: Thrips. Adults and Nymphs.	Asymmetrical; forms dorsal part of mouth cone.	Not recognizable.	Left one styliform; right one aborted.	Asymmetrical: Forms the side walls of the mouth cone.	Asymmetrical: Styliform.	2 to 8 segmented.	Styliform.	Forms ventral part of mouth cone.	Forms ventral part of mouth cone.	Small, 1- to 4-segments.

TABLE IV—HAUSTELLATE SERIES—*Concluded.*

TYPE OF MOUTHPARTS AND INSECT REPRESENTATIVES	LABRUM	EPIPHARYNX	MANDIBLES	MAXILLAE			HYPO-PHARYNX	LABIUM		
								Ligula		
				Galea	Lacinia	Palpi		Glossa	Paraglossa	Palpi
SIPHONING TYPE: Moths and Butterflies. Adult males and females.	Usually an inconspicuous, short transverse plate.		Usually entirely wanting.	Right and left grooved mesally and fused to form the food channel. Very long.	Wanting.	Usually wanting.	Present on floor of the mouth.	A small plate on the ventral aspect of the head.		Wanting.
CHEWING-LAPPING TYPE: Long-tongued Bees. Adult males and females.	As in the chewing type.	Sensory area on ventral surface of labrum.	As in chewing type; but industrial rather than trophic.	Greatly elongated, blade-like.	Reduced.	Greatly reduced.	Wanting.	Fused and greatly elongated as a tongue; with a labellum at apex.	As in the chewing type.	Greatly elongated, ensheathing the tongue.

TABLE V.

DIVISION OF LABOR IN VARIOUS HAUSTELLATE INSECT MOUTHPARTS.

EXAMPLES.	CUTTING APPARATUS.	FOOD CHANNEL.	SALIVARY CHANNEL.	HOW STYLETS ARE PROTECTED.	REMARKS.
Hemiptera and Homoptera. males and females	2 mandibles and 2 maxillae.	Apposed, mesal grooves in the maxillae (dorsal).	Apposed, mesal grooves in the maxillae (ventral).	Longitudinal groove in dorsal face of labium, and a short labrum at base.	Four stylets: the two mandibles and two maxillae. Labrum and hypopharynx short. No palpi. No labella.
Mosquitoes, Horse Flies, Black Flies. Females only	2 mandibles and 2 maxillae.	Labrum-epipharynx grooved ventrally and closed by apposition to the hypopharynx.	Salivary duct traverses the hypopharynx.	Longitudinal groove in dorsal face of the labium.	Six stylets: the two mandibles, two maxillae, labrum-epipharynx and hypopharynx. Maxillary palpi (one pair). Labella; sometimes provided with pseudotracheal channels.
Blood sucking Muscidae: Stable Fly, Horn Fly, Tse-tse Flies. males and females	Chitinous, prestomal teeth on the antero-dorsal membrane of the labella.	Labrum-epipharynx grooved ventrally and closed by apposition to the hypopharynx.	Salivary duct traverses the hypopharynx.	Longitudinal groove in dorsal face of the labium.	Two stylets: the labrum-epipharynx and hypopharynx; too short for piercing. Mandibular and maxillary stylets wanting. Maxillary palpi (one pair). Labella without pseudotracheal channels. The only piercing insects in which the labium enters the wound.
Non-blood-sucking Muscidae and other cyclorrhaphous Diptera. males and females	None.	Labrum-epipharynx grooved ventrally and closed by apposition to the hypopharynx.	Salivary duct traverses the hypopharynx.	Longitudinal groove in dorsal face of the labium.	Two stylets: the labrum-epipharynx and hypopharynx; not piercing. Mandibular and maxillary stylets wanting. Maxillary palpi (one pair). Labella very highly specialized with pseudotracheal channels for sponging up exposed liquids.

TABLE V.

DIVISION OF LABOR IN VARIOUS HAUSTELLATE INSECT MOUTHPARTS—*Concluded.*

EXAMPLES.	CUTTING APPARATUS.	FOOD CHANNEL.	SALIVARY CHANNEL.	HOW STYLETS ARE PROTECTED.	REMARKS.
Siphonaptera: Fleas. males and females	2 mandibles.	Labrum-epipharynx grooved ventrally and closed by apposition to the ventral edges of the mandibles.	Apposed, mesal grooves in ventral edges of the mandibles.	By the ensheathing, concave, mesal faces of the labial palpi.	Three stylets: the labrum-epipharynx and the two mandibles. The maxillae are broad, flat blades that do not enter the wound. Hypopharynx wanting. Two pairs of palpi, well developed.
Anoplura: Blood-sucking Lice. males and females	2, stabber-like stylets; formed from hypopharynx?	Head cone and internal pharyngeal structures.	Associated with and traverses the dorsal stabber.	Completely withdrawn into the head when not in use.	Two median stylets: retracted into a sac beneath the pharynx when not in use. Mandibles and maxillae unrecognizable. No palpi. No protruding beak (labium). A circlet of teeth about the mouth.
Thysanoptera: Thrips. males and females	Left mandible, 2 maxillae, and hypopharynx?	Head cone formed by labrum, galeae and labium.	Ducts open at apex of mouth cone.	Withdrawn into the head when not in use.	Four stylets: the left mandible, the two maxillae and the hypopharynx. Two pairs of palpi. Head and mouthparts asymmetrical.
Lepidoptera: Moths and Butterflies. males and females	None: Very rarely spines on apex of the galeae.	Right and left galea each grooved mesally and apposed to form a sucking tube.	Wanting.	Coiled like a watch spring, close under the head when not in use.	Two, greatly-elongated, non-piercing stylets, closely interlocked. Labrum, mandibles and maxillary palpi wanting. Labial palpi (one pair).
Long-tongued Hymenoptera. males and females	None.	Temporary tube formed by apposition, length-wise, of the glossae, labial palps and galeae.	Ventral channel on the glossa.	Hinged, folded back beneath the head when not in use.	No piercing stylets. Two pairs of palpi. Mandibles and labrum of chewing type. Maxillae and labium elongated.

AN ECONOMICAL METHOD OF HANDLING LABORATORY MATERIAL.

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One of the greatest problems that the present day teacher of biological subjects must contend with, is the procuring of suitable laboratory material so that it would be available when needed.

Although courses of botany, zoology, and biology are quite flexible and permit the use of almost any available material, one must admit that certain forms or types are superior to others in illustrating given phenomena or in bringing home to the pupils a specific biological truth. Then, too, in spite of the fact that very little has been done along these lines on the high school level, biological subjects can be graded just like English or Latin has been graded with reference to sequence of difficulty or in the arousing of interest. There is very little grading in any course of botany or zoology in which the teacher depends solely upon what happens to be in season. Then too, not much sympathy and goodwill is aroused on the part of our fellow citizens towards those subjects when the laboratory teacher assigns something similar to the following: ''During the next week you will kindly collect leaves from at least twenty different trees.'' Truly, it is a noble idea to acquaint our children with the various trees growing in their vicinity, but certainly it is not always in accordance, with the spirit of conservation and the spirit of respecting other people's property.

You can readily imagine the result of an invasion of good-sized high school classes into our parks or of similar attacks upon street trees, especially if the collection is made without supervision. Very frequently the students pay no regard to the possible damage, and as a rule, they carelessly break off much more than they actually need for class use. At times they fail to take immediate care of what they have collected, thus necessitating a repetition of their unintentional vandalism.

The seemingly favorable remark, as well as the promise of an additional credit on the part of a high school teacher of one of our city schools when he reviewed the fine collection of evergreens of one of his students, lead to a nocturnal raid upon the premises of a lover of pines. The next morning the owner received the surprise of his life in beholding so many of his young trees badly damaged. In vain did he try to guess who his enemy was, for it appeared to him that it was done in spite. Fortunately that morning some boys hailed him for a ride. Upon inquiring as to what they were doing so far away from their home and school at such an early hour, he learned that they were looking for evergreens, but, they failed to find any that were not on private property. The solution of his pine mystery did not offer him any pleasure. This gentleman, however, realized the futility of his attempts at beautifying his premises as long as a premium was set upon just such unqualified collection. What hurt his feelings most was the knowledge of the fact that this damage was done solely to supply a need and that the want was made by the misdirected efforts of one of our educators. This is truly a failure in education if so much ill-will and violation of property rights is caused thereby.

The scientific method as interpreted by some teachers, calls for too great a carnage of many animal forms and far too great a waste of plant and animal life. Much time is lost in trying to understand and follow out laboratory manuals. These very frequently are written above the level of those who must use them. Nothing can replace the scientific method involving individual dissection as a desirable training of our premedical students and future biological teachers. They must have their individual cats and other animal and plant forms. Along the high school level and in some college course individual dissection could easily be modified with an economy of time, with an economy of goodwill, and especially with an economy of plant and animal life. An individually dissected specimen is at times no dissection at all, but a mere cutting up, and as such, it fails to convey the desired knowledge and training. In the end it generally finds its way to the ashcan or garbage heaps. The next class calls for some more carnage, some more loss of life. This happens so often that some of these forms are already becoming scarce. This is especially true of frogs.

The lecture demonstration method, the verification method, the use of charts and models, and the use of well dissected but preserved and mounted actual specimens, generally conveys more knowledge and information than individual dissection does when poorly done. The spirit of research or the stimulus of scientific thinking so eagerly sought for by many teachers using the scientific method, can just as well be instilled into the minds of our students with much less carnage and waste of animal life. This may demand more personal attention on the part of the teachers, but the results will always be worth while. If our teachers or those in charge of providing and equipping laboratories could only think ahead, a good deal of time, life, and goodwill could be saved.

Frog skeletons and other osteological preparations are not so hard to make, especially if one takes into consideration the fact that by careful handling the natural ligaments will keep the greater part of the skeleton together. Careful students and potential osteologists can always be found in any class, especially if provided with a mounted skeleton as a model. Of course, the initial cost and initial toll of life must always be met, but in each succeeding year the economy of money, time, and life is felt. For with proper care and storage these preparations can be used over and over again.

Careful dissections can be preserved and mounted in formaldehyde or cleared according to Spalteholtz' method in synthetic wintergreen oil. Tubes and homepathic vials, sealed with a composition of tar, rosin, and sealing wax go far in relieving one of constantly buying or collecting. Specimens thus protected are permanent and almost always are more conveniently handled.

If one desires to make a comparative study of forms making up a phylum or homology of organs, these sealed vials can very neatly be sewed upon a prepared pulpboard and thus served as a teaching museum.

Some plant and animal forms like leaves, flowers, catkins, fern sporophylls, large pine seeds, lichens, mosses, wheat rust, centipedes, millepedes, scorpions, etc., permit drying and mounting between two plain lantern slides. These are then bound with gummed Hollands. If the material is thick, strips of pulpboard can serve as reinforcements. Desirable forms can thus be collected in season, properly put up, labelled, and stored away. This will then permit the teacher to grade his course, for he will always be sure of his laboratory materials in any season and in any weather. Year by year additions instead of mere replacements can be made. Very soon a wealth of truly, useful laboratory material is thus assembled, and that without much expense and also without a loss of good will of our neighbors.

However, I consider the time saved as the greatest factor. For example, the teacher can then dispense with often poorly understood laboratory manuals, take a slide in hand, the pupils doing likewise, and be free to lead the study, arousing interest and stimulating scientific thought by his questions and explanations.

Take for example the study of leaf venation and transpiration. The leaf of the American elm, being very simple, lends itself admirably for this purpose, for conspicuous veins lead to the jagged edge. A comparison with the leaves of the birch and choke cherry where the veins are not so conspicuous but the edge more jagged plus a covering up or any living potted plant enables the student to group the significance of the structure and to associate it with function. In short he is taught to be a keen observer. Delicate structures like sporangia are preserved between the two slide glasses and not rubbed off and can easily be observed with lens or microscope. The repugnance frequently met with in handling animals like centipedes and scorpions is done away with when put up this way and hence a better study is made, and by far more interest is aroused.

THE INFLUENCE OF YEAST UPON INTESTINAL ACTIVITY IN THE RAT (ISOLATED SEGMENTS).

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Yeast therapy is not new, for Hippocrates employed it as a curative agent, and Pliny, the Elder, during the first century of the Christian era called attention to its use. Although many articles appeared advocating the curative power of yeast for various diseases, it was not until the 19th century that modern medicine looked favorably upon its use for intestinal disorders.

Literature reveals conflicting reports especially concerning the effect of yeast on intestinal motility. Some workers report excellent results with the yeast for relief of constipation while others have found it efficacious in checking diarrhea.

Roos (1) highly recommended yeast as a corrective for alimentary disorders, particularly constipation. Hawk (2) and others of the Jefferson Medical College found that yeast, while not in any sense a cathartic aided in elimination of waste and was an effective remedy in many cases of constipation. Osborne (3) suggested that yeast is a useful laxative and that it should be frequently given where intestinal disturbance is associated with constipation. Beside the laxative effect of yeast, he says that it has the ability to change the flora and to more or less check fermentation. Reeves (4) reported six cases of constipation treated with yeast of which four were cured and two improved. Smith (5) kept several subjects for four weeks on a purin-free diet of bread, milk and cheese which for them was distinctly constipating so long as it was continued without yeast, but when yeast was taken with it, the condition was relieved. Murlin and Mattill (6) found that the administration of yeast not only resulted in greater frequency of evacuation, but also in a measurable increase in the bulk as well as the moisture of the stools. They offer a plausible explanation for their results based on the fact that yeast plants survive alimentary secretion. Therefore, the characteristic fermentation of carbohydrates goes on in the bowel. The resulting gas, by distention possibly induces increased peristalsis. Daniels (7) reports marked diarrhea in infants when yeast is used as the source of Vitamin B. Davison (8) confirms these findings. On the other hand, Thiercelin and Chevrey (9) reported several cases in infants where diarrhea was suppressed by the use of yeast. Faisans (10) said, "I have been struck with the facility with which the coated tongue, lack of appetite and diarrhea clear up by the employment of brewers' yeast."

The concensus of opinion among the earlier workers favors some laxative action of yeast, either by the carbon dioxide production, high Vitamin B content or change in the intestinal flora.

Thorup and Carlson (11) experimenting with rats concluded that yeast in varying amounts up to 25% of the total diet has no effect on the alimentary peristaltic rate in normal rats on an adequate diet. However, some increase in moisture content of the stools was noted. Concerning prolonged tests on 85 normal human adults, the records of these workers show that in approximately 55% there was a very slight increase in number of stools daily during a period of yeast ingestion. On the other hand some individuals showed a decreased alimentary rate on yeast intake. Therefore, they concluded that the value of yeast as a laxative in adults on average normal diets is questionable.

Allen and Burget (12) designed experiments to test the effect of bakers' yeast on gastric secretion in man and in dogs. A synthetic control meal consisting of 5 grams of powdered soda crackers suspended in 400 cc. of water was taken and on alternating days, a suspension of 20 grams of yeast in a like quantity of water. Their results showed that the bakers yeast did not exert a gastric secretagogue action as great as that brought about by soda crackers or by a synthetic meal consisting of similar amounts of protein, carbohydrate and fat as found in yeast.

So much diversity of opinion concerning the true effect of yeast upon the alimentary system prompted Dr. Erma A. Smith and the writer to test the influence of yeast in the diet of the rat upon the activity of isolated segments of duodenum and colon. The method of Alvarez (13) was employed. Young white rats of the same age were selected and divided into four groups. Each group contined a comparable number of animals as to sex. The basal diet consisted of purified food stuffs free from Vitamin B as prepared by the Harris Laboratories. Fleischmann's yeast, dried at room temperature, supplemented this diet.

BASAL DIET		YEAST SUPPLEMENT
Food	Per cent by weight	
Starch	54	Group I. Basal diet only
Casein	18	Group II. Basal diet plus 1 per cent by weight yeast
Lard	16	Group III. Basal diet plus 10 per cent by weight yeast
Butter fat	8	Group IV. Basal diet plus 25 per cent by weight yeast
Complete inorganic salt mixture	4	
Cod liver oil 2 to 4 drops daily per rat		
Lemon juice 2 to 4 drops daily per rat		

After 14 days on diets, motility experiments were begun. Experiments were conducted thereafter upon 30 rats subjected to the above diets for varying numbers of days up to 77. Four segments were compared simultaneously.

One animal of similar sex from two groups was decapitated at the same time. Strips of duodenum immediately below the stomach and of colon as low as possible were excised at once from each rat. The 4 segments, each approximately 2½ centimeters in length were suspended in warm oxygenated Locke's solution and arranged in connection with light recording levers of equal weight and length. The strips not used immediately were kept on pads of cotton saturated with Locke's solution at a temperature of 0° C. and tracings made the succeeding day.

The kymographic records were compared as to rate and amplitude of rhythmic contraction also as to duration or the length of time which the isolated segments exhibited spontaneous activity.

The following table indicates the number of experiments in which segments from rats fed diets containing no yeast or 1% of yeast were greater, less or equal in activity to those from rats fed diets having either 10% or 25% yeast content.

Considering both the records of the first day and those made from the refrigerated strips on the second day, segments from rats fed diets containing no yeast or low in yeast total greater activity in 13 experiments, less in 10, and equal in 22.

The number of days on diet is a factor in these experiments because rats fed diets containing no yeast becomes greatly debilitated through lack of Vitamin B. Before the stage of debility, segments from such rats show hyperactivity; and later hypo-

COMPARISONS	Frequency of Contraction			Duration of Contraction			Amplitude of Contraction		
	Greater	Less	Equal	Greater	Less	Equal	Greater	Less	Equal
No yeast vs. 10 per cent yeast	1	....	1	1	....	1	1	....	....
1 per cent yeast vs. 10 per cent yeast	5	2	4	3	....	4	....	6	5
No yeast vs. 25 per cent yeast	....	2	2	....	....	2	....	....	2
10 per cent yeast vs. 25 per cent yeast	1	....	....	1	....	....	....	....	1
Totals	7	4	7	5	....	7	1	6	8

activity. Vitamin B supplement provided by 1% of yeast approaches natural physiological conditions. Therefore, comparisons with these animals are more dependable.

Comparison of records and direct observation of contractions of isolated segments of rats intestine do not indicate increased activity as a result of diets high in yeast. Therefore, the laxative effect of yeast on intestinal motility is doubtful.

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THE PLANTS OF CASTLE ROCK

A PRELIMINARY REPORT

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Castle Rock is a butte left by the eroding waters that swept through the present Rock River valley in the far distant past. It stands alone, separated by stretches of sand from the bluffs along the river below and those stretching back north and west of it. It is different from the others, which are wooded. It is on the west bank of Rock River three miles south of Oregon. It is much visited by tourists since it commands a very beautiful view of the Rock River valley. This, of course, is an important factor in its plant population, though there is some effort made to protect the wild flowers and shrubs growing there.

The rock is composed of almost pure sandstone (St. Peter's), and is part of the same rock formation which has been scultpured into canyons by tributaries of the Illinois and Vermillion rivers at Starved Rock. This sandstone is soft and crumbles easily so the rock is surrounded with deepsand, loosened by weathering, giving sandy slopes by way of approach which are very similar to the dunes. Castle Rock is composed of a series of terraces, which no doubt are responsible for its fanciful name. The upper parts of the rock are nearly devoid of vegetation except for a few crustose lichens and mosses found in the crevices. Castle Rock is interesting from an ecological point of view because of its well marked plant succession passing from extreme xerarch condition at the top where there are only xerophytic lichens and mosses, through ferns, xerophytic herbaceous plants and shrubs down to the oak-hickory stand on the south side. The succession reaches an extreme mesophytic condition on the east side.

The south slope is the most gradual. It is covered part way up by a sparse growth of black oak (Hill's) and white oak. On this side there are many herbaceous perennials including blazing star, three species of goldenrod, several species of grass, the ferns Polypodium and Pteris (the brake fern), and many others listed below.

The most interesting of these plants was the blue toad flax, *Linaria canadensis* (L.) Dumont. This exquisite flower, very small, clear blue, was borne on small plants not more than four or five inches high when first seen, May 23. It was still blooming, August 30, but it had grown tall and its lower flowers had ripened into mature fruits. This species seems to be rather rare for it was seen in no other place during a summer's collecting at various places along the river in Ogle and Winnebago counties, nor was it seen at Starved Rock.

The north slope, which is very steep, has a thicket of witch hazel which extends around the western side, but there are fewer shrubs on the west. Associated with the witch hazel are many sand plums, which are characteristic dune plants, gooseberry and black-berry bushes. Scattered among the shrubs in open spots are numerous plants of the great Solomon's seal and the ferns mentioned before.

The east face, which is towards the river, is quite different, being a steep rock cliff. The upper part is xerophytic with lichens and mosses and small polypody ferns on its face, but lower down larger ferns and herbaceous plants find foothold on the narrow ledges. At the base of the rock in the numerous shallow caves cut by the water there is a luxuriant growth of liverworts, Conocephalus and Reboulia, and such mesophytic ferns as Woodsia and Cystopteris. In the moist soil bordering these, shaded by the overhanging branches of a service berry tree (shad bush) there are such typical mesophytes as wood nettle and Virginia creeper.

The steep sandy eastern slope below the rock is covered by a thicket of black-berries, but the other parts of the slope are covered with common weeds such as mullein, ragweed, climbing false buckwheat, field bindweed, etc. The eastern slope merges into a narrow flood plain covered with grass and many herbaceous plants including black night shade, several species of the mustard family, evening primrose, nettle, verbena, knotweeds, and others. The flood plain ends in a gravel beach at one point with rather interesting growth of Amaranthus and Bidens and scattered plants of asters, two species of Chenopodium (lambs' quarters), horsetails and several others. At another place the flood plain ends in a fen at the water's edge, where there is a typical fen association including arrowhead, bulrush, sedges, iron weed and several others. There is some telescoping of the flood plain with the fen in the occurrence of dogwood, ash, cottonwood and white maple.

The list of plants occurring in the several habitats described are listed below. This is, of course, a preliminary list which it is hoped may be completed at some future time.

Plants Observed.

1. Top of rock—extremely xerophytic
   Thallophytes:
   Lichens, crustose, unidentified (yellow, greenish, brown)
   Bryophytes:
   Grimmea sp.
   Polytrichum juniperinum Willd.
   Herbaceous Plants:
   Sedge, unidentified
   Juncus tenuiis Willd.
   Panicum capillare L. (?)
   Woody Plants:
   Acer negundo L. (small seedling)
   Quercus ellipsoidalis E. J. Hill
   Rhus copallina L.
   Vaccinium canadense Kalm
   Vaccinium vacillans Kalm

2. South slope—xerophytic, sandy
   Herbaceous Plants:
   Achillia millefolium L.
   Amaranthus retroflexus L.
   Ambrosia artemisfolia L.
   Antennaria plantaginifolia (L.) Richards
   Anthemis cotula L. (?)
   Anychia canadensis (L.) BSP.
   Artmesia caudata Michx.
   Arctium minus Bernh.
   Aster lateriflorus (L.) Britton
   Capsella bursa-pastoris (L.) Medic.
   Coreopsis sp.?
   Erigeron ramosus (Walt.) BSP.
   Euphorbia corollata L.
   Fragaria virginiana Duchesne
   Gnaphalium polycephalum Michx.
   Hypericum ellipticum Hook.
   Hypericum gentianoides (L.) BSP.
   Lactuca scariola L.

- *Lepidium virginicum* L.
- *Liatris graminifolia* (Walt.) Willd.
- *Linaria canadensis* (L.) Dumont
- *Linaria vulgaris* Hill
- *Lythrum alatum* Pursh
- *Mentha sativa* L.
- *Oxalis corniculata* L.
- *Phlox divaricata* L.
- *Polygonatum commutatum* (R. & S.) Dietr.
- *Rumex Acetosella* L.
- *Sismbrium incisum* var. *filipes* Gray
- *Sisyrinchium angustifolium* Mill.
- *Solidago Boottii* Hook.
- *Solidago hispida* Muhl.
- *Solidago nemoralis* Ait.
- *Tephrosia virginiana* (L.) Pers.
- *Tradescantia virginica* L.
- *Viola* sp. (blue)

Woody Plants:

- *Quercus ellipsoidalis* E. J. Hill
- *Quercus alba* L.
- *Rhus copallina* L.
- *Ribes Cynosbati* L.
- *Rosa acicularis* Lindl.
- *Smilax herbacea* L.
- *Ulmus fulva* Michx.
- *Vaccinium canadense* Kalm.
- *Viburnum lentago* L.?
- *Vitis vulpina* L.

3. East slope

a. Face of rock—xerophytic, perpendicular with narrow ledges projecting.

Herbaceous plants

- *Cystopteris fragilis* (L.) Bernh.
- *Linaria canadensis* (L.) Dumont
- *Maianthemum canadense* Desf.
- *Pentstemon* sp.
- *Polypodium vulgare* L.
- *Polygonatum biflorum* (Walt.) Ell.
- *Polygonatum commutatum* (R. & S.) Dietr.
- *Pyrrhopappus caroliniana* (Walt.) Raf.

Woodsia obtusa (Spreng.) Torr.

Woody plants

Aralia nudicaulis L.
Hamamelis virginiana L.
Prunus angustifolia var. *Watsoni* (Sarg.) Waugh

b. Base of rock—xerophytic above on steep sandy slope, changing to mesophytic below, where it merges into the flood plain.

Herbaceous plants

Datura tatula L.
Heuchera hispida Pursh
Ipomea pandurata (L.) G. F. W. Mey.
Laportea canadensis (L.) Gaud.
Lepidium virginicum L.
Linaria canadensis (L.) Dumont
Pentstemon sp.
Polygonum pennsylvanicum L.
Polygonum scandens L.
Rumex Acetosella L.
Solanum nigrum L.
Tradescantia sp.
Urtica gracilis Ait.
Verbascum thaspus L.

Woody plants

Amelanchier canadensis (L.) Medic.
Celtis occidentalis L.
Populus grandidentata Michx.
Prunus americana Marsh.
Prunus serotina Ehrh.
Psedera quinquefolia (L.) Greene
Rhus toxicodendron L.
Rubus allegheniensis Porter
Rubus odoratus L.
Smilax herbacea L.
Tilia americana L.

c. Shallow cave, water worn, at base of rocks, shaded by trees (*Tilia* sp. and *Amelanchier canadensis*).

Reboulia sp.
Heuchera hispida Pursh
Psedera quinquefolia (L.) Greene
Woodsia obtusa (Spreng) Torr .

4. Flood plain, between Castle Rock and Rock River.

Herbaceous plants

Abutilon theophrasti Medic.
Datura tatula L.
Duchesnia indica (Andr.) Focke
Erigeron canadensis L.
Mollugo verticillata L.
Oenothera biennis L. (?)
Phytolacca decandra L.
Polygonum aviculare L.
Rumex Acetosella L.
Sisymbrium officinale (L.) Scop.
Solanum nigrum L.
Teucrium occidentale Gray
Urtica gracilis Ait.
Verbena urticaefolia L.
Vernonia fasiculata Michx.

Woody plants

Acer saccharium L.
Fraxinus americana L.
Quercus stellata Wangenh.
Tilia americana L.

5. Flood plain telescoping into fen, hydrophytic

Woody plants

Acer negundo L.
Acer saccharum L.
Cornus stolonifera Michx.
Fraxinus pennsylvanica var. *lanceolata* (Borkh.) Sarg.
Populus deltoides Marsh
Salix longifolia Muhl.

6. Fen—mesophytic to hydrophytic

Herbaceous plants

Actinomeris alternifolia (L.) D. C.
Amaranthus hybridus L.
Bidens cernua L.
Cyperus sp.
Leonurus Cardiaca L.
Lippia lanceolata Michx.
Polygonum lapathifolium L.
Rudbeckia laciniata L.

Rumex Britannica L.
Sagittaria sp.
Scirpus americanus Pers.
Vernonia fasiculata Michx.
Xanthium sp.

7. Beach gravel and sand
Herbaceous plants
Amaranthus hybridus L.
Anthemis Cotula L.
Aster vimineus Lam.
Bidens frondosa L.
Chenopolium album L.
Chenopolium hybridum L.
Equisetum arvense L.

8. North slope—mesophytic
Herbaceous plants
Dicentra cucullaria (L.) Bernh.
Poa pratensis L.
Polygonatum biflorum (Walt.) Ell.
Polygonatum commutatum (R. & S.) Dietr.
Polygonum scandens L.
Pteris aquilina L.
Smilacina racemosa (L.) Desf.
Woody Plants
Amelanchier canadensis (L.) Medic.
Celtis occidentalis L.
Hamamelis virginiana L.
Prunus americana Marsh.
Prunus serotina Ehrh.
Quercus alba L.
Quercus ellipsoidalis E. J. Hill
Ribes Cynosbati L.
Rubus allegheniensis Porter
Smilax hispida Muhl.
Vaccinium vacillans Kalm.
Vitis vulpina L.

9. West slope—xerophytic
Herbaceous plants
Antennaria plantaginifolia (L.) Richards
Maianthemum canadense Desf.
Polytrichum juniperimum Willd.

Woody plants

Amelanchier canadensis (L.) Medic.

Aralia nudicaulis L.

Hamamelis virginiana L.

Populus alba L.

Vaccinium canadense Kahm.

THE MORPHOLOGY AND NATURE OF A PRAIRIE IN COOK COUNTY, ILLINOIS.

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In the fall of 1926 the outstanding brilliancy of the flora and the frequency of unusual species found growing upon a piece of apparently unbroken farm land raised the question of the primitive or virgin character of the field.

This prairie is located in Cook County, Illinois, about eight miles west of Evanston, on Milwaukee Avenue road, in the vicinity of Ridgewood Cemetery. This tract of land is situated just west of the Glenwood Beach of Glacial Lake Chicago and approximately on the divide between the north fork of the Chicago River on the east and the Desplaines River on the west. It is probably of swamp origin resulting from Wisconsin glaciation.

It is a part of the Peacock estate which was Indian territory before the government land grant of 1842. From James Long, whose grandfather was the original owner, it was learned that this piece of sod had never been broken, or to his knowledge systematically grazed, although early in the spring of each year this land is burned over. Long described a number of prairie plants which are found here, using their common names, such as the prairie clovers, rosin weeds, blazing stars, and lillies. These he stated were characteristic of all adjoining land before it had been broken but that this particular plot had always had more plants and been more colorful than any other.

This study was made during the year 1927 with the intention of supplementing these observations with further work in succeeding seasons. However, in March of 1928, after a period of warm dry weather, the annual fire caused a very severe burning of the sod, leaving barren patches in many parts of the field. As a result the observations of this year would not be comparable with those of the preceding season. However, a new and very interesting problem is opened as to the effect of such a fire on the distribution and abundance of the prairie plants. Perhaps the season of 1927 should not be considered a typical but rather an unusual one as far as the great display of brilliant flowering

*Introduced by W. G. Waterman.

plants, especially those of early spring, are concerned. A long wet spring following an unusual winter with extremes of temperature may have accounted, at least in part, for such a showing.

Physical Features.

This tract of prairie is approximately ten acres in area, measuring 465x587x633x890 feet along the sides (Text Fig. 1). Beyond Milwaukee Road to the west is a grass meadow which has not recently been cultivated; on the south a truck garden; a cultivated field to the east; and on the north another uncultivated field which is separated from the prairie by a row of trees along the fence and a ditch.

Superficial inspection indicated that there are three physiographic areas; wet or hydro-xeric, meso-xeric, and xeric. The hydro-xeric or wet areas are limited to four localities of relatively small area, indicated on the chart by numbers 61, 63, 55 and 56. In the spring and late fall these areas, particularly at 61 and 63, are covered with water. Since there is no permanent ground water level near the surface, but merely a clay sub-soil, the water disappears during the summer and the ground is dry on the surface. At 55 and 56 this occurs earlier than at the other two stations and the soil has a slightly lower moisture content throughout the season. The meso-xeric belts which border the wetter localities have a still lower percentage of soil moisture and dry out sooner. They are indicated on the chart by the numbers 39, 40, 51, 52, 53, 54, 57, 58, 59, 62 and 64.

The xeric division comprises the larger part of the field and extends from southwest to northeast, continuing around the eastern arm of the large meso-xeric zone and forming a smaller ridge along the south. Between the north and south arms of this large wet spot in the eastern section, represented by numbers 32-36, is the knoll of greatest elevation on this prairie, having an extreme difference in level of not more than three or four feet.

In general, characteristic associations distinguish these three divisions. In addition individual species serve as indicators as for instance *Eleocharis palustris,* which is universally distributed in the wet areas and characterizes the border between meso-xeric and xeric associations. No true marsh plants are present in the hydro-xeric habitats with the exception of a very few specimens of *Typha latifolia* which were small and did not blossom, but such semi-marsh plants as can stand drying out in the summer were frequent.

In order to verify this tentative division, soil moisture studies were made. Soil samples, using two hundred to four hundred grams, were taken at intervals of one or two weeks from June 9, to October 19, at nine stations. From August to October collections were made at the two hydro-xeric stations, 61 and 63, which were under water until midsummer. The surface soil was removed to a depth of two inches and the samples were taken not deeper than ten inches. The soil samples were oven dried at low temperature over a gas flame. The average soil moisture content for each station is indicated on the accompanying chart, while the complete record is found in Table I.

The results obtained show that this three-fold division can be substantiated since the average soil moisture contents are as follows: xeric 21.6%; meso-xeric 24.9%; hydro-xeric 28.4%; while the wilting coefficient of the stations thus grouped was 18.4, 22.3, and 21.5 respectively. The average soil moisture contents did not drop below the wilting coefficient. However, during the period from the middle of July to the middle of September every station except number 63, fell below the wilting co-

TABLE I.

SOIL MOISTURE CONTENT AND WILTING COEFFICIENT AT ELEVEN STATIONS.

Station	June 9	June 15	June 28	July 7	July 15	July 22	July 28	August 4	August 13	August 24	September 16	October 5	October 19	Wilting Coefficient
3	32.2	22.5	22.4	23.6	24	19.7	18.7	16.6	21.4	22.4	.....	31	31.6	21.2
24	31.3	20.8	23.1	25	22.7	19	16.8	14.2	14.8	13.6	19.6	31.2	29.8	19.5
34	26	19.5	18.7	17.3	20	13	12.6	10	16.9	12.8	17.4	26.1	24.8	16.3
60	....	30.5	25.2	23.5	27.1	18.6	17	16.7	19	18.7	16.3	32.6	29.3	16.7
51	36.6	34.5	27.8	25.4	24.3	21.3	21.1	17.7	21.1	20.2	16.2	31.6	31	20.9
54	....	33.4	28.6	23.6	27.3	20.4	17.7	18.5	20.3	18.9	.....	27.7	31.6	21.4
55	45.6	37.8	31.5	28.8	25.9	23.8	21.8	21.2	21.4	20	21.3	35.2	40.8	20.5
56	....	37.9	32.5	27.9	30	24.8	20.8	23.8	22.2	17.3	22.6	43.9	41.1	23.9
64	....	....	31	24.8	23.5	22.5	19.2	14.4	21.9	19.7	.....	37.6	36.3	24.6
61	....	....	....	....	.....	.....	.....	.....	23.4	20.9	.....	29	36.8	23.1
63	....	....	....	....	.....	.....	.....	20.9	25.8	21.5	.....	34.7	39	18.3

efficient at least once, indicating a general xeric state for this prairie during the summer.

This is practically the conclusion reached by Harvey (14) in the study of soil from a 7.5 cm. depth, on an Illinois prairie during the summer of 1911. He found that the soil water content was below the wilting coefficient during most of the period from the first of July to the last of September.

An extensive study of soil moisture content and the wilting coefficient has been carried out by various workers in Nebraska. The work of Weaver and Thiel (41) and Pool, Weaver, and Jean (17), in 1912 showed that there were fluctuations in water content for each depth from "0-60 inches" and for each station. Their results show a generally lower wilting coefficient and through June and July a lower soil moisture content than is found at the xeric stations of this prairie at approximately the same soil depth. They found that during the latter part of July and early August the soil moisture even at a depth of twenty-four inches dropped below the wilting coefficient. However, in depths of "0-6 inches" the wilting coefficient was reached sooner. These investigators state their results "abundantly prove the importance of soil moisture as a factor in plant succession between prairies on one hand and forest on the other".

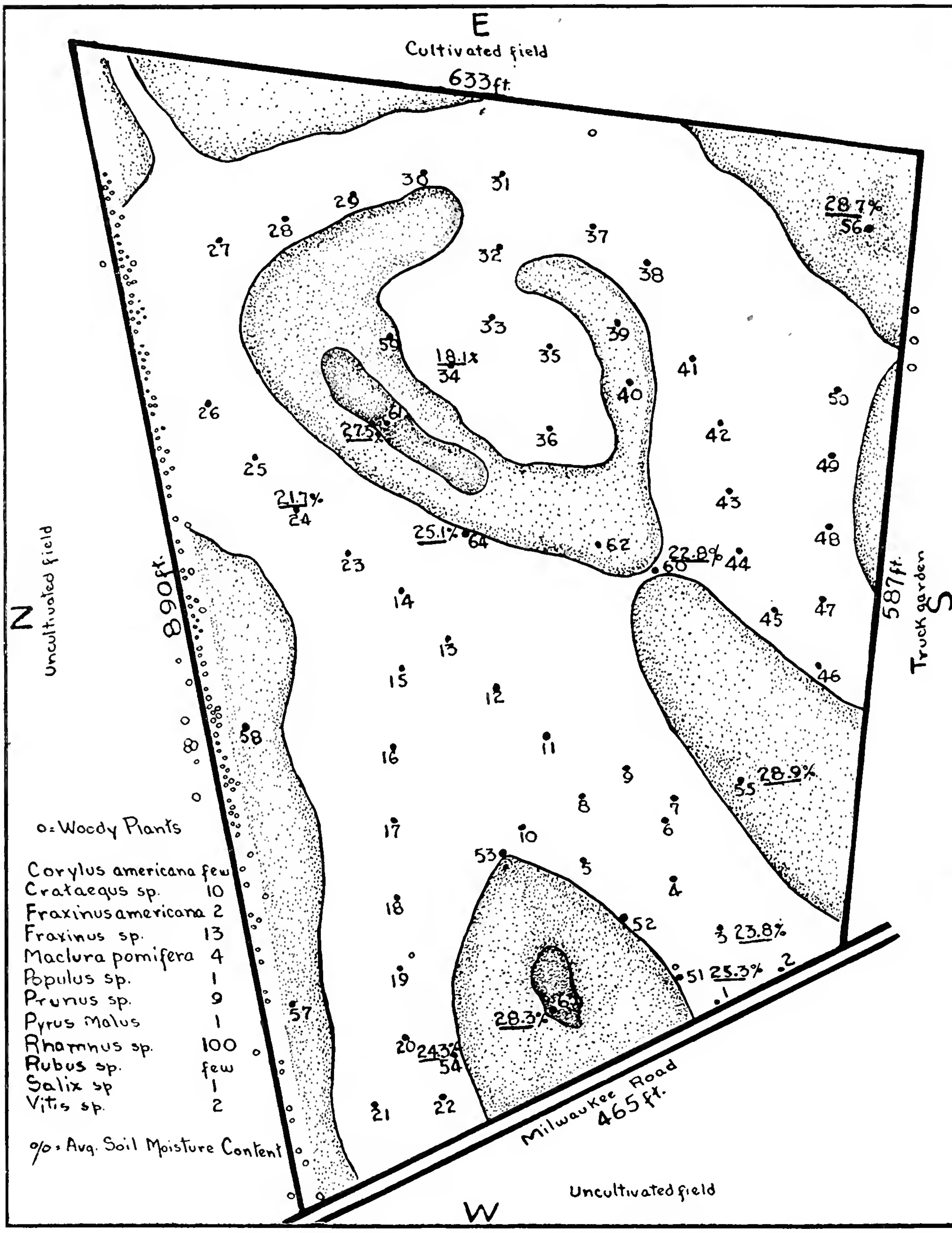
Further work of this type has been done in Nebraska by Thornber (35) with soil taken from 6-10 cm. depths. His data show a greater deviation from the results on this prairie, the soil moisture content here being higher during early spring and late autumn and considerably lower in the summer. Alway, McDole, and Trumbull (2) made studies of soil as deep as 12-21 feet and found that the ratio between the water content and the hygroscopic coefficient was higher in humid soils.

The results obtained in these experiments are not fully conclusive, as it is probable that in most plants the deeper parts of the root systems extended below the collecting level. Thus when the soil moisture fell below the wilting coefficient in these upper layers there was no evidence of wilting in the plants near these stations. According to Sampson (21) it is the height of the water table and not the chemistry of the soil that is the limiting factor determining the order of associations. This may be the explanation for the peculiar localization of a number of species of the hydro-xeric associations which will be discussed later.

Morphology of Associations.

Methods:

The quadrat method was used for determining the distribution and the frequency index (F. I.) of species. Count was made of the actual number of each species of the coarse herbs



TEXT FIGURE 1—Location of Quadrats (1-64). Average Soil Moisture content at eleven stations (percentage underlined); Wet areas stippled.

in the quadrats and the distribution and abundance was plotted on charts of the area. The association of which each was most characteristic was thus determined and the accompanying Table II compiled. Sixty-four quadrats, each one meter square, were plotted, most of which were located on the dry ridges or in border zones between the meso-xeric and xeric areas. Since much of the rest of the land was exceedingly wet in the spring when the plotting was done, and showed little vegetation other than grasses and sedges, it was thought impracticable to attempt to place quadrats upon it. Later in the season a number of quadrats were added in these regions. In most cases quadrats were placed fifty feet apart along the ridges.

Specimens of all species were preserved in the herbarium at Northwestern University. The nomenclature used is that given in the 7th Edition of Gray's Manual with the exception of *Petalostemum tenuifolium*, Britton and Brown; therefore, authority names have been omitted.

Floristic Content:

With the exception of an unidentified moss which was a frequent mesic plant in the spring, and *Equisetum* sp., the plants on the prairie were Angiosperms.

Table II gives a list of the species and the associations in which they were found. The following abbreviations are used: *ch* = characteristic, *G* = general, *a* = abundant, *f* = frequent, *i* = infrequent, *L* = local, 1-2-3 etc. = number of localities, *N. E.-S. W.* = points of the compass, *R* = ruderal, *F. I.* = frequency index. The + signs opposite the three species of Liatris indicate a greater F. I. of undetermined amounts as in early blossom many were cut by a local florist.

TABLE II.

Floristic Content.

Coarse Herbs.	Hydro-xeric.	F. I.	Meso-xeric.	F. I.	Xeric.	F. I.	Total F. I.
Achillea millefolium					2Lf	13.5	9.4
Allium canadense	1Li	25	Gf	82	Ga	69.5	68.8
Allium cernuum	2Lf	50	Lf	45.5	Gf	65.3	61.1
Ambrosia artemisiifolia					LiR	2.2	1.6
Amorpha canescens					Gi ch	14.3—22.5	10.9—17.2
Anemone cylindrica					3Li	2.2— 6.1	1.6— 4.7
Antennaria neodioica			Lf	36.3	Ga	94.0	78.2
Apocynum cannabinum			2Lf	18.4			1.6— 3.1
Asclepias Sullivantii			1Lf	9.1	2L f	4.1	1.6
Asparagus officinalis					1LiR	—2.2— 8.2	—1.6— 6.3
Aster azureus					4Li	10.2	7.8
Aster commutatus			LNWi	9.1	GSi	2.2—12.5	3.1—10.9
Aster ericoides var platyphyllus					1Li	2.2— 8.2	1.6— 6.7
Aster laevis					Gf ch	32.6—73.5	25.0—56.3
Aster multiflorus			4Li	9.1—45.5	Gf ch	8.2—34.6	7.8—34.4
Aster novae-angliae					2Li	—4.1	—3.1
Aster oblongifolius			2Li	—18.2			—3.1
Aster ptarmicoides					1Li	—2.2	—1.6
Aster spp. (white)			1La	—9.1			—1.6
Baptisia bracteata					3Lf	10.2	7.8
Baptisia leucantha					3Li	—2.2— 4.1	—1.6— 3.2
Bidens frondosa	1Lf	25	1Li	—9.1			1.6— 3.1
Cacalia tuberosa					EGi	15.7	3.2—11.9
Chrysanthemum Leucanthemum					1LaR	—2.2	—1.6

TABLE II.

FLORISTIC CONTENT—*Continued.*

Coarse Herbs.	Hydro-xeric.	F. I.	Meso-xeric.	F. I.	Xeric.	F. I.	Total F. I.
Cicuta maculata			4Li	9.1—36.4			1.6— 6.3
Cirsium arvense					1LiR	—4.1	—3.1
Cirsium Hillii					Gf	40.1	31.3
Comandra umbellata ...					Ga	69.5	53.1
Coreopsis palmata					N.W. S.E. a	24.5	18.8
Dodecatheon Meadia.....					1Li	2.2— 4.1	1.6— 3.1
Erigeron ramosus					2Li	6.1—14.6	4.7—10.9
Eryngium yuccifolium ..					WGf ch	24.5	18.7
Fragaria virginiana			Gf	81.8	Gf	30.6	37.2
Galium tinctorium			1Li	—18.2		16.3	—3.1
Gentiana affinis (?).....					Gf	42.9	12.5—32.9
Gerardia aspera			2Li	—18.2			—3.1
Geum triflorum			1Lf	—18.2	1Lf	2.2	1.6— 6.3
Helianthus grosseserratus			1La	—18.2			—1.6
Helianthus scaberrimus.			2La	—4.1	2La	—4.1	—4.7
Heuchera hispida			2Lf	18.2—36.4			3.1— 6.3
Hypoxis hirsuta	1Li	25	Gf	82	Ga	96	87.5
Krigia amplexicaulis ..			3Lf	45.5	Ef	34.7	34.2
Kuhnia eupatorioides var. corymbulosa			3Li	—36.4			1.6— 4.7
Lactuca campestris					Gf	4.1— 6.1	3.1— 4.7
Lactuca canadensis					Gf	20.2	15.6
Lactuca hirsuta					3Li	2.2— 4.1	1.6— 3.1
Lepachys pinnata					Gf ch	14.3—40.1	10.9—36.2

TABLE II.

FLORISTIC CONTENT—*Continued.*

Coarse Herbs.	Hydro-xeric.	F. I.	Meso-xeric.	F. I.	Xeric.	F. I.	Total F. I.
Liatris graminifolia					2Li	4.1+	3.1+
Liatris scariosa					Gf	9.8+	7.7—26.3+
Liatris spicata					Gf	34.7	9.4+
Lilium canadense........			2Li	—27.3		12.2+	—4.7
Lilium philadelphicum .			3Li	9.1—27.3	1Li	2.2— 6.1	3.1—10.9
Lithospermum canescen					Gf	42.8	32.9
Lobelia spicata			5Lf	63.5	Gf	55.1	53.2
Ludvigia polycarpa	1La	25					1.6
Lycopus americana	2Lf	50	Gf	45.6			7.7
Lythrum alatum	1Li	25	4La	/4.1—10.2			4.7— 9.4
Medicago sativa					N.W. 1LR	—2.2	—1.6
Melilotus alba					W. N.E. fR	10.2	7.3
Oenothera muricata					2Li	—10.2	—4.7
Oxalis cymosa					NiR	—2.2	—1.6
Oxalis violacea..........					Gf	53	40.7
Oxypolis rigidior			3Li	—36.4			—6.3
Parthenium integrifoliu					3Li	10.2	7.8
Pedicularis canadensis .					1Lf N.E.	2.2— 6.1	1.6— 4.7
Penthorum sedoides ...	2Lia	25–50					3.1
Petalostemum candidum					2LG if ch	4.1— 8.2	3.1— 6.2
Petalostemum purpur-eum					Gf ch	16.3—34.7	12.6—26.3
Petalostemum tenuifoli-um B. and B..........					2LGif	10.2—20.1	7.8—14.1

TABLE II.

FLORISTIC CONTENT—*Continued.*

Coarse Herbs.	Hydro-xeric.	F. I.	Meso-xeric.	F. I.	Xeric.	F. I.	Total F. I.
Phlox glaberrima	1 La	—25	1La	—9.1			—1.6
Phlox pilosa					Gf ch	44.8	34.2
Plantago Rugelii	1L	25	1L	—9.1	3LR	—2.2	—1.6
Polygala Senega					Gf	40.7	31.1
Polygonum amphibium	1La	25	1Lf	9.1			3.1
Potentilla arguta					1Li	4.1	3.1
Potentilla canadensis			6Lf	54.6	Gfa	24.5	26.7
Prenanthes aspera			Gf	9.1—72.7	1Li	—2.2	—1.6
Prenanthes racemosa					Li	—6.1	1.6—12.5
Prunella vulgaris					4LiP	4.1	3.2
Psoralea tenuiflora					2Li	4.1	3.2
Pycnanthemum pilosum			5Lfa	18.4—45.5			3.2—7.8
Rosa humilis					Ga ch	59	45.3
Rosa Woodsii			2Lf	—27.3			—4.7
Rudbeckia hirta			4Li	36.4	Ga ch	71.5	60.9
Rumex crispus					1LiR	—2.2	—1.6
Senecio plattensis	2Lf	50	Ga	63.5			20.2
Silphium integrifolium					S.E. N.W. Ga	14.3—24.4	10.9—18.8
Silphium laciniatum			3Li	27.3	Gf	8.2—16.3	12.5—18.8
Silphium terebinthinaceum					Gf	20.2—28.6	15.6—21.8
Sisyrinchium campestre			Gf	54.5	Ga	92	79.7
Smilacina stellata			2Li	18.2	S N.W. Ga	47	39.1
Solidago canadense					3Li	—6.1	—4.7
Solidago graminifolia					1Li	—2.2	—1.6
Solidago nemoralis			1Lf	9.1	2Li	—2.2	1.6— 3.1
Solidago Riddelii			Ga ch	36.3—72.7			6.3—20.2

TABLE II.

Floristic Content—*Continued.*

Coarse Herbs	Hydro-xeric	F. I.	Meso-xeric	F. I.	Xeric	F. I.	Total F. I.
Solidago rigida			3Li	18.2—36.4	Gf ch	6.1—38.8	6.3—42.2
Spiranthes cernua			2Li	—18.2			—3.1
Stachys palustris			1La				1.6
Steironema ciliatum ...			1Lf	—9.1			—1.6
Steironema quadriflorum	2La	50	3Lf	—27.3			4.7
Taraxacum officinale ...					3LiR	8.2	6.2
Tradescantia reflexa ...					S.E. Gi	24.5	18.7
Tragopogon pratensis ..					3LiR	2.2— 4.1	16—3.1
Trifolium hybridum					GifR	12.2	9.4
Trifolium pratense					N.W. GR	24.5	18.7
Typha latifolia	1Li	—25				—2.2	—1.6
Verbena hastata			1Li	—9.1	1Li	—2.2	—1.6
Veronica virginica			3La			—6.1	—4.7
Vicia americana			3Lf	18.2—27.3	1Lf	8.2	7.8
Viola sp.					Gf	20.2	15.6
Viola cucullata	ILa	25	2Lf	9.1—18.2	Ga	47	39.1
Viola pedatifida	1Li	—25			Ga ch	53	40.7
Xanthium commune ..	2Li	25	2Li	9.1			4.7
Zizia aurea					Gf	47	35.9
Woody Plants							
Crataegus sp.					2L		
Salix sp..................			1Li 1 plant		2 plants		
Populus sp.					1Li 1 plant		
Equisetum			Lf	27.2—45.6	GWf	25.4	**23.4**

TABLE II.

FLORISTIC CONTENT—*Concluded.*

Species	Hydro-xeric	Meso-xeric	Xeric
Gramineae			
Agrostis alba			GfR
Agrostis hyemalis		La	Li
Andropogon furcatus			G
Bromus Kalmii			GiR
Calamagrostis canadensis	f		
Elymus canadensis			Gi
Festuca elatior			iR
Glyceria nervata	Lf	Lf	
Hordeum jubatum			LiR
Koeleria cristata			i
Panicum huachucae	Li		
Panicum virgatum			Gf
Phleum pratense			1LfR
Poa compressa		LaGiR	
Poa pratense			GfR
Sorghastrum Nutans			N.Gf
Spartina Michauxiana	Gf		GLa
Stipa spartea	G		
Cyperaceae			
Carex Baubaumii	1 Li		
Carex Crawei		1Li	
Carex vulpinoidea	Li	i	
Eleocharis palustris	Gf	Ga	
Scirpus lineatus	Li		
Juncaceae			
Juncus balticus var. littoralis	1La		
J. Dudleyi	1Lf		
J. Torreyi	1Li		

Distribution:

The distribution of the plants on this prairie seems in the main to be related to physiographic conditions of the area. As a rule, the occurrence of characteristic species in each of the hydro-xeric, meso-xeric, and xeric regions, was general. However, some very interesting cases of localization were noted.

Many plants, while otherwise general, were absent from the N .E. section around quadrats 27 and 28, and frequently near 29 and 30. Similarly certain species were often lacking in the N. W. corner between quadrats 18 and 22. Some examples of the former are: Lithospermum, Lobelia, Oxalis Violacea, the three species of Petalostemum, *Phlox pilosa, Potentilla canadensis, Rosa humilis,* Rudbeckia, the three species of Silphium, all of the species of Solidago except *S. rigida,* both species of Trifolium, *Viola cucullata, Aster multiflorus,* Fragaria and the two species of Alliums. Polygala and Comandra were present in all these quadrats, while Pedicularis was only found there.

Plants which were likewise noticeably absent from the N. W.

corner are Lithospermum, the three species of Petalostemum, *Phlox pilosa, Potentilla canadensis,* Krigia, the three species of Lactuca, and also Liatris. Only two or three plants of the three species of Silphium were scattered in this area and only one Zizia plant was found. Smilacina was here abundant while Verbena, Medicago, and Psoarlea, were observed only in this section of the field. Both of the areas discussed above were of xeric nature and between wet spots.

Apocynum cannadinum and *Asclepias Sullivantii* were abundant near 56. Apocynum occurred again in the region of 59, while Asclepias spread out onto the nearby dry ridge.

Cacalia tuberosa, another typical prairie plant was found rather sparsely scattered in only the Eastern half of the field. A few plants of *Cicuta maculata* occurred in the meso-xeric regions of 51, 53, 40 and 60.

A few plants of *Dodecatheon Meadia* were observed in the vicinity of quadrat 41, and a single plant in quadrat 21. None of these plants produced blossoms. *Erigeron racemosus* which is usually reported to be common on prairie soil was rare, showing only a few plants in scattered localities. A small patch of *Galium tinctorium* occurred at the edge of the moist region north of 43. Two *Gerardia aspera* plants were located, one under shrubbery and Helianthus plants near the north fence, and the other at 64. Also, only two *Spiranthes cernua* plants were observed. These were considerable distance apart near quadrats 47 and 59. *Geum triflorum* found here near quadrats 28, 37, and 41, but infrequently found on prairies, is reported by Pepoon (16) in his Flora of the Chicago Region as "the most localized of our plants, only two stations near our area being recorded, one at Ashburn and another at West Chicago, more than 30 miles distant." He finds that it is always associated with *Heucheria hispida* as it is in this case. Heucheria, however, is not found near 28, but is fairly abundant around 19 and 54.

Several plants of *Baptisia leucantha* were noted near quadrats 10, 32, and 41, which however, were not very vigorous.

Both *Helianthus grosseserratus* and *H. scaberrimus* were limited to the ridge along the north fence, the latter extending for more than half its length. *H. Grosseserratus* was more localized, occurring in clumps in the more moist regions around quadrat 58. These plants were abundant in this general region but did not extend far out onto the dry ridge. *Kuhnia eupator-*

ioides var. *corymbulosa* was very localized, being represented by few scattered individuals about 21, 39, 40 and 60.

The Liliums were few in number, *L. canadense* especially, as there was only a total of fifteen plants found between 51 and 54. According to Pepoon (16), *L. canadense* does not appear in the Chicago Region, and reports of this species are due to mistaken identity. According to him, this species would be *L. superbum*. *L. philadelphicum* was slightly more numerous and also

TABLE III.

Showing the Occurrence of Species Absent From Iowa and Other Illinois Reports.

Milwaukee Road Prairie	Other Illinois Reports	Iowa Reports
Aster commutatus	0	0
Aster ericoides var. platyphyllus	0	0
Asparagus officinalis R.	0	+
Chrysanthemum Leucanthemum R.	0	+
Cirsium arvense R.	0	+
Dodecatheon Meadia	0	+
Gentiana affinis (?)	0	0
Gerardia aspera	0	+
Geum triflorum	+	0
Lactuca campestris	0	+
Lactuca hirsuta	0	0
Liatris graminifolia	0	0
Liatris spicata	+	0
Lycopus americana	+	0
Medicago sativa	0	+
Oenothera muricata	0	0
Oxalis cymosa R.	0	0
Oxypolis rigidior	+	0
Petalostemum tenuifolium	+	0
Phlox glaberrima	+	0
Polygonum amphibium	+	0
Psoralea tenuiflora	(Rep. from Neb.)	0
Rosa Woodsii	0	+
Silphium terebinthinaceum	+	0
Smilacina stellata	0	+
Solidago Riddelii	+	0
Steironema quadriflorum	+	0
Tragopogon pratensis R.	0	+
Trifolium hybridum	0	+
Xanthium commune	0	+
Carex Buxbaumii	0	0
C. Craweii	(Rep. from Neb.)	0
Juncus Dudleyi	0	0
Scirpus lineatus	+	0
S. validus	0	+
Spartina Michauxiana	+	0

a little more widespread. It was found associated with *L. canadense,* but also extended out onto the xeric ridge near 10 and again was fairly numerous between 12 and 62.

A number of the species characteristic of the hydro-xeric habitants were restricted to one or two of the areas. *Ludvigia polycarpa* and *Polygonum amphibium* are abundant only in the area about 63. *Penthorum sedoides* is found in two regions at 61 and 63. Localization was observed also in the following species: *Steironema quadriflorum* in 40, 51, 53, 55 and 56; *S. ciliatum* in the vicinity of 56 only; *Phlox glaberrima* abundant in the meso-xeric zone about 55; *Stachys palustris* near 64 only; *Veronica virginiana* in three locations considerable distance apart at 57, 39, and 56; *Rosa woodsii* was abundant between 40 and 60.

As nearly as can be determined from the study thus far, the cause or causes for such localization as described above are chiefly to be attributed to available soil moisture.

Most of the species listed herein are contained in reports by other investigators (see literature cited), the majority of the reports being from Illinois or Iowa prairies. The plants recorded in floristic lists of these two states and also Nebraska are very similar, at least as to the characteristic species. Table III is a list of plants identified with this prairie that are not reported either from Iowa or Illionis. The plus sign in this table indicate presence.

Seasonal Aspects

Throughout the season the prairie was very colorful. In early spring the predominating colors were the blues of Sisyrinchium and Phlox, the yellows of Hypoxis and Pucoon, the darker hues of the violets, and the less bright colors or whites of *Baptisia bracteata,* Comandra, *Allium canadense* and Polygala; a little later after the early flowers were represented only by a few colorful forms such as Senecio and Krigia, the blue Lobelia mingled with the prairie rose, *Rosa humulis,* covered the field. Then Rudbeckia began to bloom. For a week or so following these plants, the prairie was dull and lacked showy blossoms. After this short interval the nodding onion, *Allium cernuum,* dominated the field. Soon the *Amorpha canescens* lent its bright purple to the yellow *Lepacys pinnata* and *Coreopsis palmata* which bloomed everywhere. In the meso-xeric zones, the bright *Lythrum alata* dominated, and one area around 56 was brilliant with *Phlox glabberima.* The prairie clovers were everywhere in the xeric ridges, and a few orange-red lilies added color. In the autumn the dominating plants were composites, chiefly blue and white asters, and the yellow goldenrods, lettuces, and rosin weeds. Later still, the field was blue with the many gentians. A more complete list of species blooming in the various seasons is given in Table IV.

TABLE IV.

PHENOLOGY OF PRAIRIE PLANTS.

Prevernal May-June 15	Vernal June 15-July 1	Aestival July	Autumnal Aug. 1-Oct. 1
Allium canadense	Achillea millefolium	Allum cernuum	Aster azureus
Antennaria neodioica	Anemone cylindrica	Amorpha canescens	A. commutatus
Baptisia bracteata	Lobelia spicata	Apocynum cannabinum	A. ericoides var. platyphyllus
Comandra umbellata	Polygonum amphibium	Asclepias Sullivantii	A. laevis
Dodecatheon Meadia	Rosa humilis	Baptisia leucantha	A. multiflorus
Fragaria virginiana	Rudbeckia hirta	Cacalia tuberosa	A. novae-angliae
Geum triflorum	Vicia americana	Cicuta maculata	A. oblongifolius
Heucheria hispida		Cirsium Hillii	A. ptarmicoides
Hypoxis hirsuta		Coreopsis palmata	A. spp.
Krigia amplexicaulis		Erigeron ramosus	Gentiana aspera
Lithospermum canescens		Eryngium yuccifolium	Helianthus grosseserratus
Oxalis violacea		Lepacys pinnata	H. scaberrimus
Pedicularis canadensis		Lilium canadense	Kuhnia eupatorioides var. corymbulosa
Phlox pilosa		L. philadelphicum	Lactuca campestris
Polygala Senega		Ludvigia polycarpa	L. canadensis
Potentilla canadensis		Lycopus americana	L. hirsuta
Senecio plattensis		Lythrum alata	Liatris graminifolia
Sisyrinchium campestre		Petalostemum candidum	L. scariosa
Smilacina stellata		P. purpureum	L. spicata
Viola cucullata		Phlox glaberrima	Oxypolis rigidior
Viola pedatifida		Psoralea tenuiflora	Parthenium integrifolium
Zizia aurea		Pycanthemum pilosum	Petalostemum tenuifolium
		Silphium integrifolium	P. racemosa
		Stachys palustris	Silphium laciniatum
		Steironema quadriflorum	Silphium terebinthinaceum
		S. ciliatum	Solidago canadensis
		Veronica virginica	S. graminifolia
			S. nemoralis
			S. Riddelii
			S. rigida
			Spiranthes ecrnua

Woody Plants.

Other than the semi-woody *Amorpha canescens* only three woody species were represented on the prairie proper. These were one small *Crataegus* sp. near 37, a *Populus* sp. about a foot high near quadrat 20, and a *Salix* sp. of about the same size at 51. Outside the South fence near the East corner were three small specimens of Rhamnus sp.; many trees and vines formed a hedge along the North fence, occurring both inside and out but not beyond the ditch on the side toward the prairie proper. The majority were small trees from two to four inches in diameter, and these were mostly buckthorns, *Rhamnus* sp. Some of the ashes reached a size of twelve to fourteen inches, but a number of these were dead trees. Other smaller trees were the *osage orange,* (*Maclura pomifera*), wild cherry, (*Prunus* sp.), one cultivated apple, (*Pyrus malus*), and an under-shrubbery of hazel brush, (*Corylus americana*), raspberry, (*Rubus* sp.) and two vines of grape, (*Vitis* sp.). For the distribution see Text Fig. 1.

Ruderals.

There is some difference of opinion among investigators as to which plants should be regarded as invaders of virgin prairie soil, or the so-called rederals. The author has listed seven grasses and fourteen species of coarse herbs which are usually recorded as weeds. The majority of these intruders were near fences especially to the West. Of the grasses so listed *Agrostis alba* was the most frequent, being scattered throughout the xeric regions but not abundant. *Poa compressa* and *P. pratense* were not common. *Phleum pratense* was fairly common in one locality near the road at 1, 2 and 3. *Bromus Kalmii* was scattered and infrequent, while *Festuca elatior* was rare. Wild rye, *Hordeum jubatum* was found only near the road in small numbers. Of the fourteen coarse herbs it will be noted that six did not occur in any quadrat. These are a few plants of *Asparagus officinalis* along the north fence; one clump of *Chrysanthemum Leucanthemum* near the road around quadrat 2; *Cirsium arvense* near the road west of 22; *Medicago sativa* between 19 and 20; *Oxalis cymosa* near the north fence; and a plant or two of *Rumex crispus* near 58. Three species: *Ambrosia artemisiifolia, Plantago Rugelii,* and *Tragopogon pratensis,* were present in only one quadrat. Others, with their F. I., are: *Melilotus* *alba* 7.3; *Prunella vulgaris* 3.2, *Taraxacum officinale* 6.2, *Trifolium hybridum* 9.4, *T. pratense* 18.7.

Equisetum sp. is considered a weed by Sampson (21) and occurs frequently on this prairie, having an F. I. of 32.8. Sampson also considers *Tradescantia reflexa* (18.7), *Juncus balticus* var. *littoralis, Oxypolis rigidior* (-6.3), *Aster ptarmicoides* (-1.6), *Vicia americana* (7.8), *Solidago canadensis* (-4.7), as ruderals, but they are not so reported by other writers. Vestal (40) records *Oxypolis rigidior* as being characteristic of hydric localities.

Pounds and Clements (18) list *Lepachys pinnata* as a weed on Nebraska prairies, while in Illinois and Iowa it is considered characteristic.

Shimek (29) lists the following plants as weeds on original prairie: *Achillea millefolium, Ambrosia artemisiifolia, Erigeron ramosus, Plantago Rugelii, Solidago rigida,* and *Poa compressa.* In another paper (31) he places in this category also *Apocynum cannabinum* and *Hordeum jubatum.* Shimek (26) states that invasion of species not properly prairie may take place from prairie bogs and he classifies the following plants, which are found on this prairie, as of such an origin: *Cicuta maculata, Galium tinctorium, Lilium canadense, Lythrum alata, Prenanthes racemosa, Spiranthes cernua,* and *Stachys palustris.*

Thornber (35) considers *Lactuca canadensis* a ruderal. Inasmuch as the abundance of ruderals is often used as an indication of degree of disturbances of native prairie sod, it is significant to note that there is a relatively low F. I. for practically all ruderals on this prairie, a number not being represented in even one quadrat. Further consideration of this question follows in the discussion.

Discussion.

The evidence is not conclusive as to whether or not this land is virgin prairie. The floristic list comprises the characteristic species which are most frequently reported by various investigators. In this and other respects it seems to compare favorably with the other tracts which have been called native or slightly modified prairies. Elements of disturbance on a prairie are chiefly: grazing or pasturing, plowing, burrowing by animals such as gophers, and erosion by water. No data can be obtained concerning the grazing of this land by wild herds, but it seems improbable that any such grassland would have escaped buffalo grazing. Mr. Long stated positively that this tract had not been used for pasturing at least in the past fifty years. Other old settlers confirm his statement that the soil has never been broken. A considerable number of crayfish holes were found especially in the meso-xeric zones, but these were small and seemingly caused little disturbance. There is no evidence of erosion either past or present as this prairie lies in a flat upland plain. Fires are not considered to be a disturbing element as prairie fires were frequent and undoubtedly general. Fire, however, occurring in a dry spring, and burning several inches into the ground, certainly should be recognized as having a very definite temporary effect, at least, upon plant distribution.

Sampson (21) states the effect of grazing upon the natural prairie flora is as follows: "Practically every one of the dominant species occurring under natural conditions is replaced by some other species. *Scirpus fluviatilis* is replaced by *Typha latifolia; Spartina Michauxiana* and *Calamagrostis canadensis,* partly by Carex and Juncus, but mostly by *Agrostis alba; Panicum virgatum,* partly by *Agrostis alba and* partly by *Poa pratensis;* and *Andropogon furcatus,* entirely by *Poa pratensis.*"

It will be noted that on this prairie *Scirpus fluviatilis* is absent, but *S lineatus* is present and that only a very few plants of *Typha latifolia* were found. *Spartina Michauxiana* ranges from generally frequent to locally abundant. Three species of Carex are also present which are locally infrequent and three species of Juncus which vary from locally infrequent to abundant. *Agrostis alba* is common and quite generally distributed although never abundant. *Panicum virgatum* is frequent and *Andropogon furcatus* is generally distributed. The presence of the blue grasses, *Poa pratensis* and *Poa compressa,* which were introduced into the United States from Europe and which are of course not native to prairie, indicate a condition which can not be considered entirely natural. They are, however, reported as present in practically all prairie sod which has been studied. According to Shimek (31) *Poa pratensis* is the most successful invader of prairie soil, but it does not establish a sod to the exclusion of native plants. He further states that *P. compressa* is less frequent and usually occurs in areas that have been somewhat disturbed. *Koeleria crispus,* he says (24), is quite common on unbroken prairie, a grass which, on this tract, was found only infrequently.

The lack of dominance by *Andropogon furcatus* on this prairie is not an indication that it is being crowded out, but rather that this area is similar to the so-called Chicago prairie which Sampson (21) considers for the most part, under natural conditions, too wet for Andropogon. Low prairie, he finds, was dominated mainly by *Spartina Michauxiana, Calamagrostias canadensis,* and *Panicum virgatum.*

Sampson further states that there is an increase in the number of coarse herbs following a disturbance of natural conditions. In listing such species named by him, the F. I. of each is given for those which are present on this prairie: *Silphium lacinatum,* 12.5 to 18.8; *Calcalia tuberosa,* 3.2 to 11.9; *Liatris spicata,* 9.4, *Apocynum cannabinum* var. *hypericifolium Silphium terebinthaceum* 15.6 to 21.5, *Eryngium yuccifolium,* 18.7.

From these figures it can be seen that none of the species named could be considered abundant or dominant as in no case does the F. I. reach 25.

Concerning the presence of coarse herbs on the prairie, Sampson states, "The old writers speak of these prairies as 'a sea of grasses', and it is probable that coarse herbs did not occupy very large areas, as their presence would certainly have called forth exclamation from the men of those days." Search of the literature on prairies shows many articles from 1818 to recent dates, dealing with the origin of the prairies. Lengthy discussions are entered into, advocating one or more theories as to causes of origin and treelessness, such as fire, lakes and drainage, as well as climatic, or edaphic conditions. Little mention is made of any native plants of these areas and the first record found containing a floral list was in an article by Short (33) in 1845, followed by similar reports by Gray (12) in 1857, Allen (1) 1870, and Broadhead (5) 1875. These men list over forty characteristic species of coarse herbs which are common to this prairie, while only three grasses are mentioned, and these by Short.

Pepoon considers (16) the presence of *Baptisia bracteata* and *Polygala Senega* to be a sure evidence of virgin conditions. Squires (34) writes that Lady's tresses, Spiranthes, are found only where native sod has not been disturbed.

Gray (12) says that Compositae are the characteristic herbs of the prairie, while Allen (1) states that Compositae and Leguminosae are the prevailing families of the flora of prairies.

Short (23) writes that "Comparatively speaking there are but few plants except grasses (that are gregarious everywhere) which may be considered as indigenes of the prairie region generally." Among these he names over thirty coarse herbs that are characteristic of prairies, including three species of *Silphium,* six of *Aster,* four of *Solidago,* and several of *Liatris.*

Summary.

1. The presence of wet spots in the spring and the fall of the year, as well as the frequence of semi-marsh plants indicates that this prairie is of swamp origin.

2. Three divisions of the area have been recognized, namely: xeric, meso-xeric, and hydro-xeric. These are substantiated by soil moisture studies and by the distribution of characteristic species.

3. The amount of soil moisture in the upper twelve inches of earth, compared with the wilting coefficient, as well as the absence of true marsh plants, is evidence of the general xeric condition of this prairie.

4. Characteristic prairie plants were usually found to be generally distributed although particular instances of localization were noted, which were apparently influenced by physiographic conditions.

5. Eleven species of plants found on this prairie have not been reported from prairies in Iowa or elsewhere in Illinois, with this exception the prairie under study seems very similar in floristic content and also in physical features to those described by other investigators.

6. There were few woody plants associated with this prairie and they were chiefly limited to a narrow zone along one fence. Only three small tree species were present on the prairie proper.

7. Ruderals were present in comparatively small numbers and were of the usual type of prairie invaders.

8. The presence of certain introduced weeds determines that this prairie is not in an absolute virgin or natural state. However, the lack of dominance of ruderals and the presence of the characteristic species reported as such in all prairie floral lists, indicate that it is of a type generally regarded as native prairie. Therefore, a study of the floristic content should be of value in contributing to information concerning the fast disappearing prairie.

Acknowledgment.

I wish to express appreciation for cooperation and supervision of this problem by Dr. W. G. Waterman, and further to acknowledge the courtesy of Dr. E. E. Sherff of Chicago in identification of the grasses, and of Dr. F. J. Alway of Minnesota in the determination of the wilting coefficient of the various soil samples.

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SOME NOTES ON THE JAPANESE QUINCE

A. S. Colby, University of Illinois.

In connection with a study being made at the Illinois Agricultural Experiment Station of woody shrubs planted chiefly for the interest and beauty of their bloom, (Fig. I) but which are also of potential value for the edible qualities of their first fruit, some attention has been given to the Chaenomeles species, formerly included in Cydonia, and commonly known as the Japanese Quince. These are ornamental plants usually grown for their handsome, brightly colored flowers which appear early in the spring. Under some conditions the flowers are followed by fruits which vary in size and shape according to the species, usually yellow in color when mature, often fragrant and in some species of considerable culinary value.

In the summer of 1922 the Arnold Arboretum was visited and arrangements made whereby their cooperation was secured in a study of the fruit and plant characters of the collection of Chaenomeles species there, probably the largest extant. Grateful acknowledgment is hereby made for this cooperation.

Brief notes have been published from time to time with reference to the possible culinary value of the fruit in addition to its generally recognized value as an ornamental shrub (1 and 2). It was thought advisable, however, at this time to present a somewhat fuller, though incomplete report of the progress of the investigation carried on up to date, based upon the use of material both at the Arboretum and on the Illinois Station grounds. In Table I are listed outstanding plant and fruit characters of the Chaenomeles so far studied.

While ornamental shrubs are usually chosen for some particular plant character, such as vigor of growth, beauty of bloom, and size of individual flowers, it was found that several Japanese Quince varieties under observation were very desirable from the standpoint of the fruit produced as well. In such cases the fact was noted under remarks in Table I.

Some of the fruits are about as large as the common European market quince. They are five celled with many seeds in each cell; the shape varies from ovoid to round. They are borne on wood two or more years old, usually singly, sometimes in two's, often with a stem so short that the fruit at the stem end

FIG. 1.—Japanese Quince (Chaenomeles japonica) blossoms.

has the appearance of having partially surrounded the branch. The character of the skin surface was found to vary, as will be noted in Table I, from dry and smooth to waxy and very sticky. Where the skin was dotted the dots were more conspicuous on the side of the fruit exposed to the sun. Storage tests showed that the fruit would hold up very well in cold storage, all the varieties listed keeping in good condition for five months or more

FIG. 2.—Fruits of representative Japanese Quinces. From left to right: top row, **Chaenomeles superba atrosanguinea, C. lagenaria fructu alba;** bottom row, **C. lagenaria versicolor, C. lagenaria grandiflora.** (One-half natural size.)

at a temperature of 32 degrees F. The skin has a very pleasant odor, even filling a room with fragrance where a dish of quinces is kept for a short while.

While the fruits are very hard, even when mature, it has been known to a few that they contain considerable quantities of pectin and fruit acids and salts which make them a valuable addition to our present list of fruits available in the canning and preserving industry. The fruit (Fig. 2) of the following varieties is especially adapted to supply the needed pectin and acidulant in making aromatic jellies and conserves with apples and European quinces:

Chaenomeles lagenaria Baltzii
Chaenomeles lagenaria versicolor
Chaenomeles lagenaria columbia
Chaenomeles lagenaria semperflorens
Chaenomeles lagenaria grandiflora
Chaenomeles lagenaria nivalis
Chaenomeles lagenaria fructu alba
Chaenomeles superba atrosanguinea.

It has been learned only recently (3 and 4) that the Japanese Quince is the best commercial source of a valuable fruit acid, available without sacrificing its pectin and therefore its jelly making qualities. These investigators found that the fruit has a very high levo-malic acid content, (4.0 to 5.75 percent). Other valuable characteristics are its low sugar content, light color, and absence of citric acid. The acid present is 100 percent malic. The fact that the fruit tissues contain no starch (unlike the European Quince) makes possible the direct use of its juice with other fruits in preserving, without introducing the characteristic cloudy appearance found when the European quince is used.

The fruit has little, if any, flavor, and therefore should not be used alone. Because of its high levo-malic acid content, however, the juice can be used to advantage with fruits like the cherry, plum, quince, apricot and apple where the acid content is mainly levo-malic, but does not furnish in itself sufficient acidity to bring out all the individual fruit flavor which is present.

The Japanese Quince is a native of China and Japan, and, though introduced into this country years ago, it has not been greatly in demand nor featured as especially desirable by nurserymen. Its lack of popularity may have been partly due to its susceptibility to San Jose Scale, formerly considered one of the worst insect enemies of fruit trees and shrubs. With the recent advances in control measures since the introduction of oil sprays it has been found possible to combat the scale effectively. Again it has been the common practice to set out but one variety of the Japanese Quince where used for ornamental purposes and due probably to self-sterility little or no fruit sets. Few people, therefore, know of its possibilities as a fruiting plant.

Although the species is generally considered self-sterile, preliminary experiments begun this season at Illinois indicate that with some varieties at least such is not the case. It was found for example that *Chaenomeles lagenaria grandiflora* was self-fertile, in that flowers protected by bagging from cross-pollination set fruit.* Flowers bagged on *Chaenomeles superba atrosanguinea, Chaenomeles lagenaria Simonii,* and *Chaenomeles japonica* resulted in no fruit, although an abundance of pollen was noticed adhering to the pistils at the time the latter were receptive. It was interesting, however, to note that excepting in the case of *Chaenomeles lagenaria grandiflora* no fruit was set outside the bags, though bloom was abundant. Minimum temperatures varying from 28 to 32 degrees Fahrenheit occurred during the blooming period of the quince this season and that fact may account for the poor set, whether or not cross pollination occurred.

Although the varieties of the Japanese Quince most promising for fruit are not as yet available generally through the nursery trade, the Illinois Station has for some years acted in cooperation with the Illinois Nurserymen's Association in advising their planting. It is hoped that a supply of some of the best varieties will soon be available. In the near future it is probable that even better varieties may be found by breeding and selection. This is being attempted at the Illinois Station. In the meantime with more demand and common use it will be desirable that the most valuable varieties be given common names easier to use. It is suggested for example that *Chaenomeles lagenaria Baltzii* be known as the Baltz variety, and *Chaenomeles lagenaria columbia* be called Columbia.

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*The seeds were, for the most part abortive. [A. S. C. Dec. 27, 1928.]

TABLE I.

Some Characters of Chaenomeles.

Species	Variety	Flower		Bush		Branches	Fruit *					Remarks
		Color	Single or double	Height in feet	Spread in feet	Spines present or absent	Size in c. m. largest fruits	Shape	Color	Fragrance	Skin	
lagenaria	folius rubis	light cardinal	S	3	5	A	4.1 x 3.5	roundish sides unequal	yellow	medium	dry; dots conspicuous, small, brown, areolar	
"	atrococeinea plena	cardinal	D	5	9	P	3.5 x 2.8	round	yellowish green	heavy	slightly waxy; dots pitted or areolar	
"	nivalis	white	S	7	9	very few	4.9 x 4.4	oblong to roundish	yellow	medium	sticky, sl. waxy, dots conspicuous	desirable
"	Simonii	dark crimson	semi-double	5	7	P	3 x 2.8	obovate	greenish yellow	medium	dull, sl. waxy; dots conspicuous, areolar	
"	Baltzii	rosy pink	S	6	6	very few	4.8 x 5.3	oblong	greenish yellow faint blush	heavy	smooth, waxy; dots conspicuous ous	very desirable
"	fructu alba	white	S	3	4	few	4.6 x 4.9	oblong, sides unequal	golden yellow	heavy	sticky to waxy; dots inconspicuous	desirable

* It was necessary to pick some varieties before maturity for study. Variations in size, color and fragrance are possible under such conditions.

TABLE I.

SOME CHARACTERS OF CHAENOMELES—*Continued.*

Species	Variety	Flower		Bush		Branches	Fruit *					Remarks
		Color	Single or double	Height in feet	Spread in feet	Spines present or absent	Size in c. m. largest fruits	Shape	Color	Fragrance	Skin	
lagenaria	cardinalis	cardinal	D large	5	6	P	3.8 x 3.8	ovate	yellowish green	medium	dull pitted; dots conspicuous and areolar, many	
"	grandiflora	creamy pink	S large	6	9	P	4.8 x 5.0	ovate-oblong	yellowish green	medium	waxy; dots small, many	desirable
superba	atrosanguinea	deep red	S	3	6	P	4.3 x 5.1	ovate-pyriform	golden yellow	heavy	very sticky and waxy; dots small, areolar	very desirable
"		orange red	S	2	5	P	3.1 x 3.3	oblate to oblong some slightly pyriform	golden yellow light carmine blush	medium	dull, waxy; dots large	plant tender to winter cold
japonica		red	S	3	5	P	4 x 3.7	round	yellow with brown tinge	medium	rough, dots areolar conspicuous	commonly grown
"	alpina	red orange	S	3	4	A	3.5 x 4.4	ovate-pyriform	yellow red blush	heavy	rough, sticky; dots inconspicuous and few, areolar	desirable

* It was necessary to pick some varieties before maturity for study. Variations in size, color and fragrance are possible under such conditions.

TABLE I.

SOME CHARACTERS OF CHAENOMELES—*Continued.*

Species	Flower	Flower		Bush		Branches	Fruit *					Remarks
		Color	Single or double	Height in feet	Spread in feet	Spines present or absent	Size in c. m. largest fruits	Shape	Color	Fragrance	Skin	
"	grandiflora perfecta	creamy pink	S	5	5	P	2.6 x 2.5	ovate	yellowish green with red blush	heavy	very waxy; dots small, areolar, many	
lagenaria		cardinal	S	5	9	P	4.9 x 4.7	oblate ribbed	greenish yellow brown blotches	medium	smooth; dots conspicuous, areolar	
"	versicolor	pink	S	6	9	A	4.7 x 5.7	oblong-pyriform	greenish yellow	medium	smooth, waxy; dots small areolar	desirable
"	kermesina semiplena	rose	semi-double	6	7	P	2.6 x 5.4	oblong-obovate	yellowish green	medium	dull, rough; dots, many conspicuous; areolar	
"	moerloosii	rose	S	6	7	few	4.8 x 5.6	oblong slightly pyriform	yellowish green carmine blush	medium	smooth sl. sticky. dots conspicuous	

* It was necessary to pick some varieties before maturity for study. Variations in size, color and fragrance are possible under such conditions.

TABLE I.

SOME CHARACTERS OF CHAENOMELES.—*Continued.*

Species	Variety	Flower		Bush		Branches	Fruit *					Remarks
		Color	Single or double	Height in feet	Spread in feet	Spines present or absent	Size in c. m. largest fruits	Shape	Color	Fragrance	Skin	
lagenaria	sanguinea semiplena	cardinal	S	5	5	few	1.6 x 1.4	oblate	green	slight	smooth; dots conspicuous, reddish brown sl. areolar	
"	grandiflora semiplena	rose	semi double	5	6	P	4.8 x 4.1	oblate sl. ribbed	greenish yellow	slight to medium	waxy; dots small, many, areolar, conspicuous	
"	rosea grandiflora	rose	S	7	12	A	4.4 x 4.5	globular	yellowish green	medium	rough; dots few, conspicuous	
"	columbia	rose	S	5	5	P	4.5 x 4.7	oblong sides unequal	golden yellow	medium	sticky, waxy; dots inconspicuous, areolar	desirable
"	semperflorens	rose	S	5	6	few	4.8 x 4.8	oblong	golden yellow	heavy	waxy, sticky; dots inconspicuous	desirable fruit calyx elongated umbilicate

* It was necessary to pick some varieties before maturity for study. Variations in size, color and fragrance are possible under such conditions.

TABLE I.

SOME CHARACTERS OF CHAENOMELES.—*Concluded.*

Species	Variety	Flower		Bush		Branches	Fruit.					Remarks
		Color	Single or double	Height in feet	Spread in feet	Spines present or absent	Size in c. m. largest fruits	Shape	Color	Frangrance	Skin	
	macrocarpa	light cardinal	S	7	8	A	4.5 x 3.0	oblate	yellowish green	slight	dull; dots very large, scattered, areolar	flesh dry
"	marmorata	rose	S	5	7	very few	5.4 x 4.8	obovate sl. pyriform	greenish yellow carmine blush	medium	smooth, sl. waxy; dots many, conspicuous	
"	rosea plena	rose	D	4	4	very few	3.7 x 2.5	ovate ribbed	yellowish green	medium	dull, sticky, sl. waxy	

A METHOD OF STAINING MICROSCOPIC SLIDES FOR BEGINNING STUDENTS.

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Charleston, Illinois.

Those who teach botany and zoology know that the best material is none too good for beginning students. Advanced classes can get on with somewhat inferior material, but it is not so with beginners in these subjects. Some years ago Professor J. H. Schaffner said that he had used nigrosin in combination with picric acid for a cell wall stain with marked success, but that he did not remember the exact method. The writer has worked with this stain for several years and has found it to be excellent as a contrast stain with safranin.

The thinnest cell walls may be made visible with this stain with comparative ease; they are stained dark blue to black. The nigrosin will not fade if the picric acid is used and if the dehydrating alcohols during the staining and mounting process are made from absolute methyl alcohol (CH_3OH) C.P. and acetone-free. One of my colleagues has used this with animal tissues with excellent results.

The schedule is as follows:

Formula for stain: 1% aqueous solution of nigrosin
1% aqueous solution of picric acid C.P.
Equal parts of these solutions are mixed at the time of using.

1. Over-stain with safranin and destain until the nuclei and the lignified cells are the only ones retaining the safranin.
2. Wash with water.
3. Stain with the picro-nigrosin stain from thirty seconds to several minutes. This time varies with the material and thickness of the sections.
4. Wash in 50% alcohol (methyl, C.P. and acetone-free). In some cases the sections will clear better if a few drops of ammonia are added here. This is not often necessary.
5. Clear and mount in balsam.

A METHOD OF PRESERVING THE NATURAL COLOR OF FUNGUS.

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CHARLESTON, ILLINOIS.

Some years ago Professor Chamberlain showed some club mosses that had been preserved in glycerine with an excellent preservation of the chlorophyll. The writer has found that the color of fungi may be preserved in pure glycerine by first dipping the specimen in absolute methyl alcohol, C.P. and acetone-free. Some of this material has been in glycerine for one year and the natural color is still preserved. Leotia sp., Peziza sp. (red), cedar apple telial horns, and a red alga are plants that have been tried with this method. A colleague has preserved the color of an insect gall also by this method.

PAPERS IN CHEMISTRY AND PHYSICS

TEACHING OF COLLEGE CHEMISTRY.

W. S. Haldeman, Monmouth College.

Much has been said and written both favorably and unfavorably about the content of and the methods employed in teaching college chemistry. Probably no new suggestion may be given in this brief paper. A reference to some salient factors, however, may give us a new impetus in the effort to stimulate our students towards reasonable originality and accomplishment.

More Originality to Stimulate Interest.

With all respect for the tested and proved principles of sound pedagogy, we frequently come to places in our work both in class room instruction and laboratory direction where originality within reason is the only wise course to take. Our text may be one of the best in every way but the class may not become highly interested if the teacher merely assigns and hears the author's viewpoint from chapter to chapter. The text can and should serve as a guide but cannot take the place of the vitalizing and stimulating influence of the trained and experienced teacher. No two teachers are exactly alike and no two chemistry departments are exactly alike in their equipment and purposes. We should therefore try to be ourselves and not someone else. If formulated theories of pedagogy keep us from interesting our students, we should cut loose and try other methods, realizing that we have only one master pedagogue—the Universe with her unchangeable but fascinating laws of order, harmony and progress. The eager student will soon realize that chemistry is the science that goes at the very heart of matter and energy to discover nature's laws and applies them for the welfare and progress of man in medicine and other sciences, in the arts, and in the industries. Interest is certain to grow with the worthwhile student when he gets this viewpoint impressed upon him and sees on every hand the resultant progress of the application of these laws.

Recently Irving Langmuir, on receiving the Perkin Medal, made some remarks that we as college teachers may well consider. This is what he says in regard to interest: "In looking back on my own school and college days, it seems to me that the things of most value were learned spontaneously through interest aroused by a good teacher, while the required work was usually uninteresting." What must be some of the characteristics of a teacher so that he may be able to arouse interest? We probably all agree that, granting a good personality is included, thorough training is one of the first requisites. Thorough training is not a static condition. A teacher might be thoroughly qualified for his duties on completing his graduate work, but in a few years he might not qualify as a thoroughly competent instructor because his training was not continual. Contact with the industries in their many applications of chemistry is another requisite and will broaden our viewpoint and increase interest. Our students will benefit from our experience. This contact may be direct or indirect. The various industrial journals relating to chemistry give us this indirect contact. Visits to industrial plants during our vacations give more direct contact but best of all is the spending of some summers in the research laboratories of an industry. The research spirit is another essential for the wide awake teacher. By carrying on some form of actual research we add fresh fuel to our enthusiasm and there can be no doubt that the students will benefit because of our greater interest in the work.

Contents of College Courses.

In another part of the same speech, Langmuir says, "Our schools and universities devote so much effort in imparting information to students that they almost neglect the far more important function of teaching the student how to get for himself what knowledge of any subject he may need." Most chemistry teachers agree fairly well on a general minimum of basic principles, theories, laws and applications to be included in a college course. This general minimum content has been well discussed and summarized in the several numbers of the Journal of Chemical Education during the last two years (1926-1927). All of us can glean valuable data, get suggestions, new viewpoints and no little inspiration from a careful reading of these articles. Since the number of our students preparing for medical schools and graduate schools is increasing it is necessary to make our work fairly comprehensive and make it thorough in the fundamentals upon which later courses may be developed. College texts give a general outline of the content with varying degrees of stress on the different subjects. The individual teacher should use his own judgment as to what should be stressed or omitted or what additional work may be given or emphasized. Training to think and to do should be constantly kept in mind rather than a maximum content.

Methods.

On the whole, the lecture method, for most of our work, has been found to give good results when followed with frequent short written recitations. Hour tests are also given at stated intervals. The papers are read, mistakes noted and later these papers are returned to the student. Lecture table experiments are probably among the most effective means a chemistry teacher can use in first year work. Here we have the visual and other concrete factors to create interest. Instead of trying to master the preparation and properties of a given substance from the text, the student will learn by observation. The student will also gain some ideas of laboratory technique from the lecture table experiments.

Some subjects such as learning to write formulas and equations will require various methods—explanations, drill discussions of principles involved and quizzes to find out whether progress is made. Selected outside readings, exhibits from different chemical industries and occasional motion pictures also form a part of the first year course. A good list of these pictures on the applications of chemistry may be secured from the U. S. Bureau of Mines, Pittsburgh, Pennsylvania. The first year college course is not complete without definite laboratory work for the student. ''We learn to do by doing'' is a familiar statement. The purpose of the laboratory work is even more than this statement implies. Not only do we learn to do by intelligent doing but we actually DO laboratory work so that we may learn more and acquire power.

Whatever the content or the method in college chemistry, the teacher must be able to direct the student in the paths of reasonable theory and established facts. He should be able to instruct how to correlate facts and principles. He should thoroughly believe in his work. He should show enough enthusiasm so as to stimulate his students to the development of their powers.

THERAPEUTIC VALUES IN SOME RARE ELEMENT COMPOUNDS.

Preliminary Report.

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University of Illinois.

The therapeutic value of germanium as an erythropoietic agent was first advocated by Hammitt, Nowrey, and Müller (1), several articles appearing in the medical journals by these authors in the years 1922-5. However, their work was largely discredited by the published reports of work done by Minot and Sampson (2), by Bodansky and Hartman (3), by Alexander (4), by Kast, Kroll and Schmitz (5), and by Whipple and Robbins (6).

A review of the published articles shows (a) that experimentation was largely done upon healthy animals, or on animals made anemic by simple bleeding, (b) that only two types of germanium compounds were tried, (c) that the modes of administration to patients and to animals were quite limited whereas many modifications are possible, (d) that very little account was taken of the diet used at the time of treatment and (e) that the possibility of a germanium compound acting catalytically upon physiologic processes is suggested in only one article where it is given the rôle of an oxygen carrier (7).

Lenker (8) reports some success in the use of germanium compounds for severe anemia but, unfortunately, he found it necessary to use unsterilized solutions for injections and he gave no account of accompanying treatment or of diet. The solution was given by injection, never by mouth. He concludes that in cases of pernicious anemia GeO_2 has some value in that it prolongs life and makes the patient more comfortable.

The writer has worked upon the assumption that different compounds of germanium may differ in physiological properties and that a small dosage may produce a contrasting effect to a large one. Similar examples of such action may be noted in the use of alcohol, ether, and other drugs. Furthermore, a new drug may be expected to react differently upon a healthy animal than it will upon one that is ill.

A series of preliminary experiments were run on guinea pigs rendered anemic by disease, but in the process of recovery, and on albino rats in which anemic condition was produced by deficient diet. The medicinal values of several compounds of germanium thus tested showed marked variation. Germanium dioxide in water or in sodium hydroxide solution was given to anemic animals by mouth, or by subcutaneous injections in dosage of 1 to 2 milligrams GeO_2 per kilo body weight twice a week. Some of the compounds used were toxic to the anemic animals the treatment being followed by a decrease in red blood cells, a large increase in the white cells, and the final death of the animals. Other of the compounds given to the same type of anemic animals in dosage not to exceed 1 milligram per kilo body weight at intervals of five or seven days were found to yield a steady increase in red blood cells and the animals returned to health more rapidly than the controls. It is evident that germanium, according to its state of combination, and its method of administration to anemic animals, may act as a toxic agent injurious to the animals, or as an efficient remedial agent that aids recovery.

Some of the more beneficial compounds were tested upon anemic animals kept upon deficient diet. These showed a definite increase in red blood cells but the increase was much larger in animals on a complete diet. It is quite logical that the blood will build up more rapidly when all materials for repair are supplied. This constructive work was found to take place with greater speed in the treated animals given complete diet than in the controls given a complete diet.

Therapeutic values of arsenic have been shown to vary with diet. (9) The related compounds of germanium apparently vary in reaction in a similar way.

The fact that the blood coagulates rapidly where animals have received several large doses of germanium compound indicates some relation to the thrombin equilibrium. This in turn is dependent upon the calcium balance. It is suggested that germanium in its efficient compounds has to do with the calcium metabolism within the blood stream and the blood-forming organs. That it acts catalytically is evidenced by the small quantities necessary to bring about results. As in the case of other drugs there is a probability that several reactions take place as the result of its administration. Administered in large quantities other reactions appear paramount and the mild catalytic action obscured.

A germanium compound showing large efficiency in animals was supplied from our laboratory to several physicians for patients suffering from severe anemia. Both the secondary and the primary types of anemia were found to respond to this treatment as reported by these physicians. Several cases of pernicious anemia have been materially benefitted as shown in the following records taken from case histories. Practically all cases of secondary anemia were discharged from the hospital in normal health.

Case No. 1 is remarkable in that the patient recovered rapidly, was able to go about the house in three weeks, was driving his car in a month following the treatment and has had no relapse in two and a half years. He cannot be convinced that further laboratory tests are necessary, and says he enjoys the best health he has had in years.

Case No. 2 went back to work in July, had a short replase in August, returned to work in September (1926), and has worked continuously to the present time.

Case No. 4 had just returned home from the hospital when first taken by the physician reporting. Liver treatment prescribed by some physicians was continued while germanium treatment was added. It may be noted that whereas the highest point attained in red blood corpuscles under liver treatment alone was less than four and a half million, with the addition of germanium compound an increase of one and a half million was produced which gives confirmatory evidence of the catalytic action of the compound in anabolic processes where all necessary components are supplied.

A simple increase in red blood corpuscles in itself may not indicate a better state of health but when this is combined with other favorable symptoms recorded in practically all reports received it does give evidence of a positive value for certain compounds of germanium. The composition of these compounds provides a topic to be discussed in a later paper.

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CONDENSED CHART SHOWING INCREASE IN RED BLOOD CORPUSCLES AND HEMOGLOBIN IN CASES OF PRIMARY ANEMIA AFTER TREATMENT WITH A GERMANIUM COMPOUND.

Case No.	Date treatment began	RBC	Hemoglobin	Date of report on case	RBC	Hemoglobin	Comment
1.	Dec. 1, 1925	700,000	..	Feb. 21, 1927	....	..	"Best health in years"
2.	May 27, 1926	2,960,000	48	Feb. 3, 1927	4,520,000	83	"Works continuously"
3.	Feb. 17, 1927	2,560,000	28	April 5, 1927	4,160,000	40	"Heart action became normal"
4.	May 18, 1927	4,370,000	70	June 11, 1927	6,020,000	85	
5.	Nov. 8, 1927	2,700,000	65	Nov. 28, 1927	4,180,000	85	April 23, 1928 "These patients reported to be getting along nicely" (cases 5–7)
6.	Nov. 8, 1927	2,640,000	65	Nov. 28, 1927	4,200,000	80	
7.	Nov. 27, 1927	1,460,000	28	Dec. 31, 1927	2,710,000	58	

RECENT PROGRESS IN ILLINIUM.

L. L. Quill and B. S. Hopkins, University of Illinois.

The discovery of the element illinium, or element 61, by the American chemists, Harris, Hopkins and Yntema early in 1926, brings the list of elements discovered within the past five years to four, and brings the list of elements presumed to exist more nearly to completion. At the time Moseley discovered the relation between the frequency of any line in the X-ray spectrum of any element and its atomic number there were seven gaps in the list of the elements. The missing members of the atomic series as listed at that time were elements 43 and 75, analogues of manganese, 61, a rare earth element, 85 a halogen, 87 an alkali metal, and an element 91. Moseley assumed that celtium, a member of the rare earth group, for which Urbain claims the discovery, filled the space assigned to element 72. The present view seems to be that element 72 should be called hafnium, as discovered by Coster and Hevesy in 1923. It is not considered as a rare earth but as a homologue of titanium and zirconium. Number 91, a radioactive product of the actinium series was named protoactinium by Soddy, Hahn and Meitner in 1918. Mendeleeff's eka-manganese and dvi-manganese were announced by Noddack and Tacke and named masurium and rhenium respectively. Druce and Loring also claim priority for these latter two elements.

The most recently discovered element is the one of atomic number 61, and has been named illinium after the state and university in which the research leading to its identification was carried out. The announcement of its detection was first made in March, 1926 by Harris, Hopkins and Yntema at the chemical laboratory of the University of Illinois. Its discovery is of special interest inasmuch as the group of elements occurring between lanthanum 57 and lutecium 71, commonly called the rare earths, is now known to be complete. The rare earth group has always given difficulty when an attempt has been made to place it in the periodic table, there being no indication of the possible number of elements included in the group. Their complete chemical separation is also a matter of great difficulty. Moseley's relation between the various chemical elements was of extreme importance in defining the number of elements to be expected in this group and in stating that the missing element should occupy a position between neodymium 60 and samarium 62. This latter fact has been a guiding factor in the research carried out by the numerous investigators working with the idea of isolating element 61.

There were several lines of evidence offered as the basis for the discovery of illinium, and it may be of interest to review these very briefly. One of the problems in which the Bureau of Standards was interested was the mapping of the red and infrared regions of the spectra of all known elements, and material was furnished by the University of Illinois for this work. In the published reports on neodymium and samarium, Kiess gives about 1500 lines for each of these elements, and in addition gives the wave lengths of some 130 lines which are common to both spectra. These lines could not be identified with the spectra of any other known element, and it was suggested that these lines might be due to a new element. Concentration and isolation of the element causing these lines was then begun. Yntema carried out an X-ray analysis of the intermediate fractions of some neodymium-samarium fractions which had been through a considerable number of fractionations but the results were negative. He observed, however, five lines common to both elements in a small region of the ultra violet, while studying the arc spectra of these elements.

A better method of concentration seemed to be needed and a study of the various salts used for the fractionation of the rare earths was made. The double magnesium nitrates have solubilities which increase with increase of atomic number, and element 61 would be expected to concentrate between neodymium and samarium. James at New Hampshire has shown that when the bromates are used for fractional crystallization, the solubilities of the rare earths first show a decrease in solubility with increase of atomic number, reaching a minimum with europium and then an increase in solubility with increase of atomic number. As a result the order of crystallization is europium as the least soluble member of the series, gadolinium, samarium, illinium, terbium and neodymium. If only the neodymium-samarium rich fractions of a series of double magnesium nitrates are converted into rare earth bromates, the order of solubility is for practical purposes reversed. Harris carried out an extensive fractionation of the neodymium and samarium rich material in this way. While so doing, he observed that the absorption bands in the visible region characteristic of neodymium and samarium began to disappear in the intermediate fractions, and that at the same time a very faint line of wave length 5816Å units began to appear. Later another line at 5123Å units was observed to grow stronger in the intermediate fractions. Naturally the question arose as to whether these new lines belonged to a new element and on further study, it was decided that these lines were due to illinium.

An X-ray analysis of the material used by Harris in his work was carried out at the University of Illinois. Five determinations of the $L\alpha_1$ were obtained the values agreeing very well with the calculated value. A single determination for the Lb_2 was obtained and there was a faint indication of the Lb_2 on one plate but it was not accepted. The question always arises when an X-ray analysis of this type is carried out as to whether there are any first, second or third order lines of other elements which might conflict with those of the element in question. After careful consideration of the experimental work, it was decided that there was no conflict between the lines of these other elements and those of illinium.

That the research at the University of Illinois was not the only work being carried forward with the idea of isolating element 61 may be seen in that almost immediately after the initial announcement of the discovery by the American chemists, several papers appeared from other laboratories. Meyer, Schumacher and Kotowski were among the first to publish the results of their work upon illinium. They used the bromate and double magnesium nitrate method of separation, and were able to secure the K series lines of the new element.

Further confirmation of the discovery of illinium has been made by the admirable work of Rolla and Fernandez at the University of Florence. Working on a small amount of didymium material, which was fractionated as the double thallium sulphate, they obtained evidence for the existence of the new element by the X-ray absorption method of the K series. A description of this work, instead of being published at the time, was placed in a sealed package in the vaults of the Academy of Lincei in 1924, and the study of a larger supply of the material was begun. In the meantime the discovery was announced by the American chemists. Following this, Rolla brought forth his "Plico Suggellato" from the vaults of the Academy. Upon the basis of the information contained in this sealed packet, he claims priority for the discovery of the element and insists that it be called "florentium." His first announcement came some three months after the initial declaration of the discovery by the American chemists, Harris, Hopkins and Yntema. At the present time there is considerable of a controversy taking place in the literature as to whether the Americans or the Italians discovered illinium.

In our own country, James and Fogg at New Hampshire showed the presence of element 61 in their material. Some samples carefully prepared from the intermediate neodymium-samarium fractions secured from gadolinite, xenotime and monazite were examined by Cork at Michigan. The publication of these lines is convincing evidence of the identification of element 61.

On the other hand, there are investigators who doubt the existence of element 61, and discredit the announcements made. Professor Wilhelm Prandtl, of Munich, in reviewing the evidence given seems unwilling to be convinced. He severely criticizes the work of Harris, Hopkins and Yntema. He seems unable to attach any importance to the new absorption bands, considers the strange lines in the arc spectra as insignificant, and criticizes the X-ray analysis because a vacuum spectrograph was not used. He criticizes the work of Rolla and Fernandez in the same way, and claims that Meyer, Schumacher and Kotowski used too much of mixture, hence getting lines which could be attributed to element 61. Professor Prandtl himself has made a very careful search for several years for element 61, but all of his results were negative. He criticizes the work done upon masurium and rhenium in the same way. Auer von Welsbach claims that element 61 does not exist quoting Prandtl's work and his own.

Dr. W. A. Noyes and G. V. Hevesy have reviewed the evidence submitted and both give credit for the discovery to the American chemists Harris, Hopkins and Yntema. In the English books appearing within the past year, the element is mentioned as illinium.

Since the initial announcement of the discovery, the work of isolation of the element has been continued on a much larger scale. This research is being carried along in a number of different ways. A large quantity of monazite residues have been fractionated using the double magnesium nitrates and the bromates as the means of separation of the rare earths. Other methods of fractional crystallization, such as the perchlorates, simple nitrates, double manganese nitrates, etc. are being used.

The separation of the rare earth elements by means of fractional precipitation methods and the determination of the relative basicity of illinium is also being studied, using ammonium hydroxide and sodium nitrite as the precipitants. The separation of illinium from its neighbors by the Kendall ionic migration method, a method depending upon the variation of ionic velocity is also being tried. Considerable work is also being carried out on other ores as potential sources of illinium. Cerite, American samarskite, allanite, gadolinite, tscheffkinite, are among the ores that are being studied at the present time. There is a supply of several other rare earth ores on hand, all of which will be put through the process as soon as possible. Some research is also being carried out on a method of separation of illinium which makes use of the difference of the magnetic susceptibilities of the rare earths. The most promising methods for the separation of illinium seem to be the bromate and double magnesium nitrate methods of fractional crystallization. The determination of the relative basicity of illinium is very tedious work, although the evidence so far seems to indicate that illinium will fall between neodymium and samarium in basicity.

In addition to the actual work on the separation of the element, a study is being made of the absorption spectra of these elements in order to determine the exact conditions by means of which the absorption spectra can be depended upon as a positive means for following the process of fractionation. The X-ray apparatus for the emission spectra work has been reconstructed, and a Siegbahn vacuum spectrograph has been obtained for this work. The analysis of the various materials being used is under way at the present time.

This is, in a very brief form, the status of illinium at the present time, but the research under way at the time being should bring out much information concerning the new element within the next year or two.

Urbana, Illinois, March 24, 1928.

THE STATUS AND TRENDS OF VISUAL AIDS IN SCIENCE.

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"The greatest problem of our time is how we are to adjust ourselves with the necessary promptness to the rapidly changing conditions of life."

—Ernest Martin Hopkins, President of Dartmouth College.

In a larger and more accurate sense visual aids in science include the majority of the methods employed in science teaching at present. Specifically, the demonstration, laboratory, object study, observation, picturization and symbolization methods are all forms of visualization. It is not enough, however, to have these methods and the various combinations of them, together with adequate apparatus and equipment. Employment of the proper method at every point throughout the subject content for the most practical coordination of perceptions, conceptions, imagination and consecutive thinking is the desirable goal.

In the light of the rapid progress being made in visual aids for the classroom, I regret that at this time it will be possible to consider only the stereopticon slide, the film, and the more modern "film strip" or "still film." These three specific aids have individual as well as collective limitations. No one of them can completely supplant any of the others; yet, when properly utilized, each offers distinct advantages in the matter of creating the co-ordinations to which reference has just been made.

With reference to stereopticon slides, it is interesting to note that much has been written and said about the cost and storage space required, less about the selection of slides that may be utilized to advantage in more than one subject, less also about the use of slides in the place of more expensive museum mounts and exhibits, less in the way of information on sets available for loan and rental to those schools which are unable to buy at once all that is needed to carry out a visual aid program, less on the trifling cost and the comparative ease with which much slide material can be prepared, and still less on the many and effective uses to which this form of material may be adapted. Rightly used, however, the stereopticon is as indispensable as the microscope; in fact, one of its many uses includes adequate classroom interpretation of sketches prior to individual study of the microscopical material.

When we consider films, we note that the natural phenomena, including life processes and relationships, lend themselves to this means better than to any other except methods involving the actual object; while for the clearest conceptions of invisible actions and reactions, such as the flow of electrons, the film—through such agencies as the animated cartoon diagram—may actually be superior to the piece of apparatus or the manufacturing process in operation. In such cases and through such means, the senior high school student may properly encounter the significant aspects of his environment before he encounters those of science, as Professor Morrison[1] aptly states the case.

The field of the educational film is undergoing momentous changes from every angle. Among the contributing causes is the cost of projection equipment, film rental and expressage. More general use of visual aids will reduce the cost of equipment somewhat. Rental and expressage may be eliminated by purchase, with the added convenience of continued accessibility of material.

A second cause is that film exchanges are organized and administered for a distinctly different type of service from that demanded in educational work, except in such individual cases as the Neighborhood Film Corporation and the Educational Department of Pathe, Incorporated. Chain organizations such as extension libraries of State Educational Departments, dealing directly with schools and trading films of corresponding value with accompanying manuals in specified subject content offer one possible solution in the way of eliminating ''spot'' and ''block'' booking, both of which belong to the theatrical world and involve very exacting shipping requirements. Under this plan the school of limited means could acquire its library of meritorious films at a lower rate without impairing its general program.

Lack of organized data for individual subjects as taught is another difficulty. What is technically known as ''safety'' or ''non-inflammable'' film stock is the general educational requirement, yet there is no literature available which considers such material exclusively and which is organized to correspond

[1] Morrison, Henry C. "The Practice of Teaching in the Secondary Schools," p. 173.

to the individual subject needs. At present all such information depends largely upon special correspondence.

A fourth difficulty is that up to this time no organization has set forth film ratings or evaluations of classroom material, not even that which is available for transportation charges only. Much of the material to be had at present, even on the basis of rental, is sufficiently worthless from the standpoint of classroom needs to impede the use of the distinctly valuable contributions which are to be found in the loan, rental and purchase classes. Special departments of scientific magazines, or even societies having for their chief purpose the evaluation of such material and indicating whether it is adapted to the use of elementary, secondary, or college students would perform a distinct service in behalf of science. Lists of specific films and other visual aids indorsed by authors for use in connection with their texts would constitute most valuable appendices.

The trend in general educational film for strictly classroom use is rapidly changing from the 35 millimeter theatrical variety to the narrower 16 millimeter ''off-standard'' safety film, due to the saving in cost of equipment and materials. The rental of the latter is easily within the means of the average school. Furthermore, since the 16 millimeter educational film is used for no other purpose, except home entertainment, the organization and administration of the distribution centers can be made to serve the needs of education. The results of the Eastman research project on the use of very carefully prepared films in certain schools of some of our representative cities are being tabulated at this time. Mr. Dudley Grant Hayes, Director of Visual Aids for Cook County Schools, very recently predicted that when the results are tabulated all schools of the Cook County system will be ordered equipped with projectors for classroom work. The final favorable results may be expected to open certain new fields for educators, among them the field of educational scenario writing, which, although it is not without its special technique, has, nevertheless, certain features comparable to and seemingly almost as attractive as text book authorship.

The ''film slide'' or ''still film,'' consisting of topically arranged pictures on standard width safety film, may be used to advantage where a fixed consecutive order of illustrations can be utilized or is desired. Unit or topical previews and other presentations of subject matter, special classroom lectures where advisable, and supplementary textbook illustrations represent opportunities for its usage. Certain authors of science textbooks are now at work on the development of this type of material to supplement textual illustrations. When arranged in the same sequence as the units or topics of the texts and accompanied by the customary manuals, the film slide represents an extremely inexpensive form of visualization, one that readily permits the development of a permanent library of this kind in any school system. The development of film slides offers an opportunity to reduce to some extent the illustrative material in the textbooks, thereby lowering the cost to the publisher and the utimate purchaser—two important factors in the sale of texts. Furthermore, they make possible supplementary material between revisions of given texts and therefore may be utilized to maintain such books on the market. They are also peculiarly adapted to the limited audience as represented by the average class.

As to the use of visual aids in the immediate future, it would seem that until educators, manufacturers and producers have arrived at somewhat more definite standards; until good materials may be obtained on relatively inexpensive terms as a rule rather than an exception; and until effective teachers' courses dealing with the care and use of visual aids, with emphasis on the fundamental technique of using pictures, are required of all teachers, until such a time it would be expedient, even in the smaller systems, to have a staff member who has been trained in the administration, supervision and organization of visual aids to take charge of the work. Such a supervisor would reinforce many of the major and minor subjects of the curriculum and would be able to perform a service to both teachers and pupils that would be second to none.

All forms of visual aids should be thought of in terms of the efficiency they may bring about. Those specifically referred to here can be adapted to all general methods of science teaching, but they are particularly adapted to the lecture-demonstration method, which with its various modifications, appears to be gaining much ground as the future way of presenting introductory courses in elementary sciences. According to Anibal's carefully compiled records this method shows a saving of 93 per cent in the cost of apparatus and materials. In the event that it should come to predominate, there is reason to believe that the lessened margin of cost is sufficiently great to guarantee the utilization of the allied forms of visual aids at no greater expense than is customary for laboratory courses now.

The development of a valuable citizen resembles that of a motor car in that it properly involves efficiency in production for a competitive marketing. We have no reason to expect that, in either case, the future demand for efficiency in producer or product will be less. With such methods and devices as are now to be had (including those of visual aids) we may reasonably hope, with some patience, to reach the farther goal of obtaining for the student a maximum amount of training in a minimum amount of time with the least amount of expended energy, all of which seem to be a very practical attainment.

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THE SPECTRA OF BORON.

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The element Boron occupies an interesting place in the periodic table. With an atomic number of 5, it is the simplest atom with 3 valence electrons. The spectrum of neutral boron, then should throw considerable light on the spectra of other atoms with 3 valence electrons, e. g. Al, Sc, C^+, Si^+, N^{++}, P^{++}, O^{+++}, S^{+++}, F^{++++}, etc. The spectrum of ionized Boron (B II) should be similar in many respects to that of Be I and Al II, both of which have been investigated in this laboratory. In the spark, we should also expect the spectrum of B III (B^{++}) which should resemble Li I, Be II and Al III.

In spite of its importance, very little work has been done on the spectra of boron. First of all, pure boron is extremely hard to prepare. Boron is fairly easy to prepare by Moissan's method, but it still contains more than 5% of oxygen, as well as other impurities. This material is a brown powder, very light, and its spectrum hard to excite. It is an extremely poor conductor, and hard to fuse. For this reason its spark spectrum has only recently been investigated. In this present investigation we are attempting to prepare some pure boron, and to measure its spectra in the arc, spark and vacuum spark.

First of all, a quantity of boron was prepared by Moissan's method. Boric acid (H_2BO_3) was fused, and fused B_2O_3 resulted. This was crushed and ground to a powder, mixed with one-third of its weight of magnesium powder, and fused. At about 900°C. a reaction took place whereby the B_2O_3 was reduced, and a mixture of free boron and magnesium borates, and borides was formed. In all about 30 Kg. of boric was used, and 20 Kg. of crude fusion was obtained. All this work was done in the Ceramics laboratory of the University of Illinois, for which grateful acknowledgment is made.

The crude fusion was next digested with hydrochloric acid. This decomposed the borides and borates, giving boric acid, and leaving the boron. The material was filtered through an alundum filter plate in a 6 in. Buchner funnel. Some difficulty was found in getting an acid proof cement to fix the plate into the funnel. Melted sulphur was finally poured in and with this cement strong boiling hydrochloric acid solutions were successfully filtered. The material was washed a number of times with acid, finally with water, and then dried in an oven. The yield was 1300 g. of good boron. This is perhaps the largest quantity ever prepared of this element.

This boron is being used as a starting point for the preparation of pure boron. The boron is put into a combustion tube, dried at a red heat in a current of hydrogen, and then chlorine is passed over it. The chlorine burns the boron to $B\ Cl_3$ which is condensed at a low temperature. The chloride is then carefully distilled in a three column atomic weight still, to get pure $B\ Cl_3$. This is mixed with pure hydrogen and passed over a hot tungsten wire, where boron is formed on the wire. Boron prepared by this method consists of beautiful, hard, gray crystals.

In the meantime, some spectrographic work was done using the powdered boron prepared by Moissan's method. Arc photographs were taken with a copper arc loaded with powdered boron. The characteristic boron arc only appeared after the arc had been running long enough to secure high temperature, when the copper and boron appeared to alloy forming a substance which when cool was a rich plum color, very hard and brittle. With 5 or 6 amperes and 210 volts D. C. a very brilliant and very white light, requiring but a fraction of the exposure time for the copper arc, was obtained. A piece of the same copper rod was used for a comparison arc.

Electrodes for the spark spectrum were made by a similar process, using small hollow copper cylinders filled with boron powder. As the copper walls melted down the boron reaching a white heat sintered leaving a cone shaped tip capable of withstanding the shock of the high tension spark.

The photographs were taken with a Hilger El quartz spectrograph, using Cramer's Contrast plates. In the region 2000-2500Å the plates were oiled with Nujol. The spark was a condensed discharge from a 4.5 K.W. 63000 volt Thoraisen transformer. The electrodes were placed 0.5 cm. apart with a 10 cm. gap in series. Both the arc and spark were photographed from 2050Å to 5200Å, and from 4500 to 6680Å; glass parts and Ilford Panchromatic plates being used in the latter range.

Both line and band spectra were obtained and lines due to suspected impurities such as magnesium were observed.

Grateful acknowledgments are due Prof. R. F. Paton, under whose direction this work was done.

HIGH VACUUM TECHNIQUE.

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The ever increasing use of high vacua in research and in the industries has given an added impetus to pump design. The Toepler mercury vacuum pump designed some fifty years ago and modified by various research workers was the most satisfactory means of producing a high vacuum until Gaede[1] in 1905 began his well known researches. These researches[2] in 1915 culminated in his mercury-vapor diffusion pump which formed (and still is) the basis of our present efficient mercury-vapor condensation pumps. Langmuir[3] in 1916 was the first to add this condensation feature by external water cooling. The speed of exhaustion and the degree of vacuum attainable were thus very much improved.

Mercury-vapor pumps require a supporting or fore-pump. The degree of exhaustion required of the fore-pump is determined by the nozzle design of the mercury-vapor pump. If a high speed of exhaustion is required then the throat or nozzle must be large. This in turn will require a fore or backing pump capable of producing a high vacuum—of the order of .01 to .001 mm. of mercury. On the other hand if the speed is secondary then a small nozzle may be employed and the pump will function on a less efficient backing pump. Mercury-vapor pumps have been designed that work satisfactorily against a backing pressure of 20 mm. of mercury.

By placing two mercury-vapor pumps in series high speeds of exhaustion may be retained even at a considerable backing pressure. When the two pumps are built as one piece and fed by the same boiler the resulting construction is spoken of as a two-stage pump. Pumps having three or even four stages are now on the market.

Following closely upon the publication of the article descriptive of the Langmuir pump, referred to above, it is interesting to note that most every laboratory possessing glass-blowing facilities undertook the construction of mercury-vapor pumps. Successful blowing was at first beset by many difficulties, how-

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[1] Phys. Zeitschr., 6, 758, 1905.
[2] Ann. d. Phys. 46, 374, 1915.
[3] Gen. Electric Rev., 19, p. 1060, 1916.

ever, with the appearance of Pyrex glass the task became comparatively easy. This activity on the part of novices in glass-blowing (and veterans as well) resulted in many designs of mercury-vapor pumps—some exceedingly simple and inexpensive, others especially those having two or more stages, quite complex and costly.

Our own efforts[4] along this line began in 1917 when two designs were drawn up and their construction of common soda glass undertaken. The attempt was only partially successful. The following year Pyrex glass was employed and further glass-blowing difficulties were no longer encountered. The first pump blown in this laboratory was an umbrella type having an annular nozzle. Figure 1 shows this pump as it is blown at the present time. It differs from the original as designed in 1917 only in that the branch A is now fused *through the* water-jacket (as shown in Fig. 1) instead of below it. The branch A is attached to the force-pump, and B to the vessel to be exhausted. This type of pump is exceedingly simple and quite rapid. Since the annular nozzle is large this pump requires a rather good fore-pump—one that will produce a vacuum of about .01 mm. of mercury. Its action is evident from a study of Fig. 1. The second design was an upward vertical nozzle type (no figure). This type is also still in use. It is even more simple in design and operation than the umbrella type. In it the nozzle is placed near the lower end of the water-jacket. This requires that A and B be interchanged. The condensed mercury-vapor finds its way back to the boiler by trickling down past the nozzle and on through the capillary opening which serves as a valve (shown at bottom of chimney on left side, Fig. 1). Upward vertical nozzle types of pumps are successful only when the nozzle is large and there is plenty of clearance for the return of the mercury globules.

Two other interesting and newly designed forms of pumps, that we have recently constructed, are shown in Figs. 2 and 3. These have *internal* water cooling, to distinguish them from external cooling as in Fig. 1. The nipples for making the water connections are shown. Fig. 2 is a single stage pump, while Fig. 3 is a two-stage pump.

In Fig. 2 the mercury vapor issuing from the hot mercury surface passes up along the main tube next to the outside wall

[4] Phys. Rev., II, 9, Apr. 1917; Science, Feb. 17, 1922.

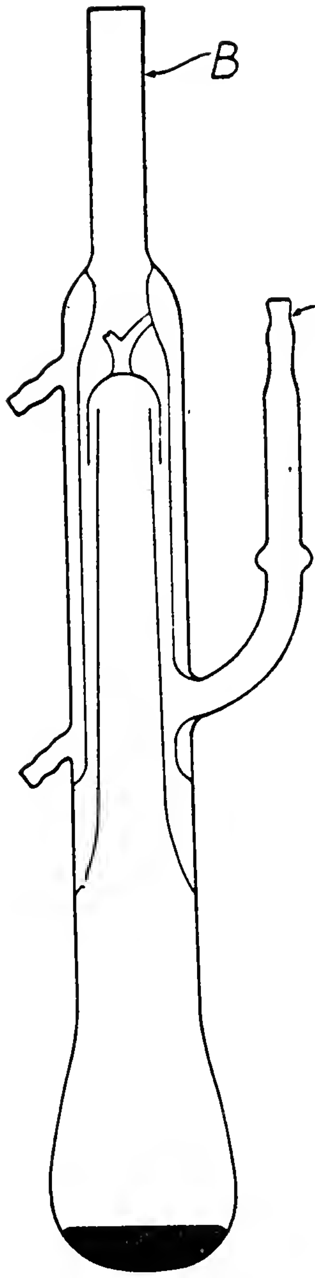


FIG. 1.

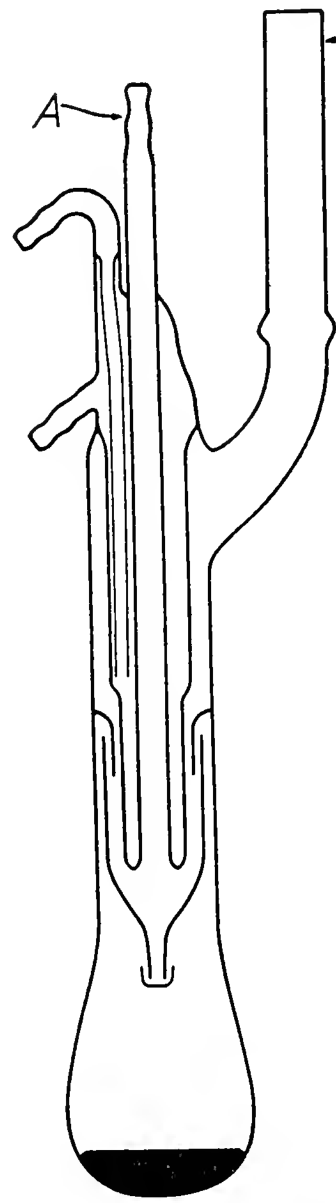


FIG. 2.

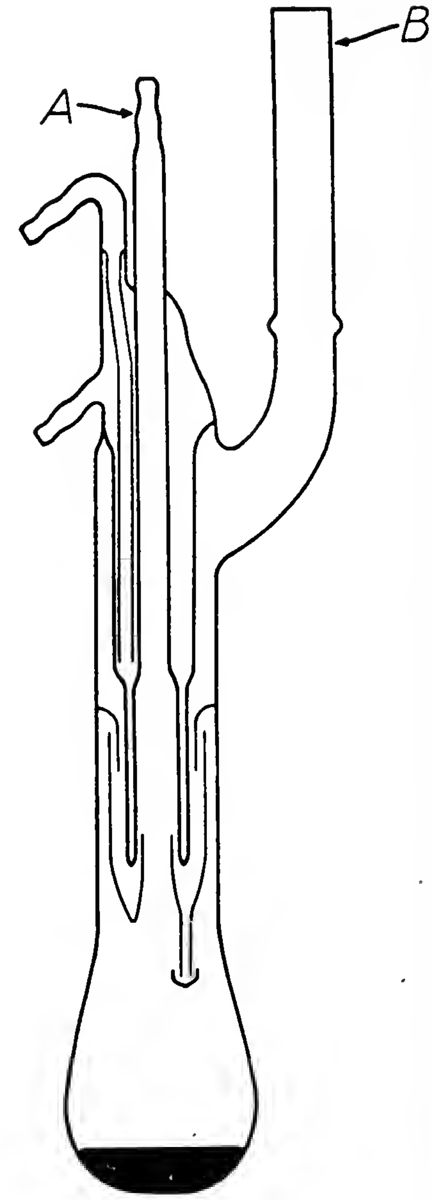


FIG. 3.

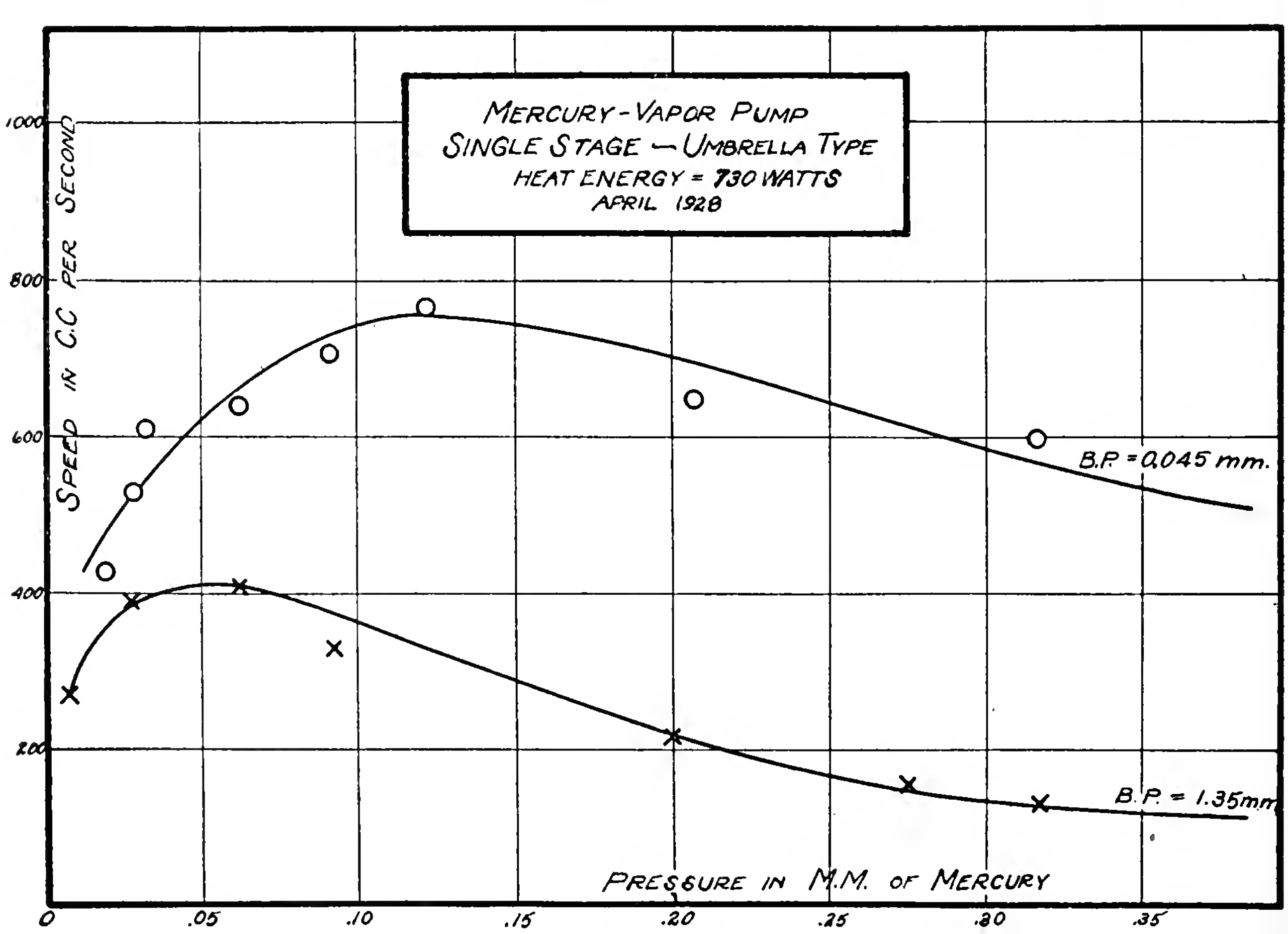


FIG. 4.

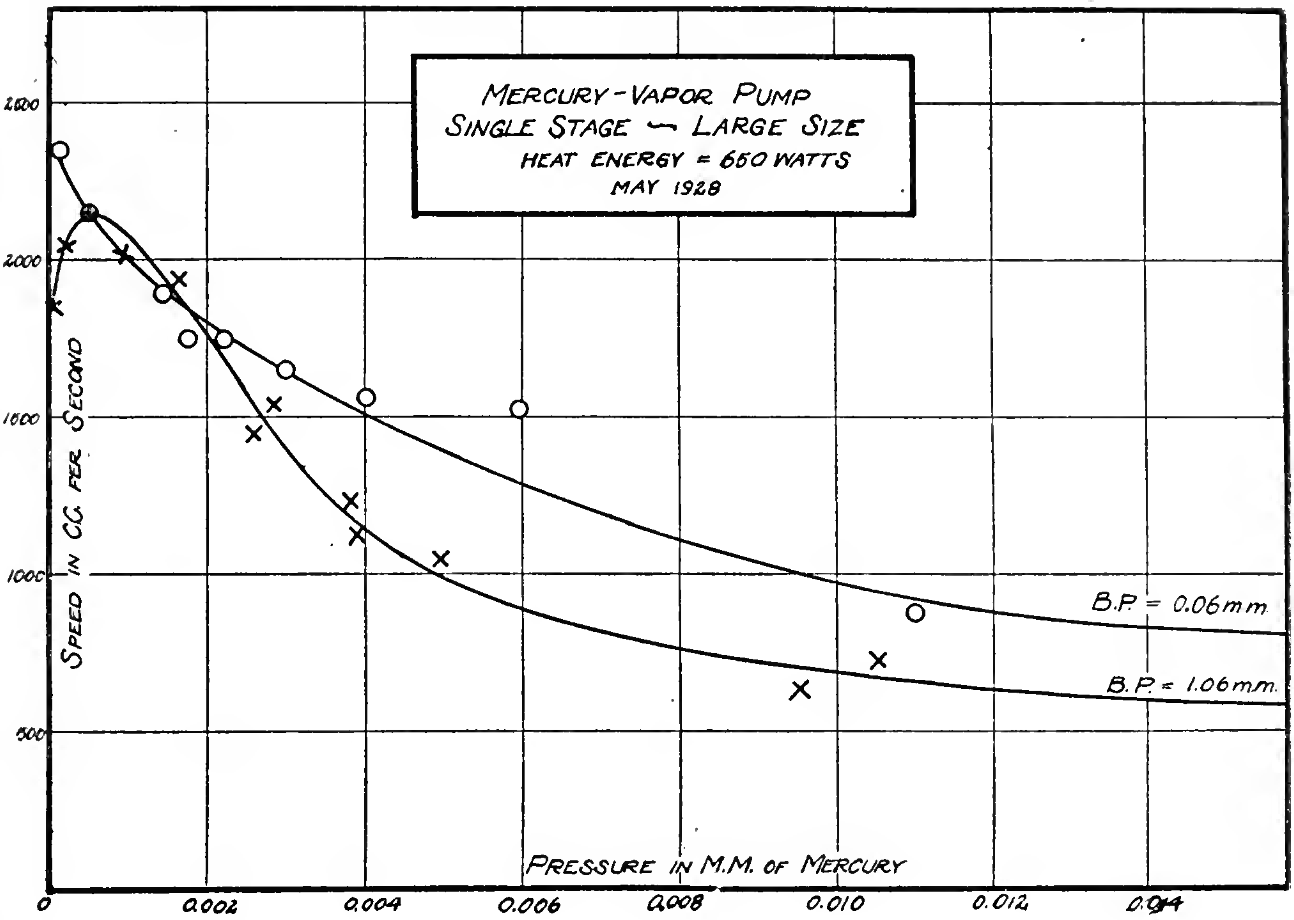

MERCURY-VAPOR PUMP
SINGLE STAGE — LARGE SIZE
HEAT ENERGY = 650 WATTS
MAY 1928
SPEED IN C.C. PER SECOND
PRESSURE IN M.M. OF MERCURY
B.P. = 0.06 mm
B.P. = 1.06 mm.
0
0.002
0.004
0.006
0.008
0.010
0.012
0.014
500
1000
1500
2000
2500

FIG. 5.

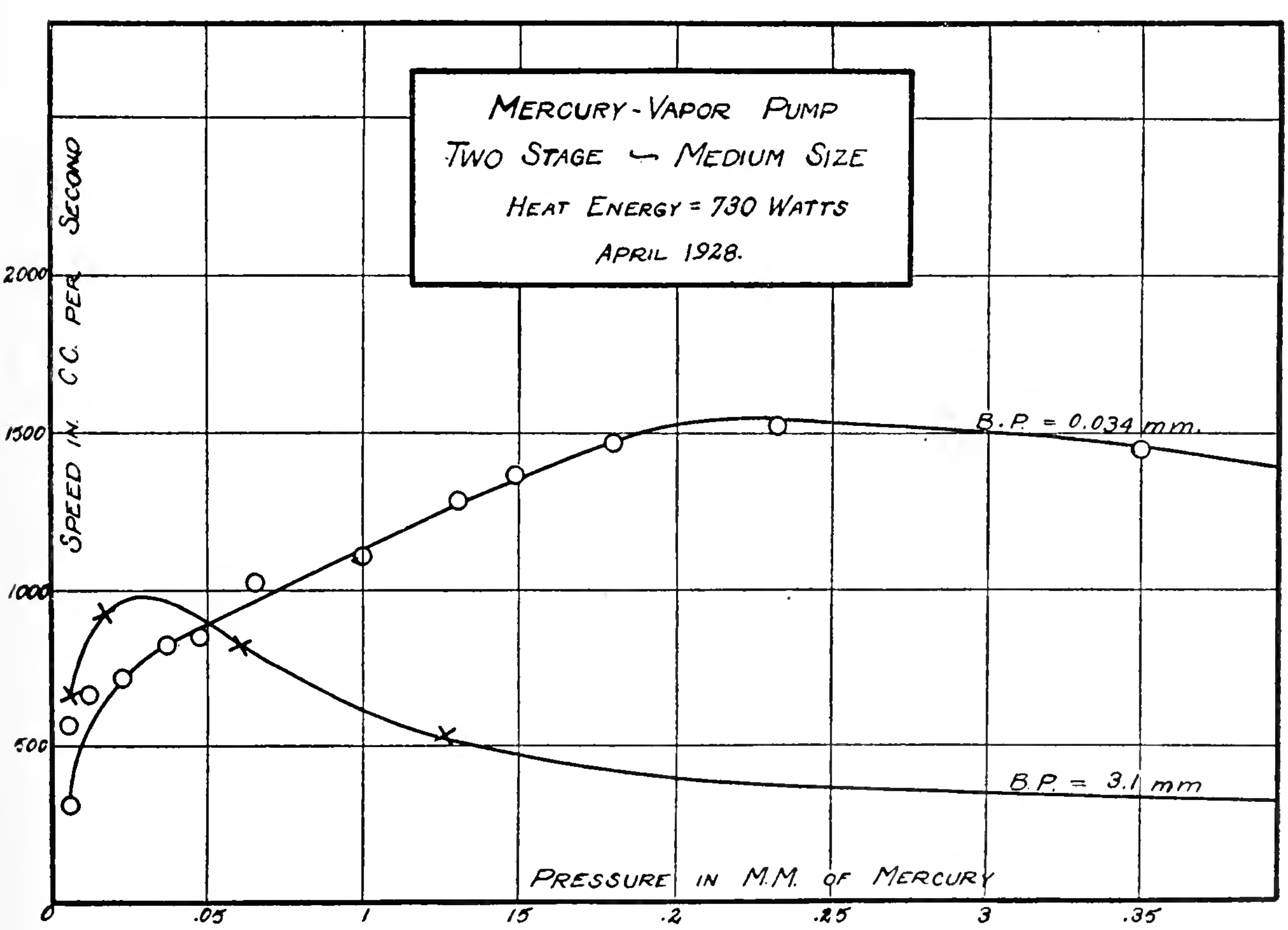

MERCURY-VAPOR PUMP
TWO STAGE — MEDIUM SIZE
HEAT ENERGY = 730 WATTS
APRIL 1928.
SPEED IN C.C. PER SECOND
PRESSURE IN M.M. OF MERCURY
B.P. = 0.034 mm.
B.P. = 3.1 mm
0
.05
.1
.15
.2
.25
.3
.35
500
1000
1500
2000

FIG. 6.

and is turned down by the collar which forms the annular nozzle. This construction is in its action similar to the umbrella of Fig. 1. The air is drawn in through B. The hot mercury-vapor encounters the water-cooled annular tube within, is condensed, and trickles back to the boiler through the suspended cup valve shown in Fig. 2. The accumulated air is drawn out through A. This pump is more complex in its construction, however, it is also more rapid in its action. This is evident from a study of the curves shown farther on.

In the two-stage pump (Fig. 3) the stage with the large annular nozzle is the same as the single stage of Fig. 2. The other is formed by an upward vertical nozzle placed at the lower end and within the inner water-cooling system. It is customary to number the stages in ascending order of size of nozzles. Thus the vertical nozzle (Fig. 3) becomes the first stage and the large annular nozzle the second stage.

The action of these pumps is understood readily by a study of Figs. 1, 2, and 3. In order to make a quantitative study of any given pump it is necessary to determine its speed of exhaustion under varying conditions of pressure and fore-pump or backing support. This was done by the mercury-pellet method[5] used at the National Physical Laboratory, Teddington, England. By speed of exhaustion is meant the number of cc. of air delivered by the mercury-vapor pump at the given pressure at which the pump is working and under definite conditions of fore-pump support. A series of pump speeds was thus measured for, say, two different backing pressures, first when the fore-pump operated at a pressure of about .04 mm. of mercury, and second, with the fore-pump vented and thus operating at a pressure of, say, from 1 to 4 mm. of mercury, depending on the nozzle construction of the particular mercury vapor pump under test. Thus for a given backing pressure of the fore-pump the needle valve is adjusted to give a minute constant leak. The mercury-vapor pump is allowed to evacuate the vessel against this leak. An observation is now made on pump speed (by the mercury-pellet method referred to above), the rate of leak is then adjusted to a new value and the speed determined again, and so on over the entire range.

Figs. 4, 5, and 6 are graphical representations of pump speeds of the pumps shown in Figs. 1, 2 and 3 respectively.

[5] High Vacua, Kaye, Longmans Green & Co., Ltd., 1927.

Measurements of speeds for a given pump were made as outlined above over a considerable range for two different backing pressures (marked BP on the graphs.) The heat energy supplied to the boiler of the pump under test was kept constant. The speeds in cc. per second are shown plotted against the corresponding pressures in mm. of mercury.

The data for the umbrella type of pump shown in Fig. 1, when graphed, are shown in Fig. 4. The upper curve is for a backing pressure (B.P.) of .045 mm. of mercury. The speed of exhaustion rose rapidly from a value of about 400 cc. per second when pumping at a constant exhaustion pressure of .005 mm. of mercury, to a maximum of nearly 800 cc. per second when pumping at a constant pressure of about .13 mm. of mercury. The lower curve shows the corresponding speeds when the backing pressure was raised to 1.3 mm. of mercury. In this case the maximum speed was 400 cc. per second, and was reached when the pump was working at a lower degree of exhaustion, i. e., at about .05 mm. of mercury.

The curves shown in Fig. 5 are for the pump sketched in Fig. 2. This is a new design evolved in the physics department, University of Illinois, and has surprising characteristics. It has internal water cooling, as previously stated. This particular pump is one of the largest that we have thus far blown. The outside diameter at the nozzle is 60 mm., the nozzle diameter 40 mm., and the area of the annular jet is 2.5 sq. cm. To reduce the air friction to a minimum the diameter of B was made 40 mm. By reference to the graphs (Fig. 5) it is evident that this pump works, at high degrees of exhaustion, at approximately equal speeds whether the backing pressure is .06 mm. or 1.06 mm. of mercury. This large range is a desirable feature, for it is no longer necessary that the fore-pump be one of high efficiency. This pump is also characterized by a high speed of exhaustion.

Finally, in Fig. 6 are shown the characteristics of the two-stage pump sketched in Fig. 3. The step in design in going from that in Fig. 2 to that in Fig. 3 is exceedingly simple. The extra stage is on the *inside* lower end of the internal water cooling system. This pump is also a new creation designed and blown in our laboratory. Two-stage pumps are primarily designed to operate on higher backing pressures. By reason of the two stages they are inherently slower in exhaustion than are single stage pumps. The two curves in Fig. 6 are self-explanatory, suffice to remark that this pump works satisfactorily on a B.P. of 3.1 mm. of mercury.

From the foregoing data it appears that for high speeds of exhaustion the design shown in Fig. 2 has promising possibilities. By increasing the size of the annular nozzle, and the other parts in proportion, a pump of exceedingly high speed should result, without exceeding the limit of any usually available fore-pumps. Pumps of extreme speed are of the utmost importance in certain researches. The two-stage pump described has possibilities of working satisfactorily on high backing pressure, approaching that of an ordinary aspirator commonly used for rough vacuum work.

The writer takes this opportunity to express his appreciation to P. C. Ludolph, graduate student in General Engineering Physics, for his skill in making the observations.

THE HYDROGEN-ION CONCENTRATION OF BLOOMINGTON WATER, NORMAL WATER, AND OF BLOOMINGTON-NORMAL SEWAGE DURING THE PRESENT SCHOOL YEAR.

H. W. ADAMS AND DON TARVIN, BLOOMINGTON, ILLINOIS.

In connection with the new Bloomington-Normal sewage treatment plant it was deemed advisable to determine and record variations in the pH values, or hydrogen-ion concentrations, of Bloomington water, Normal water, and Bloomington-Normal raw sewage during the present school year. The determinations covered a period of about six months extending from October 11, 1927, to March 31, 1928, and were made at intervals of about seven to ten days throughout that time. Determinations were made by the colorimetric method, using La Motte standards. Corrections were made for turbidity and coloring of sewage.

Tests were made at three places, involving four points, namely, (1) where water is pumped from the ground into the reservoir at the Bloomington Water Works, (2) where water is pumped from the reservoir into the city mains at the Bloomington Water Works, (3) where water is pumped from the reservoir into the city mains at the Normal Water Works, and (4) at the point where the combined sewage of the two cities flows from an intercepting sewer into a small stream known as a branch of Sugar Creek. In other words, tests were made at two points at the Bloomington Water Works and at one point each at the Normal Water Works and at the outlet of the Bloomington-Normal intercepting sewer.

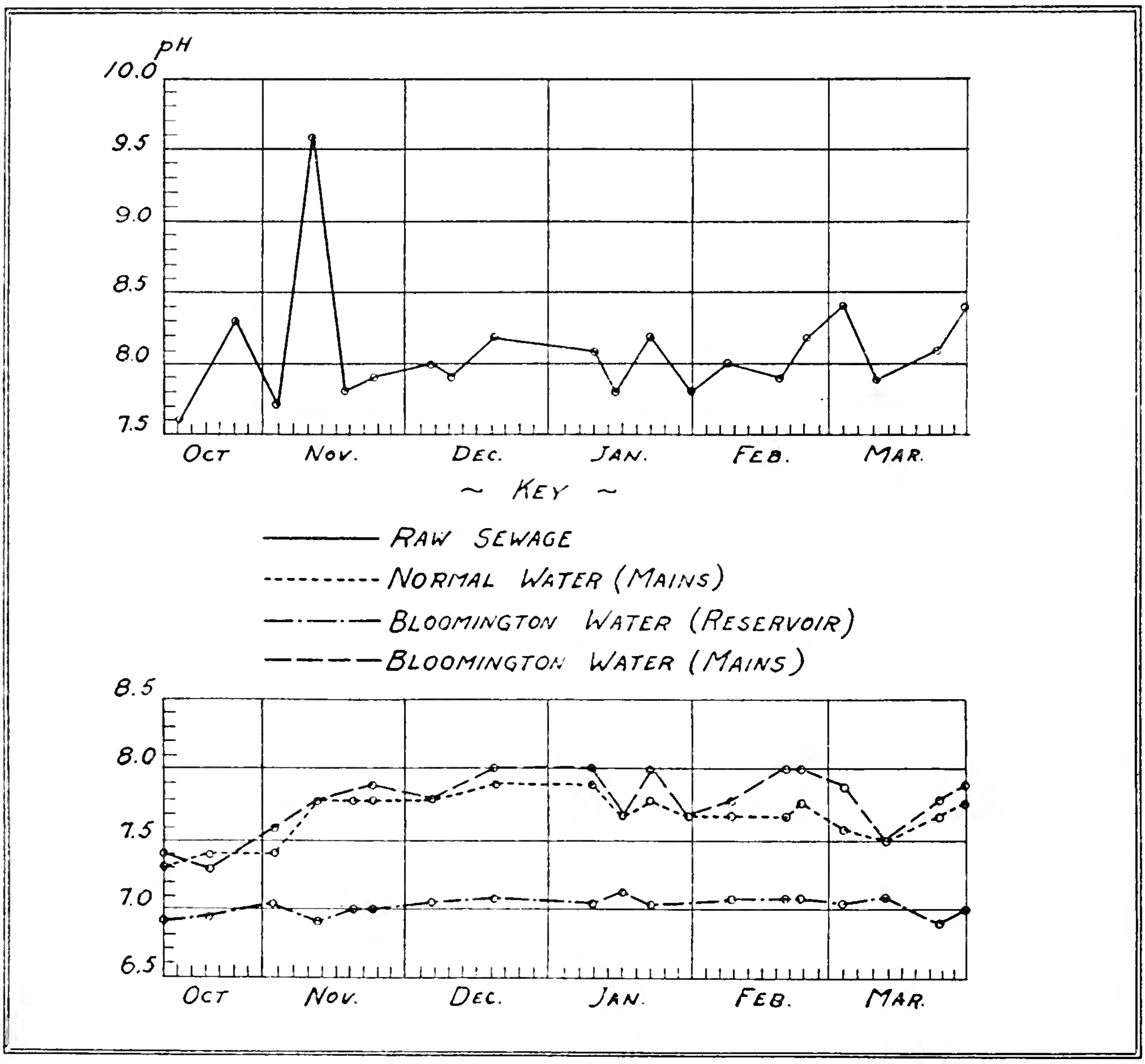
The data obtained are shown on the graph. Using pH values as ordinates and days of the month as abscissas four curves were plotted. The graph shows the following things to be evident:

1. Bloomington water at the point where it issues from the ground is practically neutral. The curve varies from 6.9 to 7.15.

2. Bloomington and Normal waters, at the point where they are pumped from the reservoir into the city mains, and combined Bloomington-Normal raw sewage have pH values which show them to be alkaline. These values are fairly constant.

3. Bloomington water, at the point where it is pumped from the reservoir into the mains is slightly more alkaline than Normal water at the point where it is pumped from the reservoir into the mains. The pH values range from 7.3 to 7.9 in the case of Normal water and from 7.4 to 8.0 in the case of Bloomigton water. pH values of the two waters were the same in five instances.

4. The curves of the pH values of Bloomington water at the mains, Normal water at the mains, and of combined Bloom-



ington-Normal raw sewage lie relatively close together when these values are plotted on a graph, the correlation between pH values of sewage and water being greatest in the case of the curve for the raw sewage and the curve for Bloomington water at the mains.

5. Of all the curves there is greatest fluctuation in the curve of pH values of sewage.

6. There seems to be some correlation between pH values of Bloomington and Normal waters and the season of the year.

Inasmuch as the waters under consideration are highly buffered, and since both waters and sewage show fairly constant alkaline pH values, it is inferred that digestion of sludge should take place nicely in the Bloomington Imhoff tanks with little necessity for addition of lime to the sewage which they will contain.

THE PRESENT STATUS OF SCIENCE IN CENTRAL EUROPE.

PAUL NEUREITER, WESTERN ILLINOIS STATE TEACHERS' COLLEGE, MACOMB.

Our machine age produced by science is of such marvelous character that we are filled with pride when we review our achievements. But our satisfaction is considerably reduced by an investigation into the nature of the raw materials which we are using in this era of the engine. Regretfully we have to admit that our industrial system stands in opposition to the dictates of geochemistry. We are exploiting those raw stuffs which are the most precious because they are the rarest and make comparatively little use of those which are furnished by nature in abundance. Our supply of metals is a good illustration. We chiefly rely on the heavy metals, but copper for instance constitutes only one hundredth of a percent of the earth's crust, lead and zinc less than a thousandth of a percent of the earth's crust, and tin is even scarcer than that. In contrast to these elements aluminum and silicon occur plentifully, but are utilized in an inadequate measure.

In no part of the world have these undesirable circumstances been realized to so full an extent and by so large a public as in Central Europe since the time of the world war. By Central Europe I mean Germany, Austria and Czechoslovakia. Had it not been for the German chemists Germany would have lost the war in 1915 instead of in 1918. In 1913 Germany imported 800,000 tons of nitrates from Chile. When in consequence of the sea blockade effected by the British navy, all importation was completely cut off, Germany proceeded to produce her own nitrates from the nitrogen of the air, and was so successful in doing so that at present she exports nitrates.

But the problem of an economically sound selection of raw stuffs has become the great problem of German science since the days of the armistice. The country faces the question: How can a population of 65 million souls be supported on a territory that is considerably smaller than the state of Texas, is deficient in many important resources and does not derive any income from colonial possessions? The answer was given by German scientists within the last ten years.

1. Endeavours must be made to shift a large section of the manufacturing system from the basis of raw stuffs of foreign origin over to those which can be obtained bountifully at home.

2. Scientific methods must be devised to the effect of re-enhancing the agricultural production.

3. A great many of the German industries fall under the classification of refineries. Partly manufactured materials are brought from foreign countries, then finished in Germany and re-exported. This kind of industry depends on the superiority of workmanship. So long as the refining processes are better by reason of their sound scientific foundation than they can be designed abroad, this manufacture is able to exist. As soon as the foreign suppliers of partly manufactured materials are technically prepared and find it economically feasible to finish their own goods equally well and as efficiently as Germany, this phase of German industry is bound to disappear.

These three postulates have been formed by the scientists of Germany and the other Central European countries, Austria and Czechoslovakia, which have to face the same problems with the purpose of remedying the precarious economic conditions. They are the expression of a situation that is unique in the world's history. If we say that Great Britain depends on her commerce and naval preponderance, Russia on her agriculture, Switzerland and Italy on their tourists' trade, we have to conceive that Germany's fate depends on science.

Germany is fortunate in having industrialists who, on the whole, have been awake to the peculiar conditions described. So a number of advances have been made along the line of an increased utilization of domestic resources. A list of the new processes which are carried through on a large and commercial scale would include the following:

1. Nitrogen and ammonia from air and water.

2. Sulfur compounds from gypsum and kieserite.

3. Acetic acid, ethyl alcohol, acetone, from coal, lime and water, through acetylene.

4. Glycerol by fermentation of glucose; glucose from sawdust.

5. Paraffins which can be oxidized to fatty acids from lignite, leading to soaps and fats.

6. Methyl alcohol from carbon monoxide and hydrogen.

7. Gasoline and oils from lignite.

In addition there are several processes which have not yet been commercialized on a large scale, but are being investigated with promising results: Synthesis of rubber, camphor, albumens, and resins.

Research work is being devoted to a method of producing aluminum from aluminum silicates instead of from bauxite which is not found in Germany.

With regard to the improvements in agriculture appreciable results have been obtained. Fortunately Germany possesses the largest known deposits of potassium salts in the world. The potassium fertilizer industry is under control of a powerful trust which has recently submitted all its plants to a radical process of reorganization by way of which a great many small plants with lesser efficiency were shut down and the production concentrated in the largest plants of greatest technical perfection.

This potassium trust produces 75 per cent of the world's supply with a yearly output of 5 million tons. The German trust has concluded an agreement with the potassium industry of Alsace-Lorraine, now under French control, with the result that the two trusts combined have a monopoly of 95 per cent of the world's supply of Potassium fertilizers. From the scientist's view-point it is noteworthy that one clause of the agreement which was emphasised by both parties dealt with the cooperation in the field of scientific research. This intensified industry enables the furnishing of a product that is within the reach of the agriculturist. In addition to the potassium fertilizers, sulfates are available at a reasonable price. According to German data the average German farmer is able to produce on a given plot of land 2.1 times as much wheat, 1.8 times as much rye and twice as many bushels of potatoes as the average American farmer. In addition to the advances in scientific fertilization science has also combated plant and animal pests.

The outlook for the refining industries is less hopeful. On account of labour troubles efficiency and workmanship have been below the standard of pre-war times. What is more important, the other nations are developing their own manufactures in fields in which they did not compete before the war. This is particularly true with regard to chemical industry. The German share in the production of chemical goods all over the world has dropped from 24% before the war to 17% after the war, or from 1/4 to 1/6. It is not without concern that Germany watches the rise of the American chemical industry. One of the captains of the corporations addressed an assembly of scientists and industrialists with the following words, "In chemistry we are still ahead of the other nations, but how long is this superiority going to last? Probably in ten or fifteen years they will have come up to our level." No doubt, serious danger is impending which to avert Germany will have to gain in the diplomatic field what she loses in the commercial one.

Considering the breakdown of the economic life at the end of the war, the moral catastrophy following the revolution, the labour turmoils, the occupation of the Ruhr district and the destruction of the State finances, it must be said that the present status of science is still remarkably high, and it is worth while for the scientists in the rest of the world to consider the efforts which have been made successfully to relieve science from the static condition into which it was thrown immediately following the war.

In 1920, the situation seemed most precarious. It was particularly the universities and polytechnical schools and state supported research institutions which depending on the government were almost compelled to stop their work on account of lack of financial support. An Emergency League of German Science was formed with a leading politician as its president, and Professor Haber, the inventor of the ammonia process, as its executive secretary. It consisted of 20 committees of experts from the various fields of science and chemistry, who were elected by the faculties of all the universities, polytechnical schools and academies of science. Representatives of this society appeared before a committee of the 'Reichstag', the German national assembly, and pleaded their cause. The Reichstag made an appropriation of twenty million marks for science relief and requested the individual states of Germany to do likewise. Financial backing was also obtained from the industrial corporations, an effective campaign was carried on in domestic and foreign papers which resulted in much valuable aid being received especially from the U. S. The 20 committees of experts which composed the League had to consider the requests of the research workers for appropriations. It was not the intention of the organization to give financial backing to the universities in general, but to allot varying amounts to certain scientists with the purpose of enabling them to carry on some particular investigations. With regard to the kind of investigation, it has always been the policy of the scientists as well as the industrialists to encourage all research work, regardless of its immediate practical value.

The activity of the Emergency League was of special benefit to science enabling it to weather the stormy period of the inflation of the currency.

Judging from the indications of the recent progress toward economic recovery in Central Europe the future of science may be regarded as optimistic. This is evidenced by the relatively great number of institutions outside of the universities, devoted to highly specialized fields of research and furthermore by the scientific periodical literature of which there are 155 publications listed in the American chemical abstracts as compared with 170 for the U. S. and 90 for Great Britain. To no small extent this is due to the intense and sincere interest which the public at large takes in scientific questions; hence a favorable vote is obtained when requests are made for the appropriation of state funds for scientific purposes.

PHYSICS FOR THE PRE-MEDIC STUDENT.

W. C. Hawthorne, Crane Junior College, Chicago, Illinois.

The time has passed when an argument for the position of physics in the pre-medic curriculum deserves a place on any program. That question has long since been settled. But the kind of physics to be taught may still be discussed with profit.

Since my first class of pre-medic students, I have been more and more of the opinion that the subject should be presented to them in a far different way than to a class of engineers. This notion was strengthened when I took a review course at the University in a class composed of pre-medics, and noted their reactions to the subject and to the method of presentation. The subject did not interest them for they saw no possible means of connecting it with their future work. The method of presentation antagonized them, for it was so different from the method of approach used in the sciences they had already studied that they could not easily orient themselves.

But when I broached to my fellow teachers the idea that pre-medics should be taught in a class by themselves and given a modified course, it was immediately assumed that "modified" meant "weakened" and the idea vigorously opposed. I am glad to think that opposition is much less pronounced now.

That medical students dislike the dose we are supposed to hand them is quite understandable if we consider the vehicle in which the drug is administered. The traditional course in physics grew up in connection with the study of engineering problems, and in the continual effort to make it interesting, illustrations, problems and applications were drawn from engineering work. What wonder that men looking forward to a study of the most intricate piece of mechanism known should fail to get enthusiastic over equations and diagrams and laws whose only application, as far as they were shown, was to inanimate assemblages of leather, wood and metal? Long after the principle of transfer of training had been discredited by psychologists, we continued to base our training upon it, and to assume that the man who had learned to use levers in the laboratory could, years afterward, calculate the strain on the gastrocnemial muscle. I could cite absurd solutions of this very problem in standard college physiologies to show the error of this assumption.

Let us admit at once that the teacher of physics should teach physics. He should not teach an emasculated subject, nor selected topics only. He should not attempt to teach physiology. But he should be familiar enough with a good modern textbook of physiology to get from it abundant illustrative material for the subject he is teaching. It goes without saying that without interest on the part of the student nothing will be taught. And the one thing that the medical student is interested in above all others is the functioning of the animal body. Why not vivify the study of physics, then, by calling his attention to the debt he will be under, as he goes on with his medical course, to the work of the physicists? To mention only a few items: the microscope, the cystoscope, the opthalmoscope, the electrocardiagraph, the X-ray tube as a diagnostic and a therapeutic agent, the use of radium, the knowledge of the mechanics of the circulation of the blood, the interpretation of the sounds detected by auscultation and percussion, etc. etc. Nor is the account all on one side. The contributions to the science of physics made by practicing physicians may well be a matter of pride to those of that profession. The work of Dr. Mayer, who first stated the law of the Conservation of Energy as of general application, and of Young, who dared to give evidence for the wave theory of light in the teeth of the authority of such a master mind as Newton's, are only two of several cases that might be mentioned.

Do not be bound, then, by traditional methods of presentation. If pre-medical students listen to your discussion of the stresses and strains in a roof truss, it is because of their politeness or because they can't get away. But show them a diagram of the compression system of trabeculae in the head of the thigh bone, and point out their arrangement to take up the stresses with a maximum of rigidity and a minimum of material, and see their eyes light up. Instead of questions about lifting barrels of sugar, get your problems from the muscles and bones. The engineer must be able to calculate the horse-power and efficiency of the engine that can lift a long ton of coal from the 900 foot level in one minute, but the same principles are used in getting the power and efficiency of a 200 pound man climbing a flight of stairs. Then let your students figure out how much glycogen must be converted to lactic acid by this effort, and you will have 100% of efforts, if not of accuracy. But is the latter so very important, if you really get the interest aroused, and the principles impressed so that they will be remembered?

When we come to the study of heat, how rich the supply of illustrative material! Do they know that the Fahrenheit scale is a development from that on one of the primitive thermometers, which divide the difference of temperature between the (supposed) temperature of the human body and that of freezing water into ninety-six steps and that it was only later that the temperature of boiling water was found to be constant at 212 of these steps above that of a mixture of snow and ammonium chloride, supposed to be the coldest thing possible, which, in turn, was thirty-two of these steps below the freezing point of water? Are you teaching Charles' Law? How much greater is the volume of expired than of inspired air on a winter day? Calorimetric problems involving the different kinds of food materials are innumerable. Diathermy is coming to be of immense importance in therapeutics. When the students realize that heat may be applied as heat itself,—as radiant energy, to be converted into heat at greater or less depths below the surface dependent on the wave length of the "light" used,—or as high frequency electric currents which become heat at the points of greatest resistance, namely: at the surfaces of the cells, they will have a knowledge of the convertibility of energy meaning much more than that which they would ever get by problems on the combustion of fuel in a power plant. Again, Atwater has proved that a man at rest must be supplied with 2700 large Calories daily, while a man at hard labor needs 4500 Calories. If we may assume that the difference is all converted into work, how many joules of work are done, and what is the efficiency of the man as a machine. McKendrick, in another series of experiments, measured the heat produced in twenty-four hours as 3724 Calories and estimated the work done by the heart, by respiration, and by muscles as 3.11×10^{11} joules. By how many per cent did his estimate differ from the second one given by Atwater? Once more. The combustion value of protein is 5.754 Calories per gram. But one-third of a gram of urea, combustion value 2.5 Calories per gram, is excreted for each gram of protein ingested. What then is the efficiency of protein as an energy producer, assuming, which is not quite the case, that all the nitrogen is excreted as urea?

What about the Second Law of Thermodynamics? Well, when they have learned that the maximum efficiency of the ideal heat engine is given by the ratio dT/T, where T is the absolute temperature of the heated stuff, and dT is the drop in temperature, ask them to calculate the necessary initial temperature if, as is the case with the muscles, 25% of the energy supplied is converted into work, and the final temperature is 37° C. It will be evident that the potential energy of the food is converted into work through some other intermediary than heat. The fact that CO_2 is not produced *during* contraction but afterward, and that most of the heat is produced after contraction, verifies this supposition. Furthermore, the possible work that a muscle can do is proportional, not to its volume, as we should expect if its activity were due to a chemical change, but to its surface. To this I refer later.

In the case of the study of sound, is there any good reason why a model of the larynx rather than the violin should not be used to teach the principles of vibrating strings? A violin or sonometer simpler, you say? Possibly, but remember, no matter how simple an illustration may be it is valueless if uninteresting. And Helmholz's work with resonators in the analysis of the vowel sounds is certainly as valuable and instructive as the physics of the wind instruments. The ear is an organ deserving study, and full of possibilities for teaching the science of sound.

The study of light should be so fascinating to the medical student that the subject teaches itself. Illumination? Make it a study of the foot-candles required in different occupations in order to avoid eye-strain. Diffused reflection? Again, a matter of eye-health. Concave mirrors? Study the opthalmoscope. Refraction? Lenses? The eye, its defects and their correction will give you every reason for going into the subject as deeply as you desire. The crystalline lens offers a splendid chance for a discussion of spherical aberration, since its peculiar structure reduces this to a minimum. Show your students why. Give more attention to the microscope your students are using than to the telescope they may never see. Look at a catalogue of microscopes. Do your students understand the terms well enough to judge which of two instruments there described is better value for the price? If you want a knowledge of diffraction to stay with them after they have left your class, show them how diffraction limits the magnifying power of the microscope to not much more than that reached at present.

Don't forget that polarized light is useful for many other things than the examination of sugars. Show them a picture of how a contracted muscle fiber looks in polarized light and in ordinary light. The laboratory should own a good polariscope. Two of my old students came back from their examinations in medical college to tell me how a remembrance of what they had learned about polarization had saved them on two important questions.

Absorption spectra can be taught as easily by reference to those of the blood and other body fluids as by the Fraunhofer lines. A solution of chlorophyll shows a good absorption band. Explain that the particular wave lengths absorbed are particularly effective in the decomposition of CO_2 and the synthesis of starch, and you have again impressed the convertibility of energy upon their minds.

When we come to the subject of electricity, there is a multitude of applications that will be meaningful to the pre-medical student where the illustrations ordinarily used will soon be forgotten. When teaching the different means of producing a potential difference, why not mention that the cut end of a nerve or muscle is negative as compared with the uninjured portion. And if the student is told that the propagation of a nerve impulse is accompanied by a wave of negative electrons, traveling at the rate of 120 meters per second or less, probably produced, as Dr. Gerhard of the University of Chicago thinks, by an explosive oxidation as in a fuse, his interest is immediately stimulated. He is not likely afterwards, to be satisfied with the careless statement that the nerve impulse is electrical in its nature, and lazily identify it with an electrical current.

Dr. Hugo Frick says that the film which surrounds the blood corpuscle is 4×10^{-11} centimeters thick, and has an electrical capacity of 0.8 microfarads per square centimeter, varying in health and disease. It has been proved that the capacity and conductivity of a tumour varies with its malignancy. Will a medical student be willing to study electrical resistance and capacity after hearing this? If he will not, it will be perfectly advisable to flunk him for he will never get through a medical course. The illustrative material from the physiological processes and from the methods of the physiological laboratories is so abundant that books have been written on Medical Electricity.

The ordinary laboratory is provided with a variety of galvanometers, the working of which the student is supposed to understand. But how many students have ever seen a string galvanometer, or a capillary electrometer, which are so important in physiological investigations, or will be able to understand them when he meets them in his advanced work. Time spent in studying instruments useful only to the engineer to the exclusion of instruments used in his own work would not seem to be the best use of the limited time for the subject.

Beyond all these topics mentioned, however, there remains something more to be said. There is one section of physics usually neglected or at best very briefly treated, that is of so much importance that in order to give it some attention, I believe we might seriously consider the omission of some things usually included in an engineering course. I refer to the physics of colloids, and to the subject of surface energy, including osmotic pressure, all of these being rather closely connected in physiological processes. These are difficult subjects, and new subjects, so that it is not easy to find material in such shape that without preparation it can safely be fed to sophomore students. But the body is a mass of colloids, and as soon as he opens his physiology he begins to read about them. The whole process of food assimilation seems to consist in changing from colloids of one kind to another, or from particles of one size to another, thus changing the surface energy. Probably chemical energy is rendered available as muscular energy with surface energy as an intermediary form. Again, the elements of the digested food get about from one organ of the body to another by osmosis, and not by any simple osmosis at that. It is sometimes an osmosis of molecules, sometimes of positive ions, sometimes of negative ions. The electrical charge on the separating membrane is often a factor of importance. It would seem as if the medical student should have a general knowledge of these topics before he is thrown into a situation where a familiarity with them is assumed. With this exception, however, I can see no reason why the pre-medic should not, in the main, study the same physics as his brother in the engineering course. But he should be in a class by himself, and his course should be enriched by illustrations drawn from his own field; not, as I have said, to teach him physiology, any more than the problems his brother wrestles with are to teach *him* bridge-building, or mining, or electrical engineering, but really to teach him physics, in such a way that he may see its value, get a love for it, and remember a modicum of its principles for use in his future work.

AN ARRANGEMENT OF THE ROTATING SECTOR DISK.

W. F. Schulz, University of Illinois.

In using a spectrophotometer for comparing the intensities of two beams of light, wave length by wave length, the intensity of the comparison beam is frequently varied by means of a rotating sector disk. There are two types of these disks.

In one type two disks with sectors cut from them to form windows, with two sides parallel to the radii of the disk, are mounted on a common axis so that one may be rotated with respect to the other. The open sections of one can thus be made to partially overlap those of the other, in order to vary the effective size of the windows. The beam of light passing through these sectors while the disks are in rotation, is thus rendered intermittent and appears to flicker. But owing to the persistence of vision, the flicker will disappear when the speed of rotation exceeds a certain limiting value. Above this limiting speed of rotation the intensity of the beam will seem to be continuous but will vary as the sectors are changed in size.

According to Talbot's law the apparent intensity of the intermittent light bears to the actual intensity of the incident light the same ratio as does the time of exposure to the period of rotation.

In the Napoli-Abney and Keuffel & Esser disks this variation of sector size may be produced while the disks are in rotation.

In the other type a single disk has windows cut in it each varying in width with its radial distance from the axis of rotation. In the Hyde sector disk these sectors are formed of three arcs, one concentric with, and near the axle of the disk, the other two meeting near the circumference and forming with the first a triangle. There are six of these windows, their total width at the outer edge being zero, and at the inner edge 85% of 360 degrees.

This type of disk is usually mounted close to the slit of the collimator.with its axis parallel to that of the collimator. To vary the intensity of the beam while the disk is in rotation it is shifted parallel to its own plane by means of a micrometer screw so that a different width of sector comes in front of the slit of the spectrophotometer. The incident beam can thus be varied continuously from 85% of its full intensity to zero. A calibration curve gives the intensity of the transmitted beam for each reading of the micrometer screw scale.

The disk is usually enclosed in a housing and sometimes a comparison prism is mounted in front of the collimator slit, so that the disk can not be brought very close to the slit. As a result, when rays of light are focussed on the slit, they form a thin wedge with its base at the disk. The effective radial range along which the intensity of the beam can be varied is thus decreased by an amount equal to the width of the beam at the disk.

Besides, the disk and the motor for rotating it are usually mounted on a heavy metal base to avoid vibrations, and in shifting this considerable wear and strain in the fine threads of the micrometer screw may result.

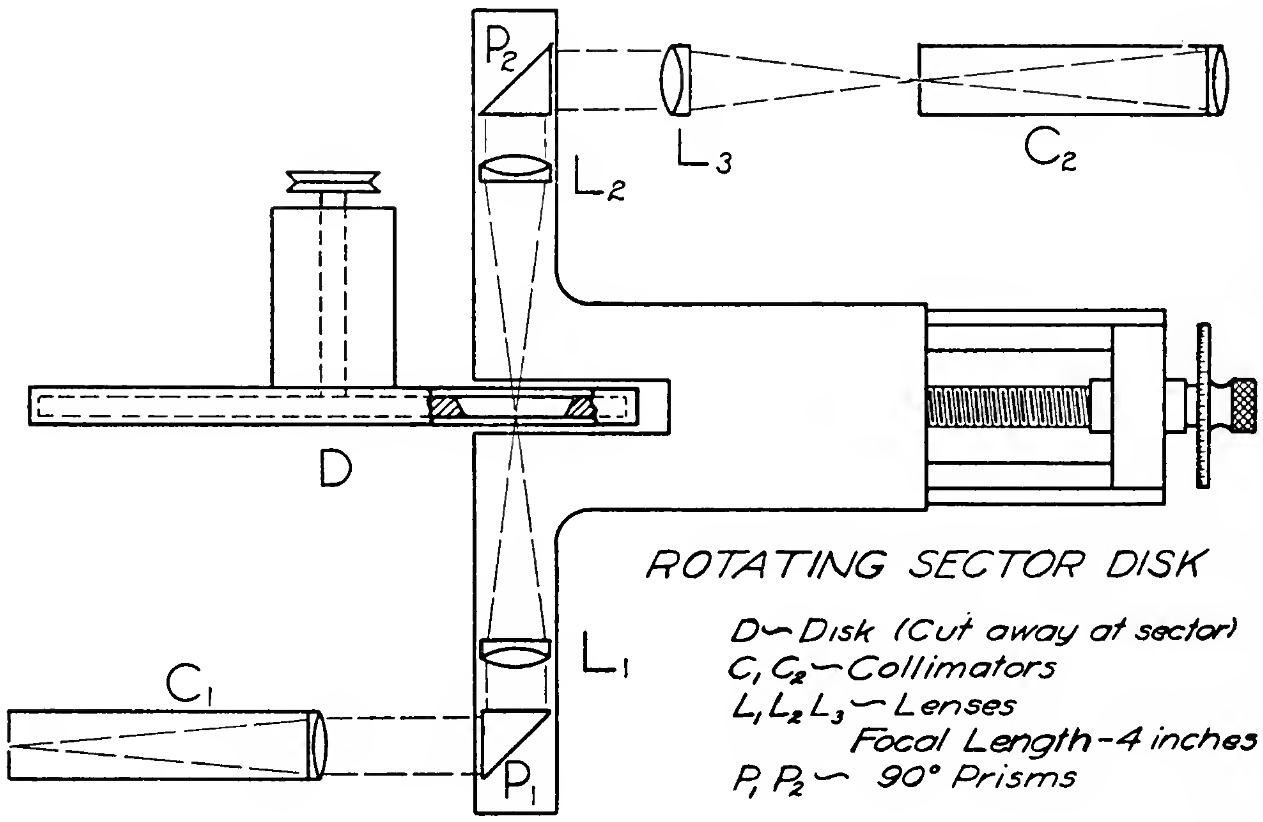


FIG. I.

To avoid these difficulties the following optical system has been devised: Fig. 1—The disk is mounted with its plane parallel to the axis of the collimator and remains at rest. The light to be varied in intensity is rendered plane parallel by a separate collimator, C_1 having its axis parallel to that of the spectrophotometer, C_2. It is then totally reflected by a right angled prism P_1 and brought to a focus at the bevelled edge of the rotating sector disk D by means of a short focus achromatic lens L_1. A second lens L_2 renders the beam once more plane parallel, and after reflection by a second prism P_2 in order that the beam may travel along the axis of the photometer collimator, it is brought to a focus on the slit of this collimator C_2 by means of a third lens, L_3.

The two prisms and two lenses between them are mounted on a light aluminum carriage, which straddles the disk and travels on tracks in a direction parallel to the disk. It is shifted by means of a fine micrometer screw, and the radial position of the beam in the open sector of the disk can be read off on the scales of the screw.

Because of the short focal length of the lens L_1, the image of the first slit which is formed at the disk has a very small radial thickness, hence the full range of the radial sector length can be used. Also the movable parts are quite light and cause no strain or wear on the micrometer screw.

The two prisms move along beams of plane parallel light and with proper adjustment the slit image remains in position on the collimator slit as the carriage is shifted. The prisms must be "squared on" with the aid of a telescope having a Gauss ocular by observing the images of its cross hairs reflected from the four perpendicular faces of the prisms and adjusting until these images are superposed.

As constructed this optical system gave very satisfactory results. The lenses had a focal length of 4 inches and a diameter of 1.25 inch. The short sides of the prisms were also 1.25 inch in width. The radial range of the sectors was 2 inches and a micrometer screw of half a millimeter pitch was used.

The disk was calibrated by comparison with a Keuffel & Esser sector disk. Readings could be repeated within 1.5% usually.

Since the absorption of glass varies for different wave lengths, a correction curve was plotted to allow for this difference. The following table of values taken from this curve gives in A, the intensity of the beam direct; in B, the intensity after passing through the optical system described above.

Wave length	6563	5893	5270	4862
A	99.6	87.0	77.1	82.6
B	67.4	51.7	46.0	44.0
Difference	32.2	35.3	31.1	38.6
%Difference	32.3	40.6	40.3	46.7

It will be seen that the absorption varied from 32.3 to 46.7 percent for different wave lengths. (expressed in Angstrom units).

The system could therefore not be used to advantage with beams of low intensity.

DISTILLATION AND FRACTIONATION PROCESSES USED IN THE ALCOHOL INDUSTRY.

D. B. Keyes, University of Illinois.

The technical and scientific literature contains many articles on the manufacture of alcohol by fermentation. The emphasis, however, has been put on the fermentation process and very little has been said regarding the various distillation and fractionation processes that are now in use for the purification and concentration of the crude alcohol. Furthermore, very little has been written on the manufacture of ethyl acetate, absolute alcohol, ether and other valuable products made from alcohol. It is the purpose of this article to describe briefly these processes which have been developed within the last few years and are responsible for the large scale production of certain valuable solvents.

Alcohol Distillation.

The so-called "beer" which is produced by the fermentation of black strap molasses usually contains between six and ten percent alcohol. The remainder is largely water with some salts, higher sugars, and yeast. In order to make the commercial 95% alcohol it is necessary to concentrate and refine this crude product.

Figure 1 shows a typical refining scheme now in common use.[1] The beer is stored in tank 1. It passes through the partial condenser 2 where it is preheated by the condensing vapors. It then enters the top of column 3. Live steam enters the bottom of column 3, passes up the column and extracts the alcohol. The water, salts, and higher sugars, therefore, pass out of the bottom of the column. The vapors at the top contain approximately 50 per cent alcohol. They pass to column 4 which also operates on live steam. In this case water is added which aids in the purification, as indicated in the drawing. Out of the top of this column comes most of the low boiling impurities (aldehydes) with some alcohol. These are condensed in condensors 2 and 5, and are drawn off at point 10. Fusil oil accumulates on

[1] This is the Guillaume process.

the upper plates of column 4, is drawn off, and passes directly to the fusil oil purification column 7. Most of the water and alcohol is removed at the bottom of column 4 and passes to still 8. It is again vaporized with live steam and fractionated in column 9. Fusil oil and higher boiling esters accumulate on the lower plates of column 9. These impurities are drawn off and pass directly to column 7. The excess water is drawn off from the bottom of still 8 and the purified alcohol passes on to a further purification column 6. A product containing some aldehydes comes off the top of the column, is condensed, and flows out at point 11. An impure alcohol is drawn off near the top of the

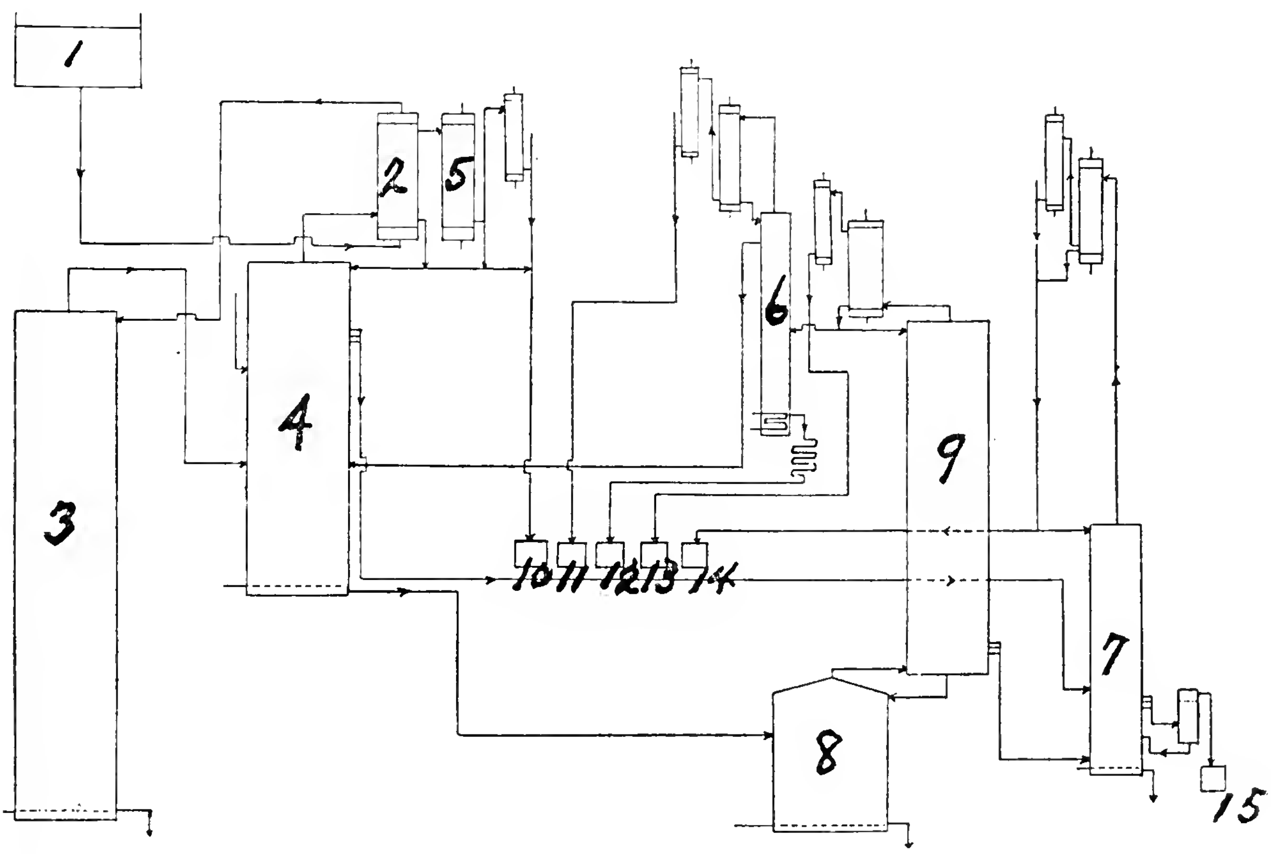


FIG. I.—ALCOHOLIC REFINING PROCESS.

column and flows back to column 4. The pure product is drawn off from the bottom of column 6 and appears at point 12. Some impure product is also drawn from a final condensor on the top of column 9 and appears at point 13. The fusil oil column 7 produces an impure alcohol at the top which is drawn off at the point 14. Water is drawn off at the bottom of column 7, and the concentrated fusil oil is drawn off from the side, passes to a separator where water is added, and the oil layer containing most of the fusil oil is taken off at point 15. The water layer is returned to the column.

Absolute Alcohol Processes.

One of the simplest methods of producing absolute alcohol from a 95 per cent product is shown in Figure 2.[2] Ninety-five per cent alcohol in storage tank 1 passes to the dehydrating column 2 where it also meets benzol. The addition of benzol at this point disrupts the constant boiling binary mixture and produces a constant boiling ternary mixture containing a relatively greater concentration of water. This results in producing absolute alcohol at the bottom of column which is drawn off as

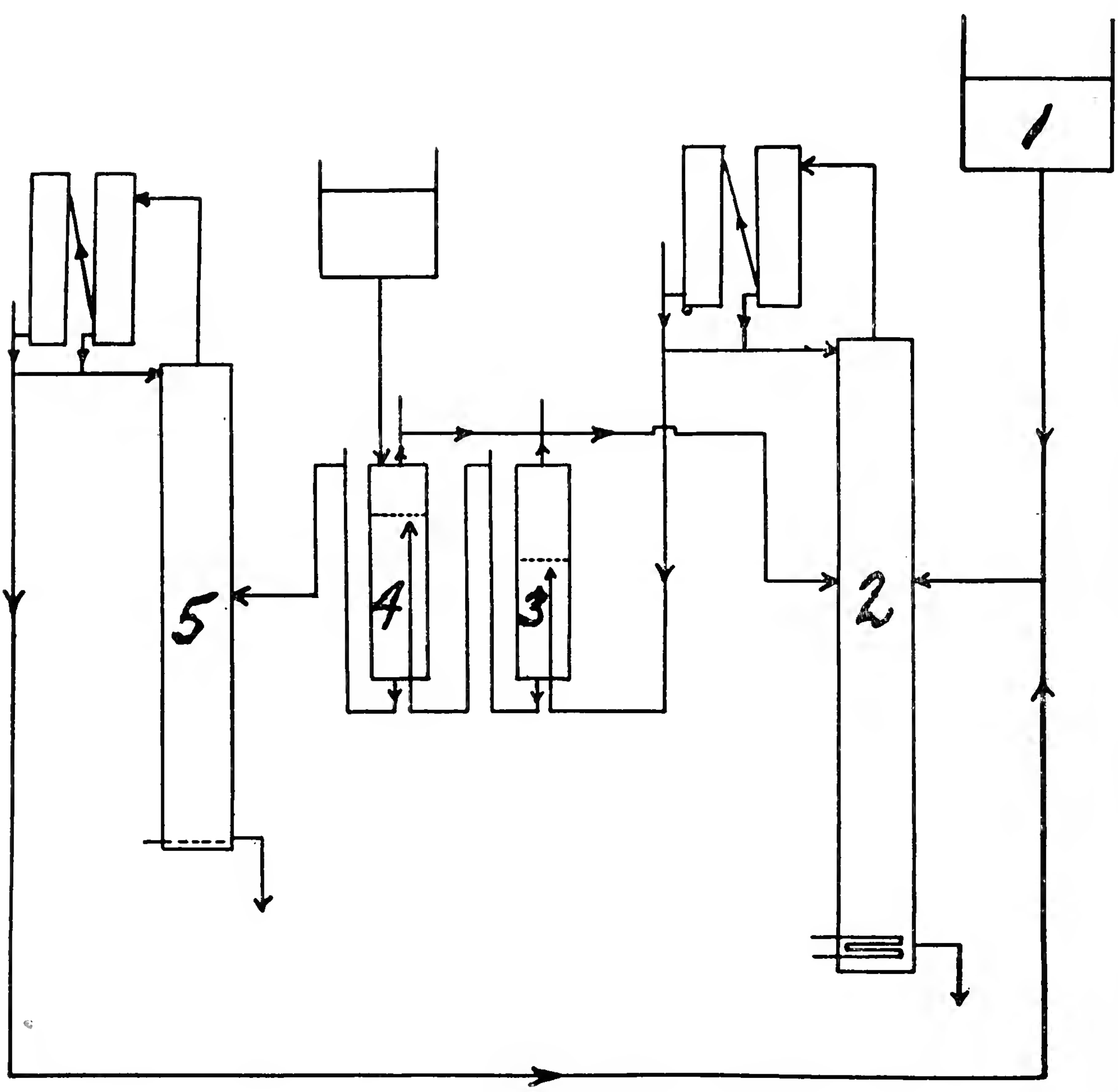


FIG. 2.—Absolute Alcohol Process.

the product and the ternary low boiling mixture at the top of the column is condensed and passes to separators 3 and 4. In the second separator additional water is added. This ternary mixture separates into two layers. The upper layer containing principally benzol is returned to column 2. The water layer containing also an appreciable amount of alcohol is sent to column 5 where it is concentrated to 95 per cent. The excess

[2] The Steffens Process covered by U. S. and foreign patents.

water is drawn off the bottom of this column. The condensed 95% alcohol then is returned to the dehydrating column 2 as indicated.

A more elaborate process for the same purpose is shown in Figure 3.[3] In this case the oil layer in the separator 1 passes to a refining column and the pure "third liquid" is returned to the dehydrating column 3. The ternary mixture produced at the top of this column[2] is returned to the separator. The water

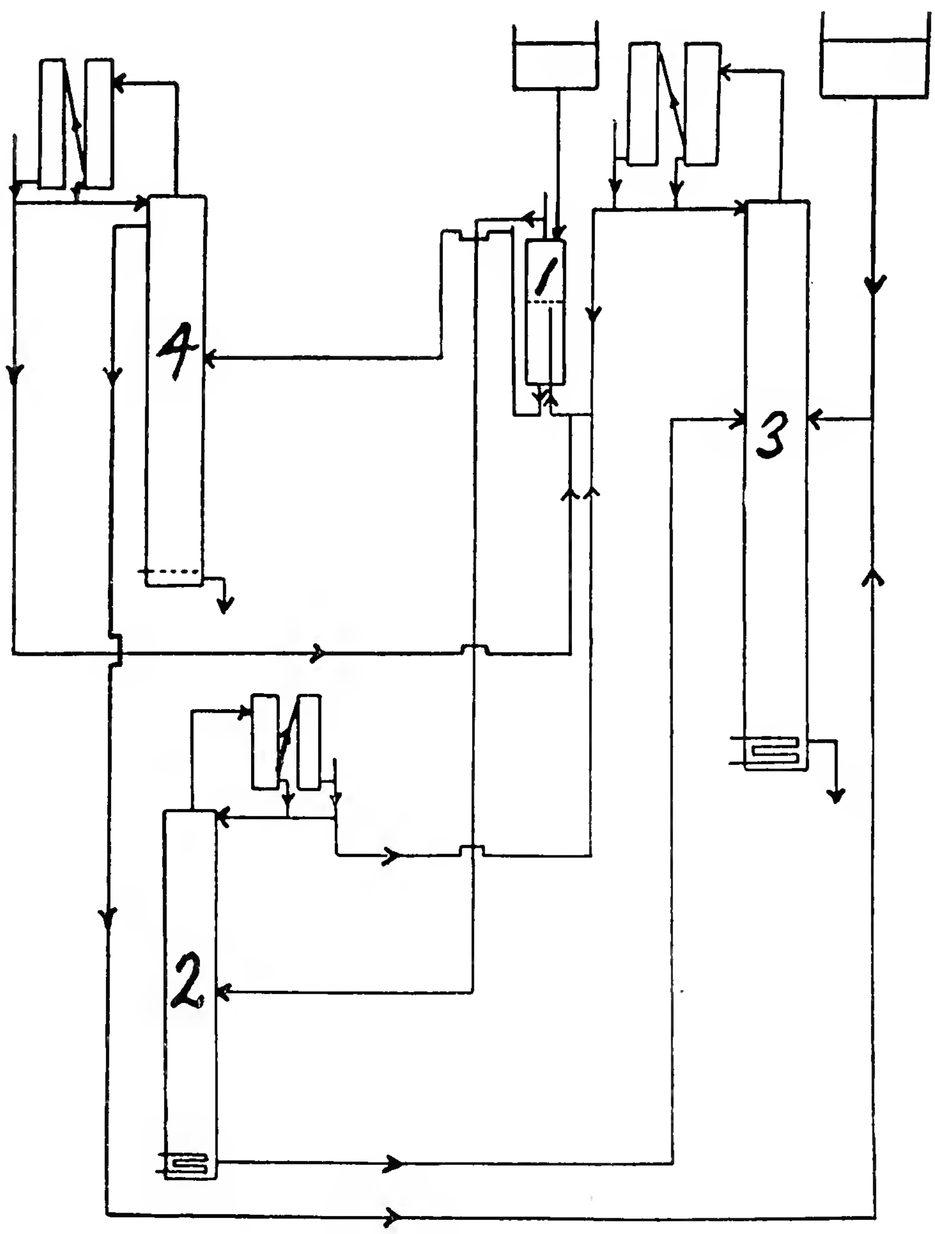


FIG. 3.—Absolute Alcohol Process.

layer from separator 1 passes to the recovery column 4. The 95 per cent alcohol in this case is taken off near the top of the concentrating column 4 and returned to the dehydrating column while the ternary mixture containing some of the "third liquid" comes off as vapor from the top of this column, is condensed, and is then returned to the separator 1.

[3] The Rodebush process covered by U. S. and foreign patents.

A still more elaborate system for the same purpose is shown in Figure 4.[4] In this case two columns are used for the refining of the water layer instead of one as was shown in the second case. Also two separators are used.

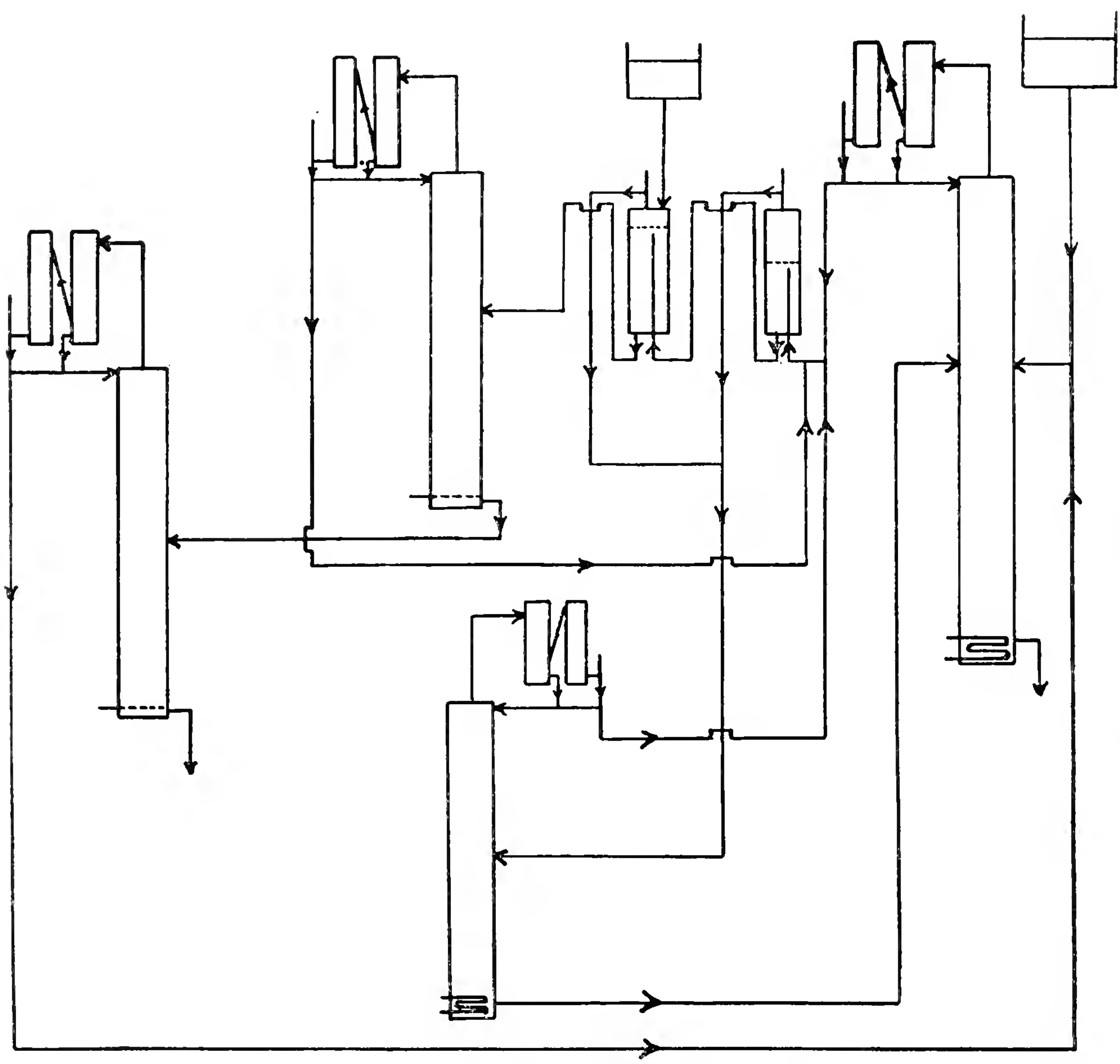


FIG. 4.—Absolute Alcohol Process.

Ether Manufacture.

The common practice for the manufacture of ether from alcohol is shown in Figure 5. Denatured alcohol is stored in tank 1, passes to the weighing tank 2 and then is pumped to the operating tank 3. From here it passes to the reaction kettle 4 where sulfuric acid is added. The reaction products with the exception of the excess sulfuric acid is vaporized and passes to the sodium hydroxide neutralizer 5. The ether, alcohol and water then pass to the fractionating column 6, which produces pure ether as a vapor and a mixture of alcohol, water and some ether as a residue. This residue passes on to column 7 and still 8. Any excess water is drawn off from the bottom of this

[4] The Keyes Process covered by U. S. and foreign patent applications.

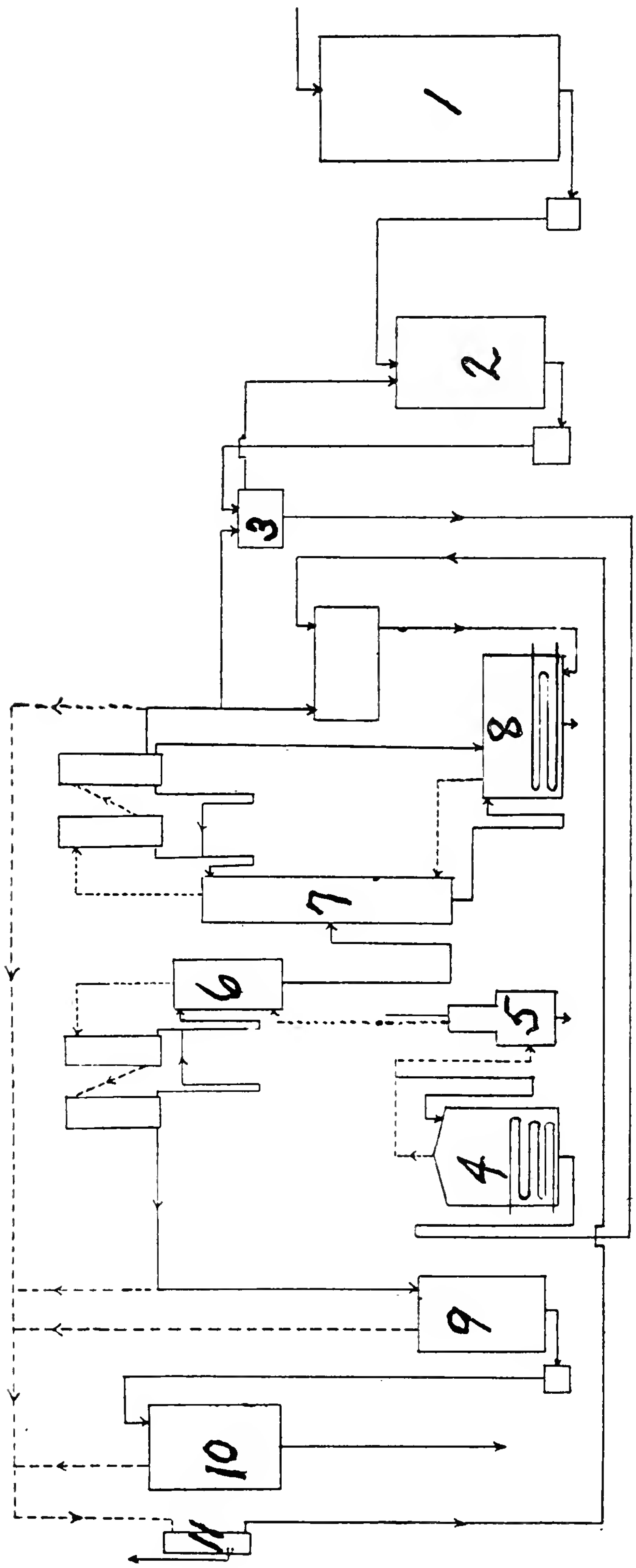


FIG. 5.—Ether Process.

still. 95 per cent alcohol with some ether comes off the top and is returned to the feed tank 3. The pure ether from the fractionating column 6 goes to the weighing tank 9 and delivery tank 10. It will be noted that all vents are connected together and lead to the condensor 11 in order to save as much of the volatile ether as possible.

Ester Manufacture.

Anhydrous ethyl acetate is now being made in enormous quantities by the process outlined in Figure 6.[6] A mixture of ethyl alcohol, dilute acetic acid and small amounts of sulfuric acid which acts as a catalyst are pumped into reaction tanks 1 and 2. From here the partially formed ester together with the

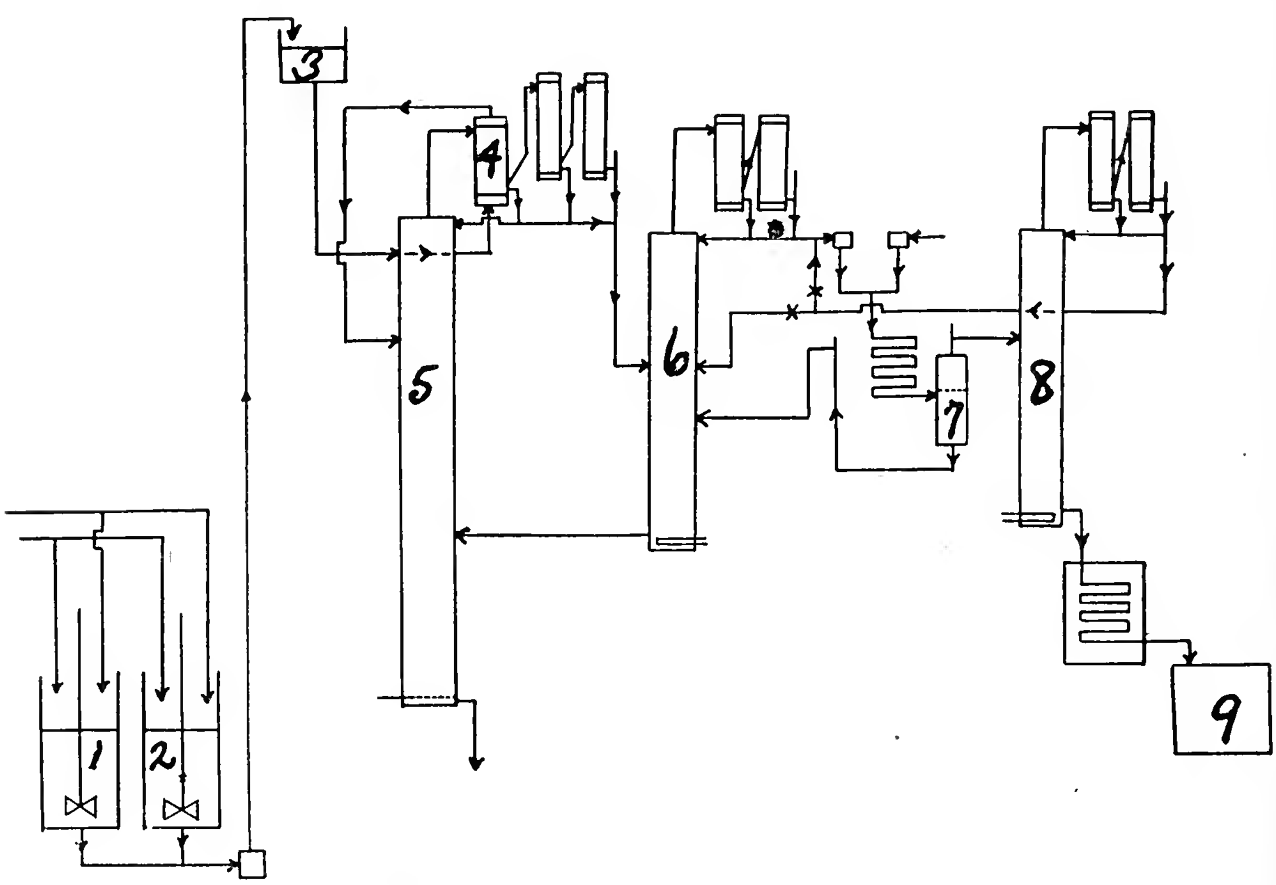


FIG. 6.—Ethyl Acetate Process.

other materials passes into a storage tank 3 through a partial condensor 4 where it is preheated and finally into the manufacturing column 5. Live steam is used in this column. The excess water is removed from the bottom. From the top comes a ternary mixture which must be further purified in Column 6. The excess alcohol and water are drawn from the bottom of this column and pass back to column 5. A constant boiling ternary mixture goes out as a vapor from the top of column 6, is condensed, and water added. It is then cooled and finally lead into

[6] The Backhaus Process covered by U. S. and foreign patents.

separator 7. The upper layer contains most of the ethyl acetate and passes to column 8. The lower layer containing alcohol and water with some ethyl acetate passes back for further purification to column 6. From the top of column 8 comes a ternary mixture of ethyl acetate, alcohol and water. This is either returned to the separator or to column 6. From the bottom of column 8 comes pure ethyl acetate which is cooled and passed to the storage tank 9.

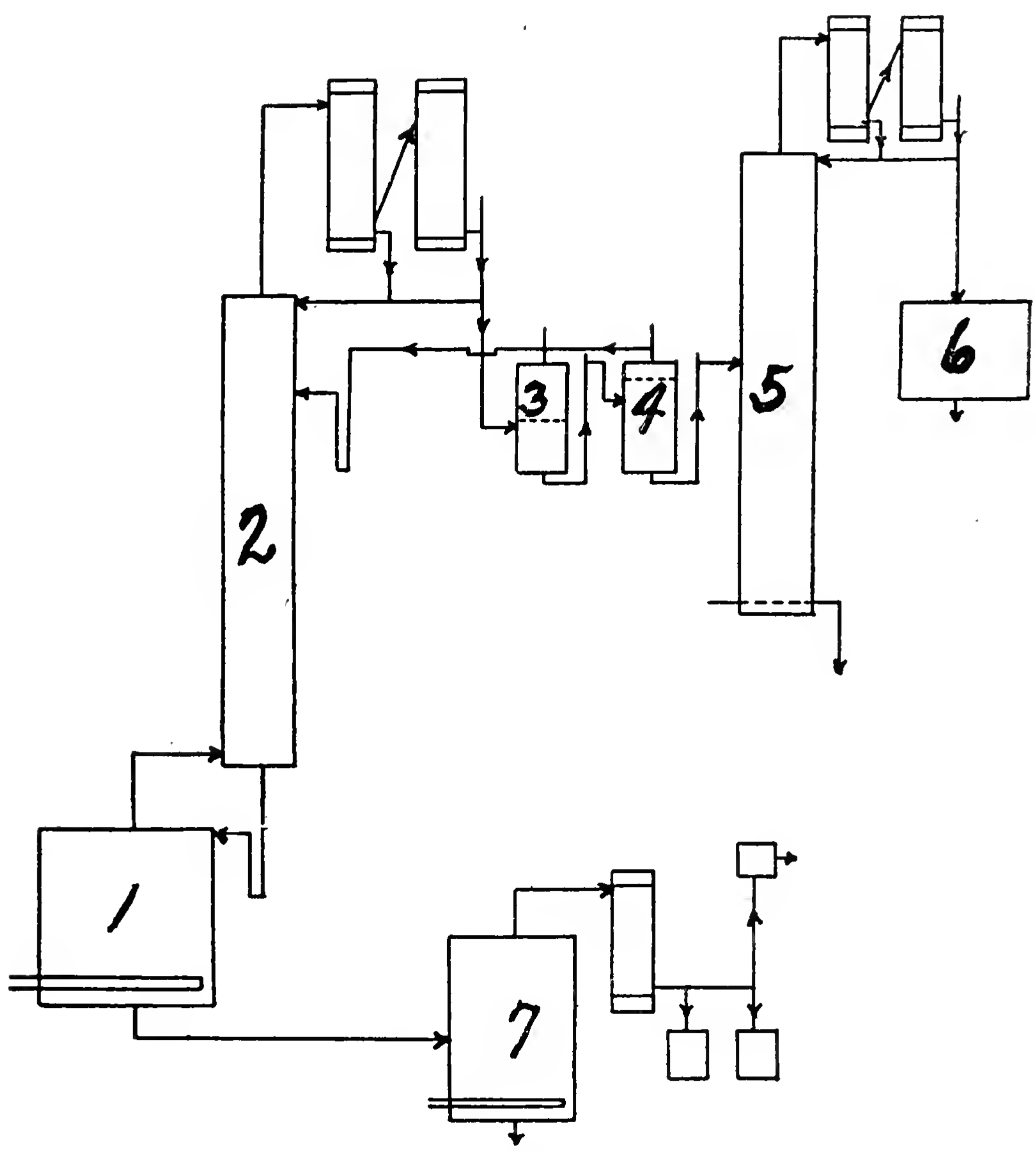


FIG. 7.—Ethyl Lactate Process.

Another interesting ester process is shown in Figure 7.[7] This process is especially adapted to the manufacture of high boiling esters, such as ethyl lactate. The reaction mixture of ethyl alcohol, lactic acid, and some sulfuric acid is placed in still 1 which is indirectly heated. The vapors pass through column 2 where they meet benzol coming down. This benzol has the property as shown in the absolute alcohol process of acting as a liquid dehydrating agent. In this particular case benzol has a tendency to wash down the alcohol into the re-

[7] The Stephens Process covered by U. S. and foreign patents.

action kettle 1, and at the same time water is being removed as vapor from the column more rapidly. The condensate from the top of column 2 is separated in the two separators 3 and 4. Water is added to the second separator. The oil or benzol layer is returned to column 2 while the water layer containing some alcohol passes to column 5. The excess water comes out of the bottom of column 5 and the 95 per cent alcohol which can be used again comes out as a condensate and passes to the storage tank 6. In order to remove any volatile or non-volatile impurities from the final product, ethyl lactate, which remains in Still 1, the crude ester is passed to vacuum still 7. The low boiling impurities are first distilled off and then the pure product is distilled over at a higher temperature, leaving in still 2 any solids or very high boiling impurities.

ELECTRO-CHEMISTRY APPLIED TO BOILERS FOR CORROSION PREVENTION.

O. W. Carrick, Water Engineer, Wabash Railway Co., Decatur, Ill.

To the research scientist who is experimenting in pure science to more thoroughly understand the basic causes for certain phenomena, mankind is greatly indebted. However, in most cases, before his results can be successfully used, the scientist in the field is forced to do further experimental work. For example in 1903 Dr. W. R. Whitney of Massachusetts Institute of Technology (J. Am. Chem. Soc. Vol. 25, 1903) presented his hypothesis for the dissociation of iron but we are just now beginning to make practical application of his theory in the industrial world.

Dr. Whitney pointed out that "Practically the only factor which limits the life of the iron is oxidation under which are included all the chemical processes whereby the iron is corroded, eaten away or rusted. In undergoing this change, the iron always passes through or into solution, and as we have no evidence of iron going into aqueous solution except in the form of ions, we have really to consider the effects of condition upon the potential differences between iron and its surroundings. The whole subject of corrosion is simply a function of E. M. F. and resistance to circuit. The Velocity with which the process proceeds will depend on the temperature and on the hydrogen ion concentration of the water."

Since that time many research men have been investigating this probem with varying results. In most cases they have agreed upon the theory that the dissociation of iron is an electrochemical phenomenon. Many articles have been presented and books written on this subject, examination of which will show many erroneous and varied conclusions having been arrived at by the authors, and are responsible for considerable dissention in the research field.

In 1923 Dr. R. E. Wilson (Ind. and Eng. Chem. Feb. 1923) presented a paper before American Chemical Society, in which he discussed the various factors that affect the rate of dissociation of the iron and it is his opinion that improper recognition of these factors are principally responsible for the incorrect conclusions. The factors that affect the dissolving of the iron, as given by Dr. Wilson are "Solution pressure of the metallic iron, hydrogen overvoltage, hydrogen ion concentration, velocity of flow, temperature, density, catalytic agents, oxygen, character of protective films, current density, passivating agents, metallic salts in solution, etc."

With incorrect consideration given to the effect these factors have upon the rapidity of the solution of iron, one can readily understand the possibility of an investigator arriving at improper or unsatisfactory conclusions.

The principal reaction in the corrosion of iron, as first pointed out by Dr. Whitney, is expressed in the simple equation

$$\underset{\text{Metallic Iron}}{Fe} + \underset{\text{Ionic Hydrogen}}{2H^+} \longrightarrow \underset{\text{Ionic Iron}}{Fe^{++}} + \underset{\text{Monatomic Hydrogen}}{2H}$$

Since this is the basic reaction, any method of prevention must counteract it.

When the ionic hydrogen gives up its electrical charge to the iron, a galvanic couple is produced and the gaseous hydrogen plates out at the opposite or negative pole. As the hydrogen film accumulates and if it is not disturbed, the electrical potential of this pole will be raised to that where the iron went into solution (the anode) and the reaction ceases.

It has been found that certain metals, such as arsenic and tin, have the peculiar property of increasing the polarizing effects of the hydrogen film as it plates out upon the cathodic area, thus causing the more rapid establishment of the equilibrium between the cathode and anode. The removal of the hydrogen, or deplorization as it is termed, caused principally by oxidation, will permit the plating out of more hydrogen, thus allowing iron to go into solution until the potential of the cathode area is again raised to that of the anode. The elimination of oxidizing agents or decrease in the hydrogen ion concentration of the liquid, has a direct effect upon the rapidity of solution of the iron.

These galvanic couples or small localized batteries are set up by difference in solution pressure along the metal surface resulting from heterogenity, hydrogen ion concentration of the electrolyte and many other factors previously mentioned.

There is another distinct type of current flow known as electrolysis currents whereby the electrical energy is produced by some exterior source and passes from the iron to the electrolyte causing the iron to go into solution in direct ratio to the E. M. F. At the same time hydrogen plates out on the negative pole where the current leaves the electrolyte and produces its polarizing effect the same as in the galvanic couple.

It is the specific purpose of the Electro-Chemical Polarization Process for the prevention of corrosion to maintain a plating of arsenic on the cathodic areas in a liquid bath that are to be protected, by using a counter electro-motive force taken from an external source and the secondary function of the imposed current is to maintain a polarizing film of hydrogen on the arsenic surface, in excess of that removed through oxidation or by mechanical or other means. The arsenic and hydrogen plating will eliminate any local galvanic currents and the E. M. F. of the imposed current is greater than the E. M. F. of any electrolysis currents reaching the liquid container.

This system of corrosion prevention has gone through the experimental stages in the railroad field, the first test installations being made in two Chicago & Alton Railroad Company's locomotive boilers at Bloomington, Ill., in 1924 under the direction of Mr. L. O. Gunderson, Chemical Engineer for the road.

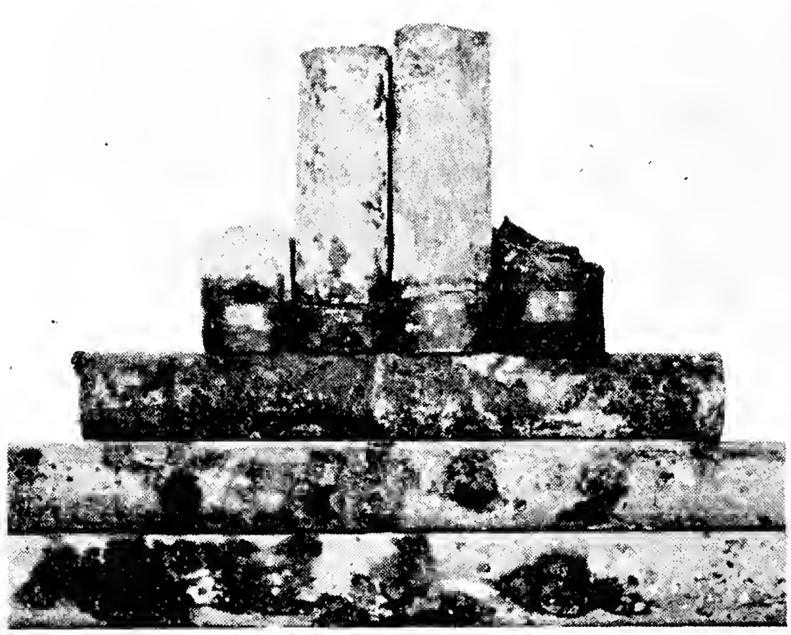
Before explaining the mechanism of the process, I wish to give a few pertinent facts covering the losses to the railroads through corrosion of boilers. According to records the boiler corrosion problem is about as old as the boiler itself, but within the last few years it has become increasingly serious. One railroad official recently wrote, "If you desire to render a real service to the railroads of this country find out and tell them how to stop pitting and corrosion of locomotive boiler flues, shells and fireboxes, and all mechanical men will forevermore call you blessed."

There are approximately 72,600 locomotives operated on the American railways and the losses due to flues, boiler sheets and staybolts being made unserviceable through pitting and grooving are conservatively estimated to reach $12,000,000 annually.

There are six or more technical committees attempting to analyze the causes for corrosion and trying to find a means of prevention. Many specially prepared steels, irons and alloys such as copper content steel, nickel steel, Molybdenium steel, leadized steel and several others have been experimented with but today we are unaware of a metal suitable for the severe boiler stresses, which will in all cases withstand the corrosive action of a boiler water.

Attempts to inhibit corrosion by treating the boiler feed water with various chemicals such as soda ash, lime and soda ash, zeolite, arsenic, mercury and chromium have produced erratic results. Deaerating or de-activating apparatus that will remove 100% of the dissolved oxygen has not yet been developed for locomotive application and, due to the exactness of control required to obtain gas free water, it is rather doubtful as to whether such equipment is practical for locomotive service.

In studying boiler corrosion you will find the majority of destruction due to the local or galvanic couples on the metal surface. Because of its localized nature this type of corrosion known as "pitting" is very severe for the metal is soon penetrated and made unserviceable whereas the surrounding surface is in perfect condition. The other type of corrosion known as grooving appears to be due to or accelerated by electrolysis currents caused by thermal differences in the boiler or stray currents from various exterior sources.



PITTING, GROOVING AND GENERAL CORROSION.
CONTEMPORARY POWER EQUIPPED WITH ELECTRO-CHEMICAL POLARIZATION SYSTEM PERFECTLY PROTECTED AGAINST THIS DESTRUCTION.

FIG. 1.

Figure 1 shows flues attacked by the various types of corrosion just mentioned.

The city water at Bloomington, Illinois, the poor quality of which you are all familiar with, produces destruction of the boiler metal such as shown in Figure 1 in as short a period as 9 months after flue application. This causes a damage to the boiler interior amounting to from $500 to $1500 annually. The original test installations on the Chicago & Alton gave immediate protection against the corrosion damage and only slight changes have been made up to the present time.

The operation of the system is best described by referring to Figure 2.

The positive pole of a turbo-generator is connected to resistor coils and fuses located in a metal box on the interior of the locomotive cab and from this box a connecting wire runs to two electrodes protruding through the boiler shell at points diagonally opposite each other. These electrodes are securely connected to two thoroughly insulated and rigidly clamped iron anodes, both of which are at all times below the surface of the boiler water. The negative pole of the generator is grounded to the boiler shell, thus causing the direct current to flow through the resistors to the anodes and from the anodes through the boiler water to the waterimmersed portions of the boiler and back to the negative pole of the generator thus completing the electric circuit. This causes the metallic portions in the boiler to function as the cathode area of the electric circuit and as long as the E. M. F. of the imposed current is greater than the E. M. F. of any stray or electrolysis currents the cathode area will be protected from the deleterious effects of such currents.

There are from 3000 to 5000 sq. ft. of exposed metal surface on the boiler interior, consequently there is greater possibility of galvanic couples being set up due to difference of potential caused by speck impurities such as slag, carbon, etc. Since the counter-current does not prevent these local couples it is necessary to resort to the use of some metal such as arsenic that has a high discharge potential when hydrogen is plated upon it so that the potential of the cathode areas will soon be raised to that of the anode when conditions are satisfactory to produce the potential differences. Several research men have brought out the fact that a metallic body acting as a cathode in an electric circuit does not stop local galvanic couples from functioning. This can very easily be demonstrated by beaker tests.

Mr. F. N. Speller in his researches has found this condition to exist and in his book "Corrosion, Causes and Prevention" 1926, page 433, says, "Local electro-chemical action will continue on a surface which is within the protective influence of an externally applied current. It is therefore, unsafe to rely too much on electrolytic protection without taking other precautions."

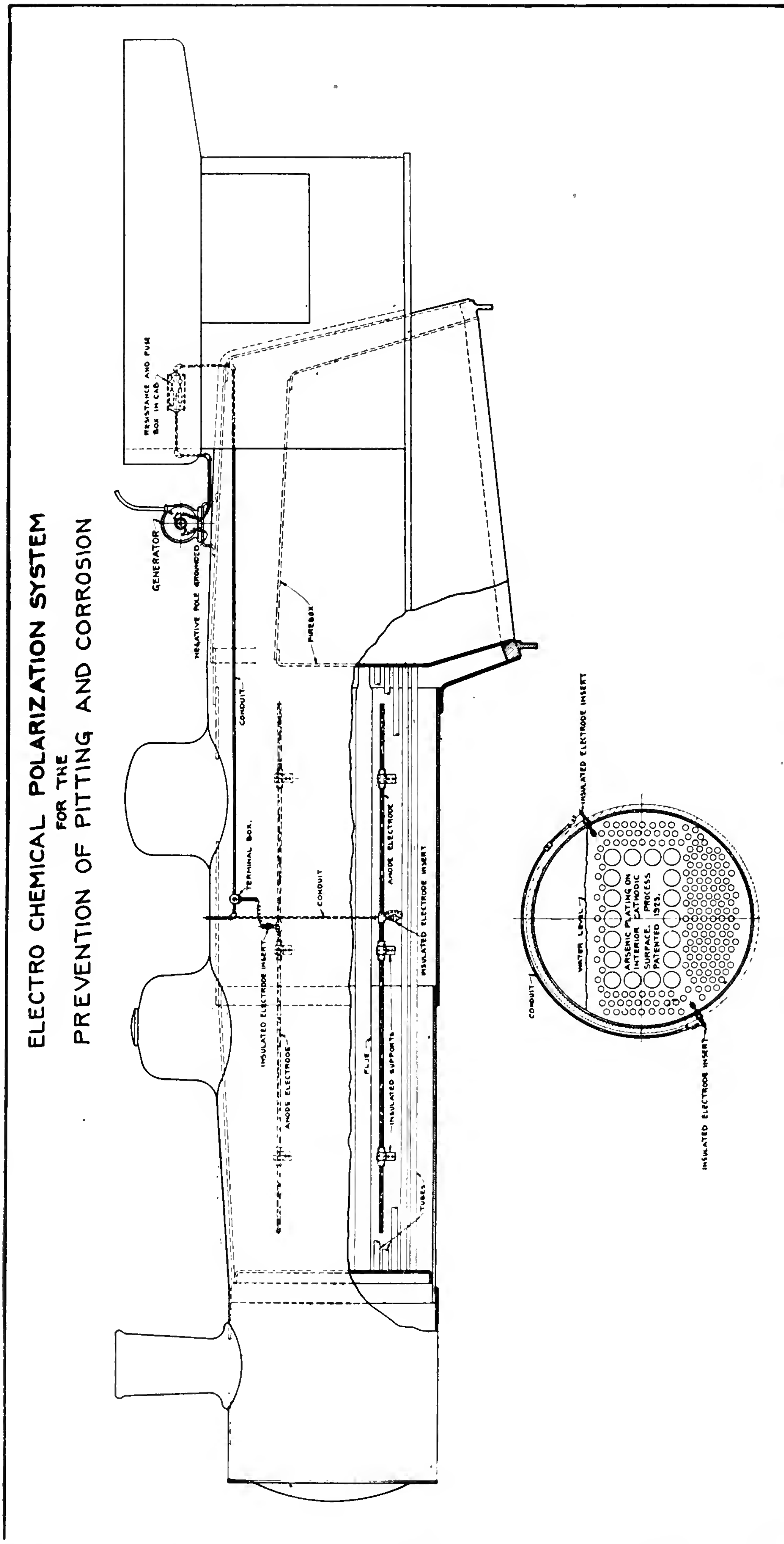

ELECTRO CHEMICAL POLARIZATION SYSTEM
FOR THE
PREVENTION OF PITTING AND CORROSION
RESISTANCE AND PUSH BOX IN CAB
GENERATOR
NEGATIVE POLE GROUNDED
FIREBOX
CONDUIT
TERMINAL BOX
CONDUIT
INSULATED ELECTRODE INSERT
ANODE ELECTRODE
ANODE ELECTRODE
INSULATED ELECTRODE INSERT
FLUE
INSULATED SUPPORTS
TUBES
INSULATED ELECTRODE INSERT
WATER LEVEL
ARSENIC PLATING ON INTERIOR CATHODIC SURFACE. PROCESS PATENTED 1923.
CONDUIT
INSULATED ELECTRODE INSERT

FIG. 2.

In the Electro-Chemical Polarization system of protection the extra precaution was taken with the use of arsenic. The arsenic plating is maintained by adding from 2 to 4 pounds of a soluble arsenic salt to the boiler water or electrolyte each month. Since arsenic plates out on iron by immersion it eliminates the necessity for definite current density to get the plating, and from the practical point of view this as a most desirable condition.

The imposed current is used during period the locomotive is in service to maintain the arsenic plating and on top of this a plating of monatomic hydrogen. This produces a high discharge potential on the arsenic surface which tends to establish a potential equilibrium. Incidently a surplus of hydrogen is kept on the cathodic surface to combine chemically with oxidizing agents entering with the fresh boiler feed water. The direct current used amounts to about 2 volts and 2 to 3 amperes to each electrode giving a current density of around two milliamperes per square foot of protected surface.

The cost of current will vary from ½c to 2c per hour. For an average locomotive the annual cost of protection by this process will run from $18.00 to $36.00, which includes the cost of the arsenic compound. You will no doubt agree that this is a very low cost for protection and can readily understand why it is being applied to all locomotives on the Chicago & Alton Railroad.

Figure 3 shows pieces of three flues removed from C. & A.

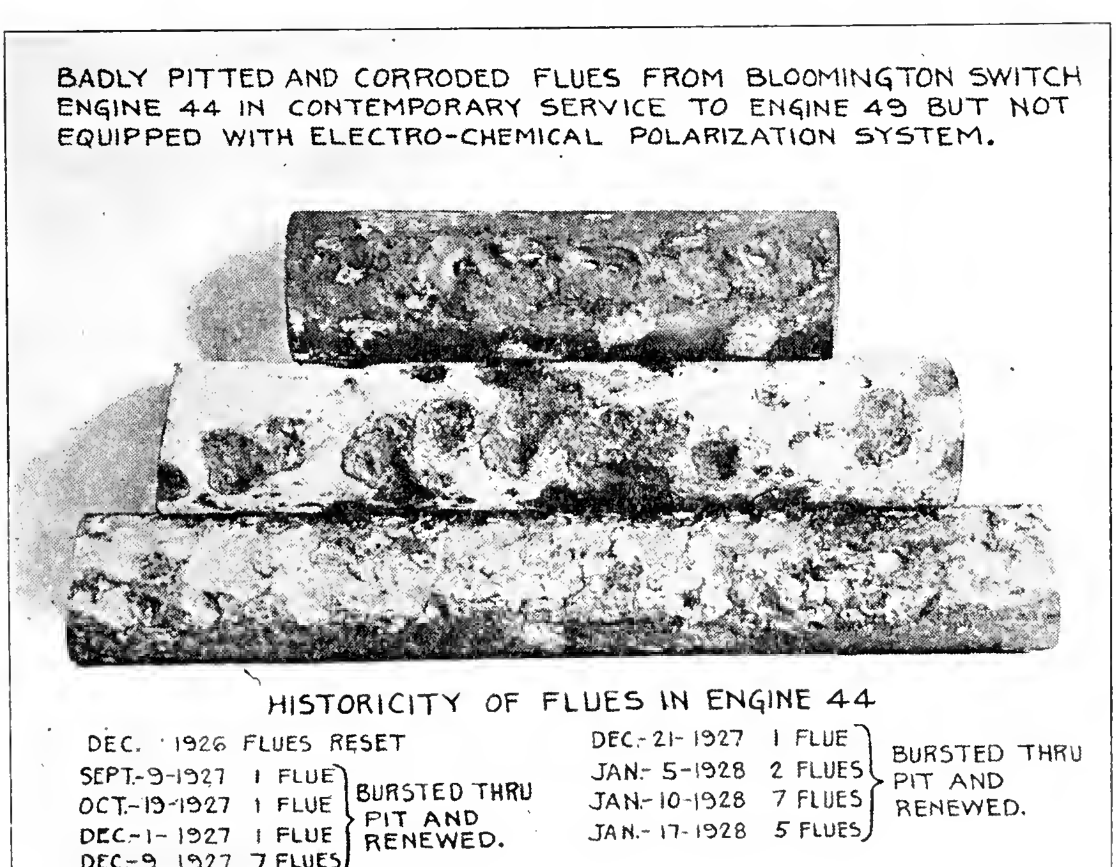


FIG. 3.

switch engine 44 at three different times. This engine is not equipped with the electrodes and you can see the deleterious effects the Bloomington, Ill., city water has when used in unprotected locomotive boilers.

In Figure 4 a group of flues removed from C. & A. switch engine 49 is shown to illustrate the complete absence of corrosion on the flues after installing the protective systems as compared with the severely corroded flues removed just prior to making the installation. This engine has been in contemporary service with engine 44 (Fig. 3) using the same water, etc., the only difference being the use of the counter current and arsenic in the 49. This surely is conclusive proof that the system does work and and due to its simplicity and low cost is a very practical installation.

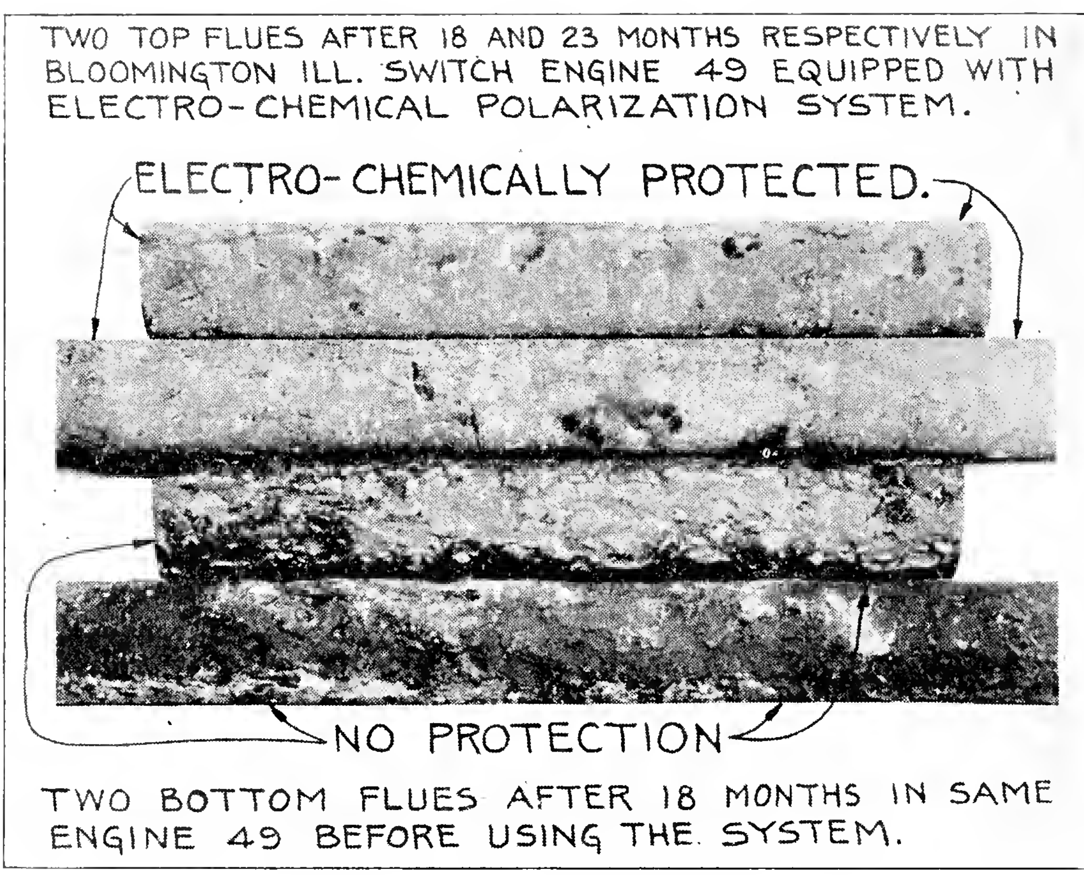


FIG. 4.

About 35 engines have now been equipped with this anticorrosion scheme and in every instance the boilers have been kept free from pitting, grooving and general corrosion. The iron pipe anodes on the boiler interior disintegrate and in a way are sacrificed to protect the boiler. The disintegration is slow due to the small current flow and it is only necessary to renew them about every four years.

A great deal of time has been spent in the development of apparatus that has permitted the practical application of our knowledge of the electro-chemical theory for the dissociation iron. However, the actual operating results have been gratifying and it appears as though the industrial worlds corrosion loses can be greatly reduced by using the Polarization Process or some modification of it.

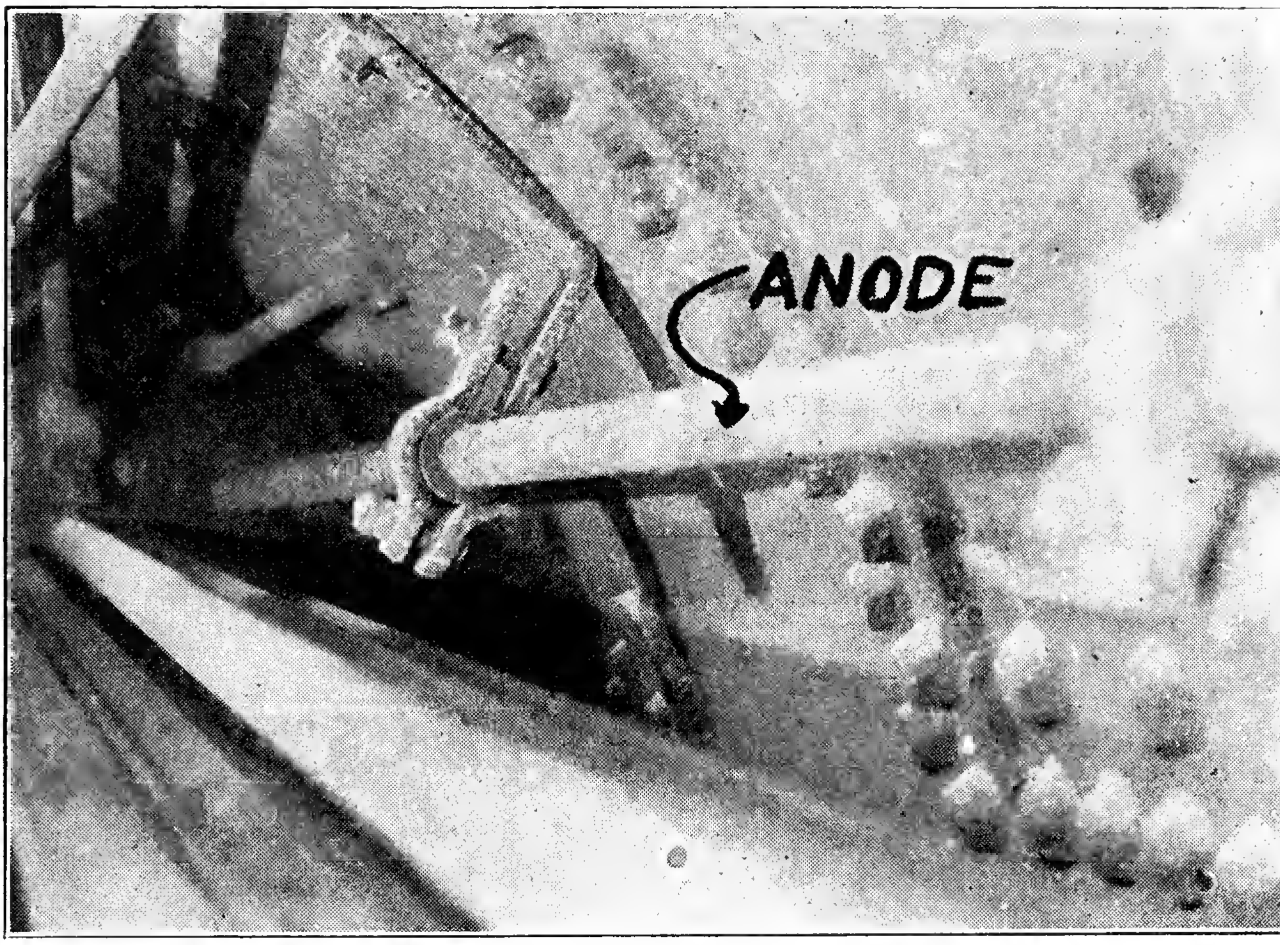


FIG. 5.

PAPERS IN GEOLOGY

THE PROBLEM OF THE MISSISSIPPI.

W. H. Haas, Northwestern University.

Engineers have expressed the opinion that the Mississippi challenges their profession as no other single problem. Geologists, with an equal regard for truth, might very well make an equally strong assertion. There is this difference, however, the engineers have studied their particular difficulties for nearly half a century; the geologists, on the other hand, have been busy elsewhere, seemingly, and have not produced a single high-grade study on the Mississippi that brings us any nearer to a solution of the problem. This seems the more strange since, unquestionably, the control of the Mississippi involves far more than engineering principles, and a permanent solution can be hoped for only when geologic principles are likewise taken into account.

Roughly, the suggested solutions of the problem, or problems, for their number is legion, may be thought of as falling into two main groups. The one tries to retard the waters before they reach the master stream. The soundness of this type of reasoning has been recognized, but much doubt has been expressed as to the feasibility and effectiveness of the various measures proposed, such as reforesting certain steep slopes, the building of storage reservoirs, and the like. The other group stands for a control of the waters after they once have started to move between high embankments down toward the Gulf. The river itself, by its building of natural levees, gave the suggestions for the present methods of control advocated and applied by the Army during the last 50 years. So tenaciously have the Army engineers held to the idea of "levees only" that to the popular mind the levee system is the only possible method of control. In the beginning it was undoubtedly the only method for the engineers to follow. It is perfectly natural also that with all the solicitation and care expended by them, for so long a time, that they should look upon the doctrine of "levees only" almost reverently. However, since the latest, not last, great disaster, the Mississippi River Commission has adopted an extension of the "levee only" policy. There are to be in addition spill ways, also controlled by levees, which are to be used only when the first line of defense shows signs of weakening. Whatever we may think of this method of control, it nevertheless places the engineer and all his work wholly on the defensive. There is no aggressive attack which looks to the time when man and not the river shall be master of the situation, and one seriously questions the possibility of ever finding a solution so long as this defensive attitude of mind prevails.

Based on geological principles, this policy should be replaced by a more aggressive policy. Nothing short of a complete solution should be sought and planned for. To this end the geologists, probably, will find no efforts so fruitful as those which look to the speeding up of the waters within the main channel. This possibility comes strikingly to the fore, with a study of the so-called improvements made by man, many of which unquestionably, have had the effect of slowing and piling up of the flood waters.

To appreciate the situation fully it must be remembered that the primary purpose of the Mississippi River Commission, organized in 1879, has been to keep a navigable channel during low water stages, and not to control the high waters. During the earlier period the Commission was definitely forbidden to use any funds for such a purpose unless by doing so a direct aid to navigation resulted. All the work done has been directed from that angle, and although effective in this, has disregarded the effect on the flood waters. The increasing heights of these recurring floods may and probably are due in part to uncontrollable causes; but, just as truly, are they due also to the efforts of maintaining at all hazards, and in all places, navigable depths.

To make this clear it may be permissible to bring to mind a few fundamental facts. We speak of a river being at grade when, on the whole, it is neither aggrading nor degrading. Such a stream, however, must have a certain amount of fall or gradient to do its work. Besides the work of moving the silt, it also expends some of its energy in friction and in overcoming obstacles. Having only a certain definite amount of energy to expend, determined by the volume and altitude of the water, the river's gradient, is determined by the energy expended. If this balance is disturbed for any reason the river at grade then becomes either an aggrading or a degrading stream.

Other things being equal the greater the gradient of a stream, the faster the water flows, the velocity increasing as the square root of the gradient, but the velocity in the various streams at grade does not bear a definite relation to the gradient. There are other controlling factors also, such as volume, friction, obstacles met, and the load carried. In whatever way energy is expended, it tends to slow up the velocity of streams flow no matter what the gradient, and if there is an additional expenditure, the river must silt up its bed and thus raise its waters to a sufficient height to maintain enough energy for the work required. A study of a number of rivers at grade shows that the gradients are strikingly unlike, because of the influences of some of the factors mentioned above.

It may be pertinent here to ask also what we mean by the gradient of a stream. Surely, not the bed over which the water flows. Were the lower Mississippi to dry up sufficiently to stop flowing the bed would become a succession of deep pools and dry stretches. It becomes manifest that not the bed of the stream, but the surface of the water becomes the datum plane for measurements of gradients. But as the water does not always stand at the same altitude in the stream bed there are an infinite number of gradients with high and low-water extremes. In the case of a river with an extremely low gradient the altitude of the body of water into which it flows must be taken into account also. As in case of the Mississippi, extreme low tide at the head of the passes is —2.5 feet with an extreme range of 3.9 feet. This must be taken into consideration when one is confronted with such facts as a low-water stage of 1.73 feet below mean gulf level at Carrollton, 111.5 miles from the Gulf. If mean Gulf level is taken as the datum plane, then this section of the river at low water would have a gradient up-stream of 0.186 inches per mile. This, of course, in general is an absurdity, but is possible under favorable conditions of tide and the special condition of a strong northwest wind blowing in the general direction of stream flow.

The variation in the gradients of streams at grade seems very large. Thus the low-water gradient of the Mississippi below Red River Landing near the mouth of the Red, a distance of 303 miles, is only 0.11 inches per mile. The Missouri of all the rivers studied has the highest gradient and strange as it may seem the lower 100 miles has the higher gradient of 12.24 inches per mile.

Certain definite conclusions, it would seem, with a good deal of confidence may be drawn from this somewhat semi-critical study on gradients. The balance between aggradation and degradation in stream flow is very delicate. The shifting from one basis to another does not require great changes. This becomes very evident when seemingly the most minor obstructions result in the depositions of enormous beds of silt in certain sections of a stream bed. Any sort of obstruction in the lower part of the river may result in the silting up of the entire section of the river at grade above it. Conversely also a slight lessening of obstruction in the lower part of the river may also cause a desilting of the bed for the entire distance above. The elimination of one of the lesser meanders where the water travels ten miles to go one, would at first increase the gradient in the cut-off ten times, instead of a gradient of 3 inches, it would have 30 inches fall per mile. Immediately, however, the headward cutting would begin and all other conditions remaining the same, this would ultimately lower some two feet the entire base of the graded channel above the cut-off.

The question naturally arises is the river now at grade or is it slowly silting up? Unfortunately there are no data available at present which give us any positive clue to the situation. The Commission insists it is not. Others from observation insist that it is. This, however, is a most vital part of the problem and all efforts should be made to find out the actual conditions

If we trust our reasoning the bed is silting up. (1) Long before man came to modify the stream flow, the lower Mississippi, presumably, was at grade. With the recurrence of the floods the bed, somewhat silted up during the low water stages, was scoured out and the silt spread out over the flood plain. Passing down over the flood plain the quieter waters after dropping part of their load were returned to the main channel by the next tributary, there again to get another load, to repeat the process. The stopping of this has forced the river to carry this part of the load down through the passes. (2) According to the Commission they have been successful in preventing any cut-off since their control. Before man's activity many cut-offs occurred as a study of the flood plain will show. Each cut-off shortened the river by just so much and increased the gradient for the time being, ultimately de-silting the river proportionately. (3) At present, in order to keep a navigable channel, dikes are built also in channels to concentrate the waters at the outer bends where the water is already deeper. This undercuts the banks, makes the meanders larger and the river longer, reduces the gradient and consequently must result in silting up the river above the part affected. (4) The great problem has been to keep the passes open to navigation where the river builds out into the Gulf at the rate of about 2000 feet annually. Jetties and walls are built in this section to narrow the channel and increase the water depth. However, by doing this, there is an increase in the length of the water flow and consequently a decrease in the gradient. As silt cannot be moved on a level surface, a silting up must take place to restore the equilibrium. Time does not permit the mention of other factors.

Were there such a thing as an efficient stream from the standpoint of transporting water effectively and economically it would have certain definite characteristics. Naturally its course would be straight. Its waters would be free from silt and flow over smooth surfaces. The wetted perimeter would be semi-circular in outline, and thus the river would be twice as wide as deep. The Mississippi at present is far from this ideal. It may not be vital to philosophize on its wide departures; but it is vital to consider whether at present it is departing still farther from this ideal through man's activities. If it is, and evidence seems to show that it is, then we are farther from the solution than ever before. The geologists can point the way to a solution and their duty is clear.

GEOLOGIC INTERPRETATION OF ANNA CITY WELL POLLUTION*.

L. E. Workman, Illinois State Geological Survey Division.

Introduction. At the request of the Central Illinois Public Service Company the State Geological Survey and the State Department of Public Health undertook an investigation of the pollution of the Anna City Well. The writer visited Anna on December 2d and went over the data with Mr. D. W. Johnson, engineer of the Central Illinois Public Service Company and Mr. J. Lyell Clarke, engineer of the Department of Public Health stationed at Carbondale. This paper deals with the geologic aspect of the problem and gives suggestions toward preventing the contamination.

Collected Data, City Well. The city well belongs to the Central Illinois Public Service Company and is situated on their property in the eastern part of the city, about 100 feet northeast of the electric plant between Vienna Street and the Illinois Central Railroad. The well was drilled in 1904 and is reported to be 550 to 650 feet deep. It has 100 to 135 feet of 12-inch casing at the top and the lower part is an uncased 8- or 10-inch hole. It was drilled all the way in limestone. Considerable difficulty was experienced in getting through the upper part because the casing had a tendency to hang on the rock. On December 1st the water stood at 92 feet when not being pumped, and on December 2d at 94 feet. Mr. Johnson says that it pumps down to 113 feet in summer when giving about 500 gallons per minute.

A test was made on December 2d to determine either the length of the casing or the depth at which a leak occurs in the casing. Air was run into the well at 80 pounds per square inch pressure. The pressure gauge, connected to the air pipe on the side of the valve next to the well, immediately registered 10 pounds upon turning on the air. This pressure continued during the first 60 seconds. It then rose slowly until at the end of 3 minutes and 45 seconds it stood at 18.8 pounds where it remained stationary. At the end of 5 minutes the air was turned off and the pressure immediately dropped to 15.8 pounds from which it very gradually fell off, being at 15.0 pounds 5 minutes

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later. 15.8 pounds per square inch is therefore taken to be the weight of a column of water depressed to permit the escape of air at the bottom. The computed length of this column is 36.4 feet. The outlet of the air is therefore at 94 plus 36.4 equals 130.4 feet depth. Since the casing was reported to be between 100 and 135 feet in length, this figure probably represents its true length.

It was noted by Mr. Perrine, of the Central Illinois Public Service Company that, while the last well at the State Hospital

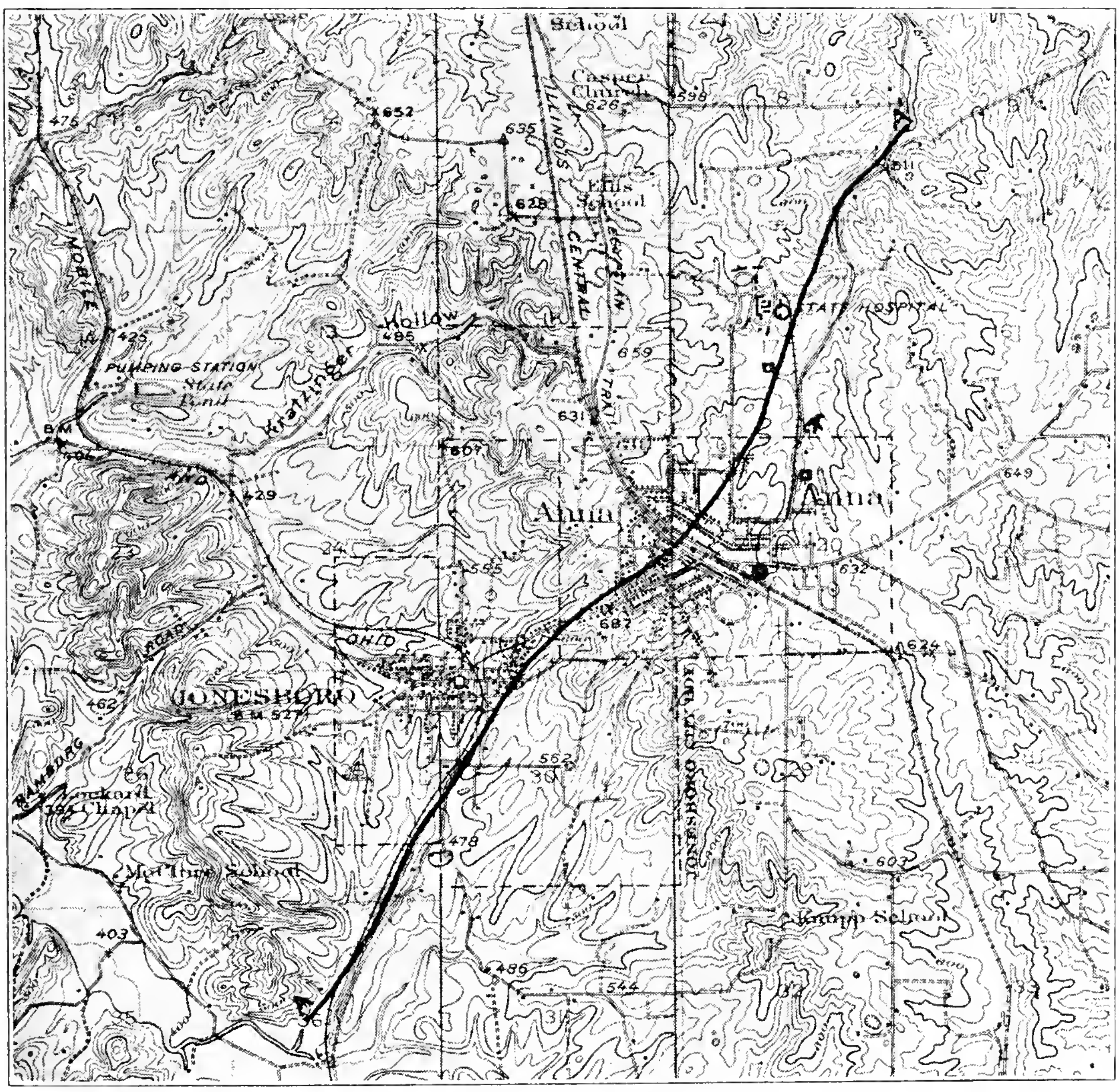


FIG. 1.—Solid circle, city well; open squares, septic tanks; open circle, hospital well; cross, quarry; AA[1], line of cross-section.

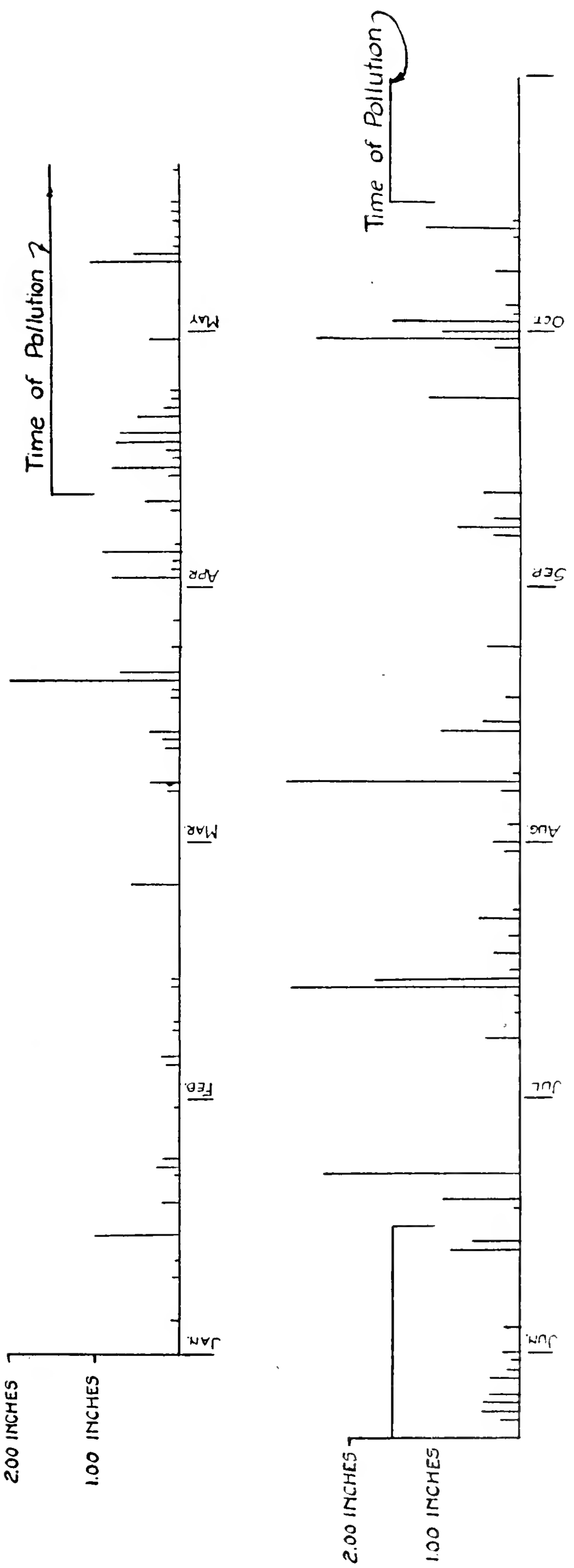
was being drilled, the water in the city well contained reddish clay and silt. He also states that when the pump is started after a few days of idleness this same reddish clay and silt shows up.

In an attempt to locate the source of contamination, and suspecting a certain sink hole at the Hospital into which the sewage from a dwelling was emptied, a small amount of fluorocene was poured into the suspected sink hole. None of it however was ever detected in the city water. To test whether or not there is a downward movement of water from the creek, 25 feet east of the well, a hole was bored a foot deep in the bottom of the creek and a small amount of fluorocene was poured into it. None of this showed up in the well water.

Old Ice Plant Well. A well was drilled in 1897 at the ice plant about 330 feet southwest of the city well by Mr. Halderman, a driller of Anna. The well is not used now except in an emergency. Mr. Halderman states that the well was about 300 feet deep entirely in limestone. The limestone contained much chert, making drilling difficult. There were some crevices in the upper part and at the bottom a crevice 4 or 5 feet deep was entered. The driller poured two wagon loads of gravel into the well in order to fill up the crevice and continue on down with the hole, but, since all the gravel disappeared with no effect, further drilling had to be stopped. The well yielded 60 gallons per minute. Approaching storms raise the height of the water in the well, and it becomes muddy. The water also contains reddish silt when pumping is started after a period of idleness. Mr. Halderman states that the water in a Hospital well became riled when this well was being drilled. Hospital employees however do not remember this incident

State Hospital Wells. The State Hospital is located 1¼ miles north of the city well. Several wells have been drilled on the property, none of which was very satisfactory. According to Mr. Alexander, of the machine shop, a well over a thousand feet deep was of small bore and produced little water. The last well was drilled by Buck Wilson in 1910 to a depth of about 500 feet. The top casing is 14 or 16 inches in diameter and about 50 feet long. Below this there is no casing and the well tapers down to 8 inches in diameter. Mr. Alexander was there at the time of drilling and states that the city water became riled when the lower part was being drilled. The well was finally abandoned because it did not supply sufficient water.

The Hospital then pumped water from a spring in a draw one quarter of a mile south. To insure a continuous supply a reservoir was constructed in a sink hole west of the Hospital. In dry weather the water was allowed to run into an open sink hole coming out lower down in the spring. It took half a day for the water from the reservoir to affect the water in the spring.



RELATION OF RAINFALL TO POLLUTION

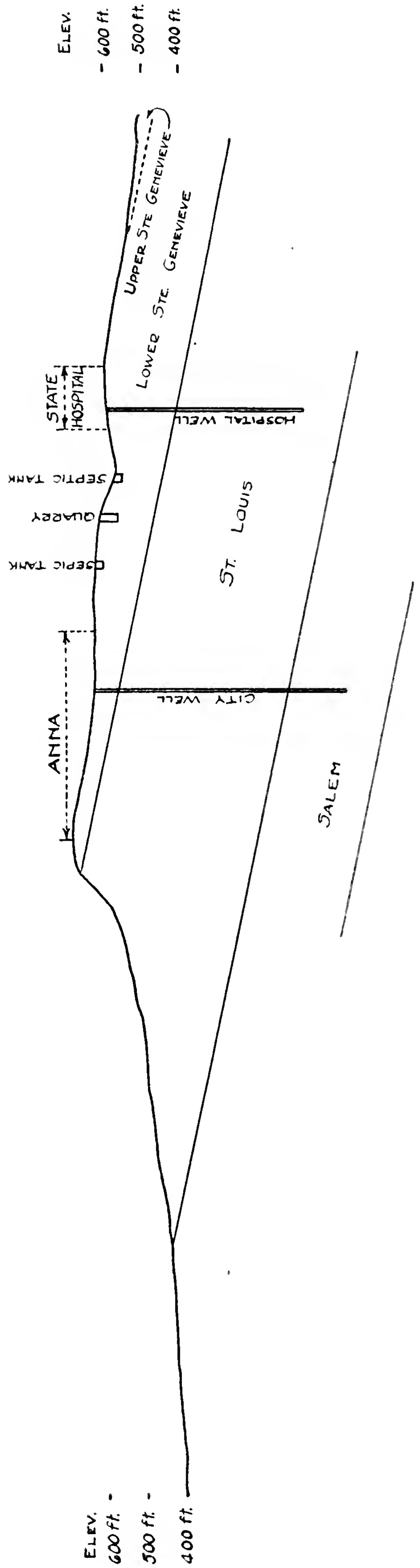
FIG. 2.

City Sewage. At present a septic tank of the city sewage system is located just across the stream from the old spring south of the Hospital. The overflow runs eastward down the draw on bed rock to the upper part of Cache River which flows northeastward from Anna. Another septic tank is located in the bottom of the valley of Cache River a few hundred feet south of the north boundary of the City. The overflow runs out in Cache River over bed rock.

Limestone Quarry. A limestone quarry about 50 feet deep is located just north of the northern city boundary and a few hundred feet east of Cache River. The faces of the quarry show joints in the rock running N. 10°W. and N. 45° W. The upper beds have many solution cavities more or less filled with red clay and silt. Drillers in the quarry state that most of the water enters the quarry from the north side and especially from the northwest corner.

Contamination. Contamination of the water in the well has been reported by the State Department of Public Health as far back as 1921, but was first noticed recently on April 11, 1927. This continued until the middle of June. It again showed up in the middle of October and was present at the time of investigation. The accompanying chart shows the relation of the rainfall to the periods of contamination from January 1st to November 1st. A heavy rainfall on March 19th followed by another good rain on the 20th indicates that on these two days the rainfall was probably continuous and soaking. During April 2d to 10th a wet season is indicated. Contamination showed up on April 11 or 22 days after the first heavy rains. From June 4 to September 28 there were several heavy rains recorded, but the weather was clear before and after, indicating that in most cases they were more in the nature of downpours with quick run-off. On September 22 came a single rainy day, followed six days later by heavy, more or less continuous rains for four days. Contamination showed up October 15, or 23 days after the first of the series.

Geologic Situation, Topography. As shown by the accompanying topographic map, figure 1, Anna is situated on an upland which has a general slope to the northeast. Elevations in the city range from 670 feet in the southwest to 620 feet in the northeast. The top of the well stands at about 600 feet. Cache River has its source about a mile south of the well and flows



Cross Section Along 'A-A' Through Anna, Illinois

FIG. 3.

north and northeast past the well and east of the State Hospital. The bed of the stream reaches an elevation of 525 feet about 1½ miles northeast of the well. West and southwest of Anna the surface slopes steeply from the upland to the tributaries of Dutch Creek. The streams reach an elevation of 500 feet in less than 1½ miles southwest of the well and 400 feet 3 miles southwest.

The accompanying cross-section, Figure 3, is drawn from southwest to northeast through Anna and the State Hospital as shown by the reavy line on the map. The verticle scale is exaggerated to 7½ times the horizontal.

Geologic Structure. All rock formations in the region have a general dip of 2 to 5 degrees per mile in a northeasterly direction. Outcrops of the various formations therefore extend across the area in a northwest-southeast direction with the youngest beds outcropping to the northeast.

Formations. The Ste. Genevieve formation underlies the whole city of Anna in a belt about three miles wide. The northeastern limit is about a mile northeast of the Hospital and the southwestern is along the brow of the steep slopes west of the city. The formation is divided into two parts. The upper Ste. Genevieve lies just northeast of the Hospital and consists of 100 feet of interbedded shales, sandstones, and limestones. The shales are impervious to the motion of ground water and, since they dip northeast, form a barrier to all movement below the highest shale bed outcropping in the bed of Cache River. The lower part of the Ste. Genevieve consists of about 200 feet of nearly pure limestone. This limestone outcrops in the quarry and at various places along Cache River and its tributaries north of the city. The quarry faces show the presence of solution cavities and joints, and regions directly underlain by this formation have sink holes.

Below the Ste. Genevieve is the St. Louis limestone which outcrops in the steep slopes west of Anna and in a large area two to eight miles southeast of the city. It consists of 400 feet of very cherty, bluish, fine-grained limestone. The area of outcrop southeast of Anna is characterized by numerous sink holes, and it is reported that there are many springs flowing out of the formations along the steep slopes west of Anna. The large cavity found in drilling the ice plant well is in the St. Louis.

The Salem limestone lies under the St. Louis. It is gray, crystalline and oolitic, and fairly pure, and has a thickness of 200 or more feet. Outcrops are found in the Jonesboro region west of the St. Louis limestone outcrops. Solution cavities and sink holes indicate that the formation permits the movement of underground water. The city well, if it is 650 feet deep. extends 100 to 150 feet into the Salem.

Interpretation of Pollution, Ground Water Movement in the Limestone. All the formations described are characterized by sink holes and cavities. These were first produced by the solution of the limestone during slow percolation of water along joint planes and relatively porous parts of the rock. It is a common observation that joint planes are very important in determining the direction of movement of the water, and it might therefore be expected that the ground water in the Anna region flows along lines N. 10° W. and N. 45° W. Drainage factors however are very important in producing a change in direction of flow in this region.

The ground water table conforms in a general way to the variations in the topography of a region. Being the upper surface of a liquid, however, it has the tendency to flatten out, sinking lower under the hills and flowing out on the surface in springs and as seep water along streams. There are two major drainage systems into which the ground water may flow. These lie on either side of the northwest-southeast divide through the western part of Anna. The surface drops off with much steeper slopes to the southwest than to the northeast, so that three miles southwest of the divide the outlets may be at an elevation of 400 feet above sea-level whereas the closest lowland to the northeast is the Cache River valley at an elevation of 500 feet in the same distance. The elevation of the northeastern outlet may even be up to 525 feet due to the impervious beds of shale which prevent lower movement to the northeast. To the southeast the elevation reaches 400 feet about six miles away. Thus it seems very probable that because of the nearness of the outlets in that direction and in spite of the joint system which often governs the direction of ground water movement, the general movement under the city is to the southwest.

Evidence of the relatively large amount of drainage to the southwest is given on the topographic map, where numerous permanent streams are shown to flow out from the steep slopes in that direction, whereas Cache River is the only permanent stream on the map northeast of the surface divide. Other evidences of such a direction of drainage are the movement of ground water into the quarry from the north side and the fact that while the last hospital well was being drilled the city water became muddy.

Source of pollution. Pollution of water in the city well may come from the vicinity of Anna in close proximity to the well or from the region to the north and northeast.

If from the city close to the well, pollution comes from that portion north and east of the well or within a block around the well. Movement of the underground water below the level of the stream, which is about 600 feet at the well is probably in a general southwesterly direction although the water may follow the joints in a S. 10° E. direction for a short distance before finding a channel to the west. It cannot be definitely stated that local currents would not bring water from any direction within a limited distance of perhaps a block from the well. It is possible however that such water cannot get to a depth of 130.4 feet to enter the well below the casing, for the general movement westward would tend to carry it away before it could get that deep.

It is more probable that pollution comes from the region to the north and northeast. Here also the exact source of the pollution has not yet been determined, but it seems altogether likely that it is the water from the septic tanks which overflows and runs downstream on bed rock. The more southerly of the two tanks is between the well and the quarry and seepage from the overflow may be expected to follow the movement of the water as seen in the quarry.

Relation of Rainfall to Pollution. Pollution seems to show up only after heavy and continuous rains. This may be explained in two ways.

First, it is possible that ground water flowing from the region of the septic tanks to the well follows a different course in wet seasons from the one taken in dry seasons. As in the case of surface drainage in times of flood, the main channels cannot carry all the flow and the water must seek other lines. Thus the polluted water may be in the nature of flood water from the main streams.

Second, the underground seepage from the septic tanks may in dry seasons have outlets to the northeast, east, or southeast but in wet seasons flow to the southwest. Naturally the outlets to the southwest do not drain the entire region and a ground water divide exists somewhere northeast of the surface water divide, conceivably in the general region of the septic tanks. In wet seasons the ground water may be so backed up by the small size of solution channels, by a limited number of openings, or by the greater friction encountered in traveling underground for a long distance to the outlets, that easier exit is found to the southwest. Blocking of the water in this way may serve to shift the location of the underground water divide to the northeast during the period of saturation changing the direction of flow from the septic tank. Comparison of the time of appearance with the times of heavy and continuous rainfall (Figure 2) suggests that the length of time necessary to bring about such a change in conditions and the movement of the polluted water to the well is about 22 or 23 days. This interval may also explain the fact that only while the last of the 500-foot well was being drilled at the Hospital did muddy water appear in the city well.

Recommendations. It is recommended that the casing in the present well be continued on down as far as possible without shutting off the water supply. If contamination comes from the near vicinity it cannot go deeply into the ground water before it flows off to the west or southwest. If from the septic tanks it may enter at any depth in the well because of the varying elevations of the solution channels. But since the outlet is not below 400 feet elevation and the bottom of the well is about 50 feet below sea-level, the contamination is most likely to come in in the upper part. There is doubtless some vertical diffusion, and mixing because of the action of the pump, but the danger decreases rapidly with depths below 250 feet.

Any well drilled in the future should also be cased as far down as possible. To make it very safe the location of a new well should be over half a mile east of the present location. This will place the well away from a southwesterly flow from the septic tanks.

To test whether contamination comes from the neighborhood of the well a dye should be introduced around the casing to see if the upper ground water enters the well. If pumping draws the dye into the well, it may reasonably be assumed that some private cesspool in the vicinity is giving the trouble. If the dye does not appear, the possibility is not eliminated, but the chances are small that pollution from this area is able to reach 130.4 feet depth.

In case contamination shows up continuously in the future or is likely to prove dangerous in any way the septic tanks should be moved to a new location. The best location is in the bed of the stream flowing southward through the eastern half of sec. 30. T. 32 N., R. 2 W., half a mile south of the city. A second but not so desirable location would be in Cache River at least a mile northeast of the State Hospital.

NEBRASKAN TILL IN FULTON COUNTY, ILLINOIS.[1]

HAROLD R. WANLESS, UNIVERSITY OF ILLINOIS AND
ILLINOIS STATE GEOLOGICAL SURVEY.

The records of five glacial epochs in the Pleistocene period are preserved in the Mississippi Valley. These are, beginning with the oldest, Nebraskan, Kansan, Illinoian, Iowan and Wisconsin. The deposits of the Wisconsin, Iowan and Illinoian glaciers cover extensive surface areas in Illinois, but pre-Illinoian glacial deposits, which were overridden and buried by the ice of one of the three later glacial epochs, are known in Illinois only from scattered exposures. Buried pre-Illinoian till, usually assigned to the Kansas epoch, is known in western Illinois.

During the mapping of the Havana quadrangle for the State Geological Survey, two exposures were discovered in the southern part of Fulton County, which show evidence of three distinct tills in an area where the youngest till is known to be Illinoian in age. The interpretation offered is that the two buried tills represent both of the pre-Illinoian epochs of glaciation, the Kansan and the Nebraskan. These are the first exposures so far known in Illinois in which the Nebraskan age of a till has been proved by its relations to two later tills. Other exposures in eastern Illinois have been considered Nebraskan in age, although they directly underlie the Illinoian till.

Acknowledgment is made to Mr. H. B. Willman, who assisted in the mapping, and discovered one of the exposures, and to Dr. M. M. Leighton, Chief of the State Survey, who visited these exposures with the writer, and has made many valuable suggestions for their interpretation.

Recognition of Buried Drift Sheets.

The presence of glacial deposits older than those of the last glacier which covered this area is proved by: (1) a buried soil profile[2] on the older drift, (2) loess on the older drift, (3)

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[2] The soil profile has been recently classified into zones, as follows: (1) an A zone in which the material is completely oxidized and leached of calcareous matter, usually dark colored and loose in texture; (2) a B zone, which is completely oxidized and leached, and is compact in texture; (3) a C zone, which is completely oxidized and leached, with a texture intermediate between the A and B zones; (4) a D zone, which is oxidized and calcareous; and (5) an E zone, unoxidized and calcareous, the unaltered material.

weathered sands, gravels, or water-laid silts on the older drift, and (4) calcareous and unoxidized till overlying the interglacial materials.

A comparison of the pebble counts made from glacial tills of different ages shows the proportion of different kinds of rocks present, thus giving information as to the kind of bedrock over which the glacier advanced, and therefore information as to the direction from which the ice came. Such pebble counts were made of the three tills described below.

Pleistocene Succession of Southern Fulton County.

The complete succession of glacial and interglacial epochs in the Mississippi Valley, as known at present, together with their representative deposits in Southern Fulton County, is as follows:

Wisconsin glacial epoch (outwash sands and silts, and wind-deposited loess).
    Peorian interglacial epoch (wind-deposited loess).
Iowan glacial epoch.
    Sangamon interglacial epoch (wind-deposited loess, weathered before Peorian time).
Illinoian glacial epoch (glacial drift, sand, gravel and loess).
    Yarmouth interglacial epoch (wind-deposited loess, silt, sand and gravel).
Kansan glacial epoch (glacial drift).
    Aftonian interglacial epoch (sand and loess).
Nebraskan glacial epoch (glacial drift).

Description of Exposures.

The Illinoian glacier was the last to cover Fulton County, and its till is present over nearly all the area. There are two exposures in which two pre-Illinoian tills have been recognized, (1) in a ravine on the west side of Otter Creek in the N. E. ¼ N. E. ¼ Sec. 5, T. 3 N., R. 3 E. (Kerton) and (2) in a ravine on west side of Otter Creek in the S. W. ¼ S. E. ¼ Sec. 32, T. 4 N., R. 3 E. (Isabel). The second exposure is about one-half mile northwest of the first, and each of the exposures is within one mile of the hamlet of Enion. The locations of these exposures are marked on the accompanying sketch map (fig. 1).

Exposure (1) in ravine in Sec. 5, T. 3 N., R. 3 E.

The succession of Pleistocene formation in the largest ravine in the N. E. ¼ Sec. 5, T. 3 N., R. 3 E. (Kerton) is described from a short gully (a) on the south side of the ravine about 200 feet northeast of the junction of three main head forks, and (b) from a cut bank on the north side of the ravine about 200 feet northeast of the gully section.

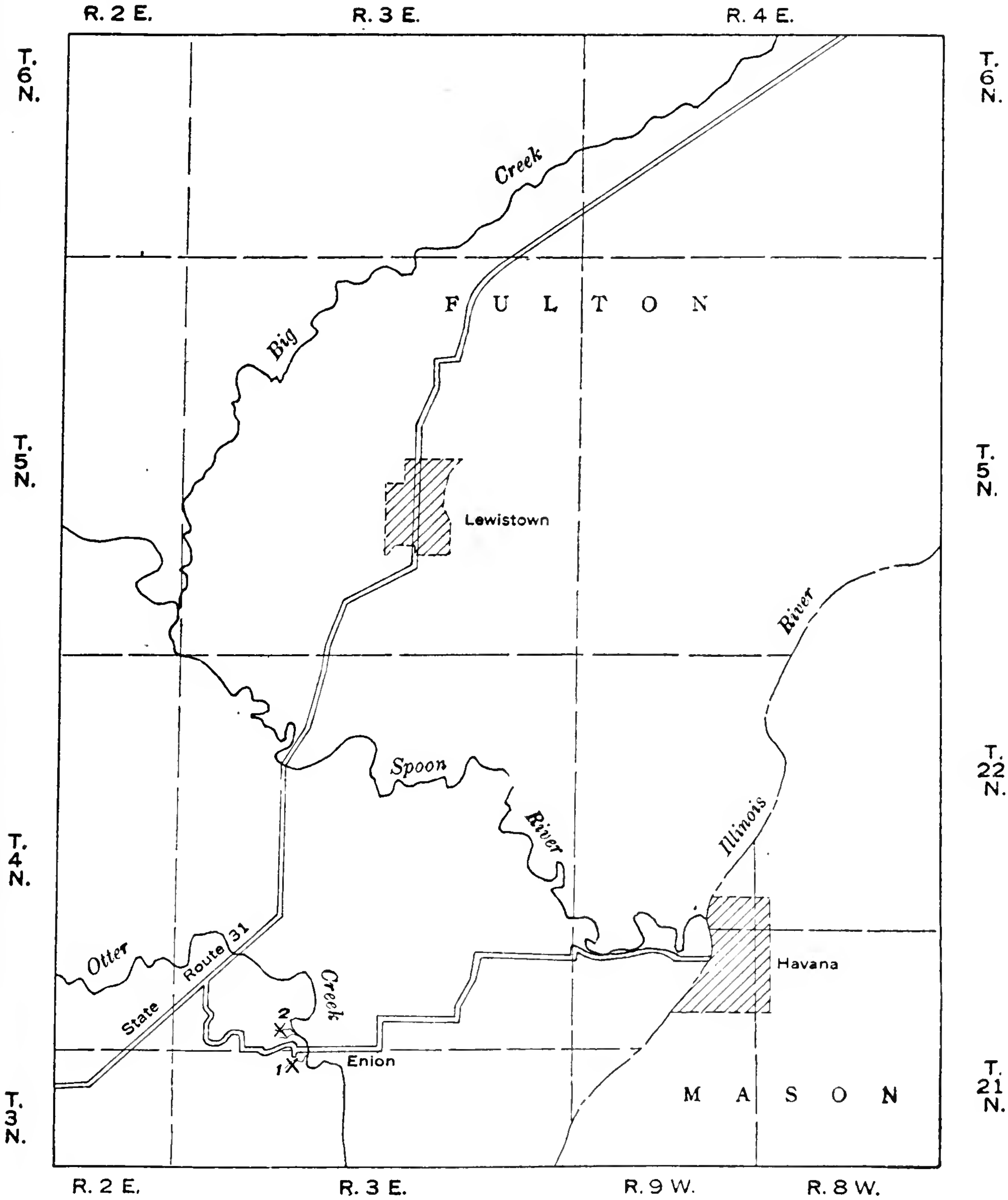


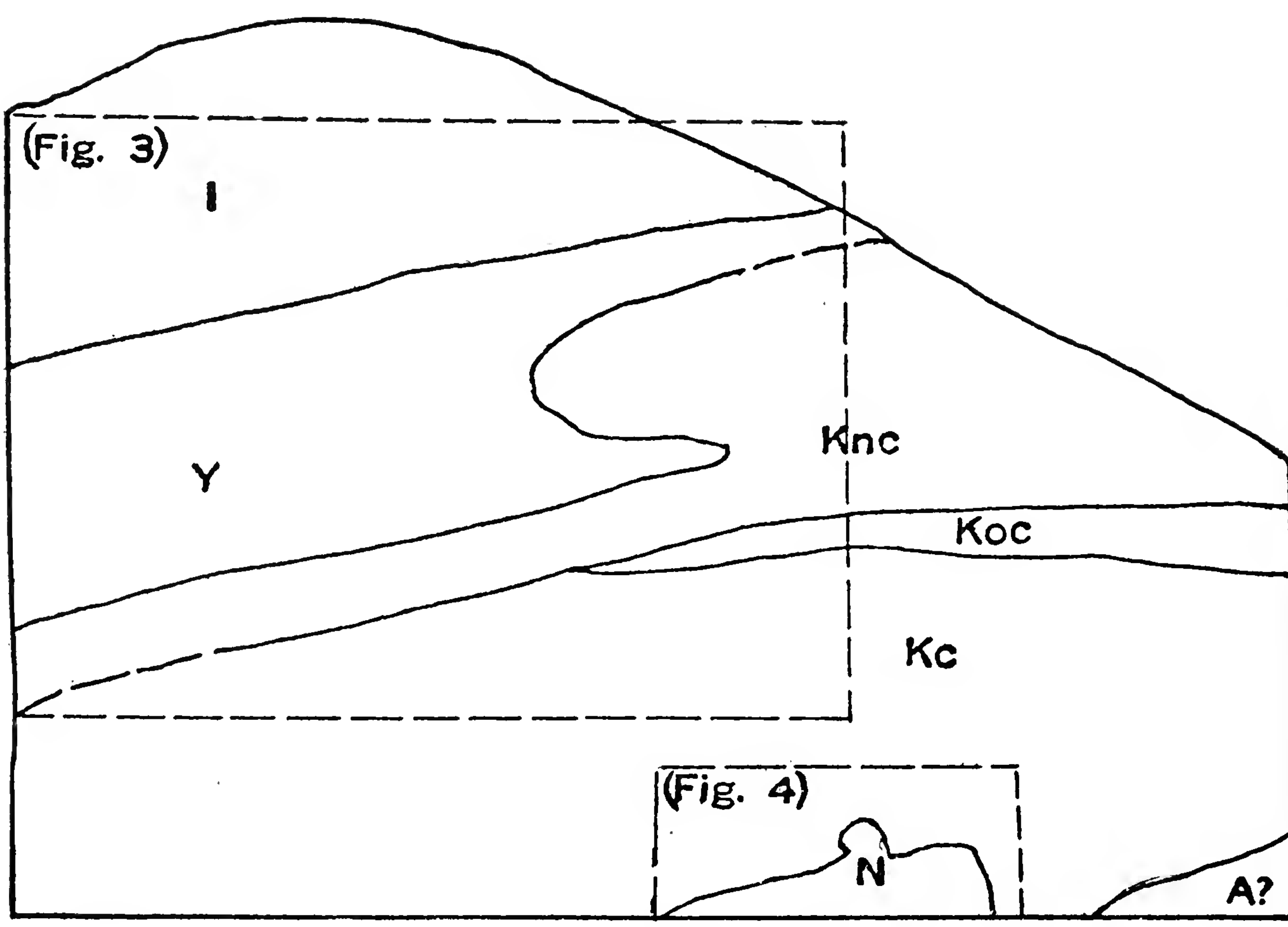
FIG. 1.—Outline map of Havana quadrangle, showing locations of exposures of Nebraskan till described in this paper, and routes by which they may be reached from Havana or Lewistown, Illinois.

The gully exposure (a) shows the following beds:

	Thickness Feet	Thickness Inches
Peorian and Sangamon—		
Loess and silt, loess-like, poorly exposed	25	
Illinoian—		
Till, calcareous, gray, upper part covered	8	
Gravel, calcareous, well assorted		6-12

	Ft.	In.
Silt, calcareous, gray, fine grained; compact; non-fossiliferous; not distinctly bedded (resembles a loess in texture and structure); weathers to yellowish brown	1	6
Till, interbedded with assorted sand and gravel, reddish brown	2	
Till, calcareous, light gray	5	
Gravel		6
Yarmouth—		
Silt, calcareous, dark gray, compact; fossiliferous (fauna of 16 terrestrial gastropods); weathers to brown; bedding contorted (by shove of Illinoian glacier) lower portion contains inclusions of brown oxidized till (Kansan?) and lenticular masses of sand and gravel	10	

The beds exposed in the cut bank (B) about 200 feet down stream from the above gully are described below and illustrated in figures 2, 3 and 4.



I	Illinoian till, calcareous
Y	Yarmouth fossiliferous loess
Knc	Kansan till, noncalcareous
Koc	Kansan till, calcareous, oxidized
Kc	Kansan till, calcareous
A?	Aftonian? sand, calcareous, oxidized
N	Nebraskan till, calcareous, oxidized

FIG. 2.—Diagram of cut bank on north side of ravine near center of NE ¼ sec. 5, T. 3 N., R. 3 E. (Kerton.) Areas included in figures 3 and 4 are outlined with dotted lines.

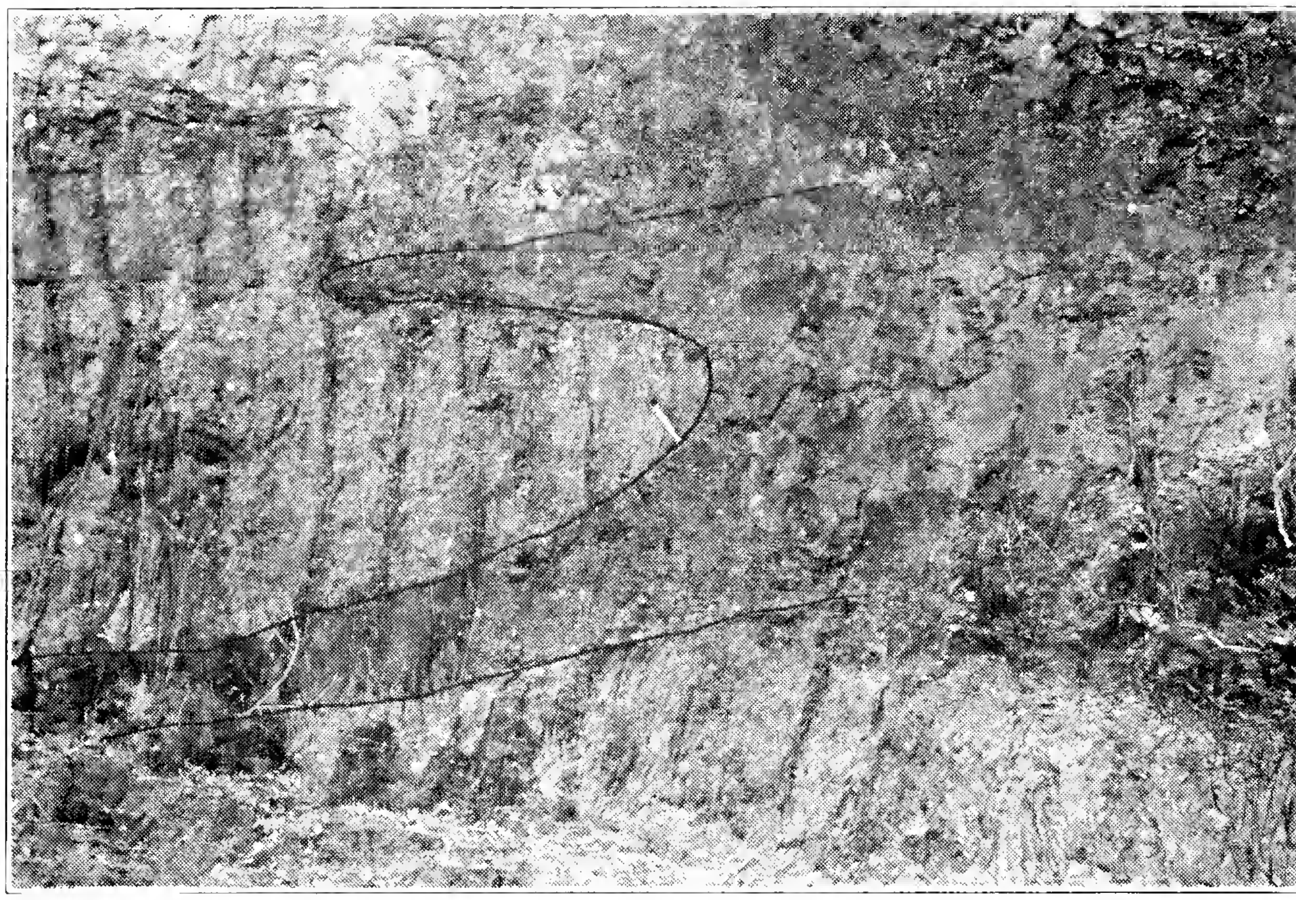


FIG. 3.—Upper portion of cut bank sketched in figure 2, showing dark compact fossiliferous late Yarmouth loess, lying between calcareous Illinoian till above and non-calcareous till below. Yarmouth silt is outlined.

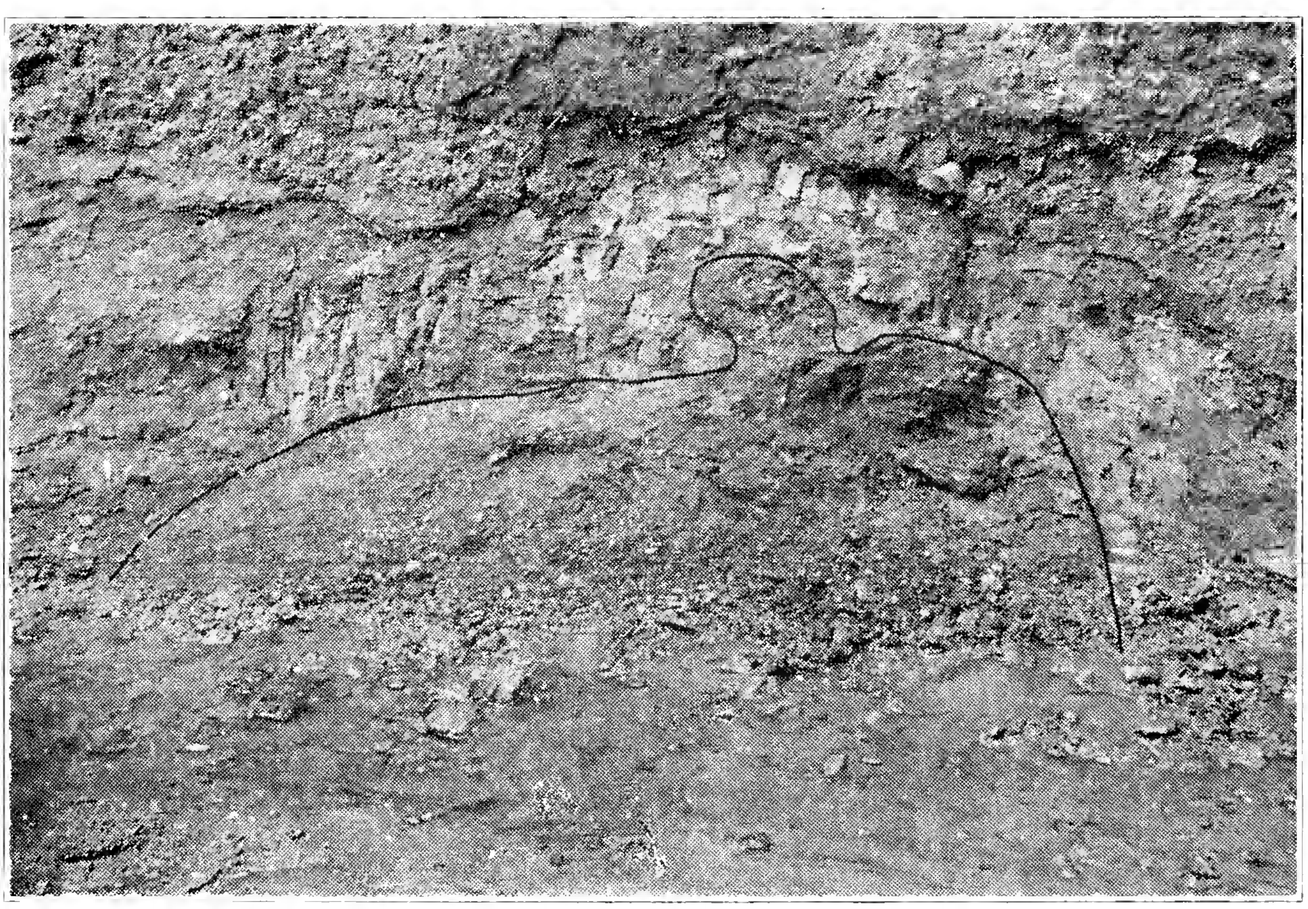


FIG. 4.—Detail of lower portion of cut bank sketched in figure 2, showing rolled mass of calcareous oxidized Nebraskan till incorporated in unoxidized calcareous Kansan till.

	Thickness Feet	Inches
Top of bank covered with vegetation and slumped soil......	3–4	
Illinoian—		
Till, calcareous, light gray..........................	12	6
Yarmouth—		
Calcareous concentration, white, in clay...............		1
Silt, calcareous, bluish to dard blue-gray, compact, fossiliferious (containing a loess or terrestrial fauna); not distinctly bedded; contains numerous iron stained concretions of irregular shape as large as 1 foot 6 inches diameter; weathers to dark chocolate-brown; smoothed upper surface; shows a lenticular mass of noncalcareous Kansan till thrust into it (fig. 3)..	6	
Kansan—		
Till, noncalcareous, gray (B or C zone of buried soil profile); including 3-foot lenticular mass thrust into Yarmouth silt	6	6
Till, calcareous, rusty colored (D zone of buried soil profile)		6
Till, calcareous, dark blue-gray, to stream level........	3	3
Aftonian?		
Sand, calcareous, yellow-brown (at east end of cut)....	2	
Nebraskan—		
Till, calcareous, oxidized, brown; a rounded ball with projecting knob, surrounded by dark blue-gray, unoxidized Kansas till (figs. 2 and 4).		

About 200 yards east of the above cut, yellow-brown, calcareous Aftonian (?) sand is exposed above brown oxidized, calcareous till, like the rolled ball of Nebraskan till incorporated in the Kansan till.

Exposure (2) in ravine in Sec. 32, T. 4 N., R. 3 E.

The succession of Pleistocene formations in the ravine west of Otter Creek in the N. W. ¼ S. E. ¼ Sec. 32, T. 4 N., R. 3 W. (Isabel) is described from (a) a sharply cut gully on the west side of the ravine, (b) outcrops along the ravine about 150 yards below the gully and (c) a high cut bank on the southwest side of the ravine at the lower end of the main ravine outcrop (b).

The gully exposure (a) shows the following beds. The top of the cut in the gully is 22 feet below level upland.

	Thickness Feet	Inches
Peorian—		
Loess, noncalcareous, gray, buff above; with reddish brown spots along joints and root canals..........	3	4
Loess, calcareous, gray; some ferruginous concretions and a few kindchen	7	6

Sangamon—		
Loess, noncalcareous, reddish; some carbonized wood fragments; lower surface dips north.........	3	3
Illinoian—		
Silt, slightly calcareous (probably around local centers such as root canals); pink and gray laminated; pebble concentrated at top; thins and disappears to north	1	
Till, noncalcareous, brownish-gray (B zone of buried soil profile	2	9
Sand and gravel, noncalcareous.......................	2	6
Till, slightly calcareous above, more calcareous below; reddish brown; (lower part of C zone and D zone of buried soil profile	1	6
Till, calcareous, light gray..........................	15	
Yarmouth—		
Sand, noncalcareous, yellowish, very fine; gravel concentrate at top..................................		6–8
Gravel, noncalcareous, brownish; including some beds of coarse reddish sand............................	5	6

About 100 feet west of this gully up main ravine, one foot of gray calcareous silt or loess overlies sand and fine gravel corresponding in altitude to the Yarmouth beds above.

The exposure along the main ravine (b) below the side gully shows the following beds below those described in (a):

	Thickness	
	Feet	Inches
Yarmouth—		
Gravel and sand, noncalcareous, brown and reddish-brown; similar to but below basal bed in (a)....	10	
Kansan—		
Till, calcareous, dark gray, bouldery; deformed into sharp folds (by shove of Illinoian glacier, see fig. 6); containing the following kinds of inclusions: (1) numerous large blocks of well preserved wood (fig. 5); (2) large blocks of thoroughly oxidized and leached till (Nebraskan); (3) numerous blocks of blue-gray, calcareous, fossiliferous loess (Aftonian); and (4) numerous blocks of dark forest soil, with small fragments of carbonized wood....	12	

The exposure in the high cut bank (c) on the southwest side of the ravine is as follows. (Figs. 6 and 7.)

	Thickness	
	Feet	Inches
Recent—		
Soil and slump..	2	
Kansan—		
Till, with slight concentration of sand and gravel above; calcareous, dark blue-gray; rests on very irregular surface inclined toward west.....................	12	
Nebraskan—		
Till, noncalcareous, brownish-gray; including a large mass 2 feet 6 inches thick, projecting into sand below; separated by sharp contact from till above (Figs. 6 and 7)................................	1–1	6

FIG. 5.—Kansan till contorted into sharp folds by overriding Illinoian ice, in bank of the same ravine shown in figure 5.

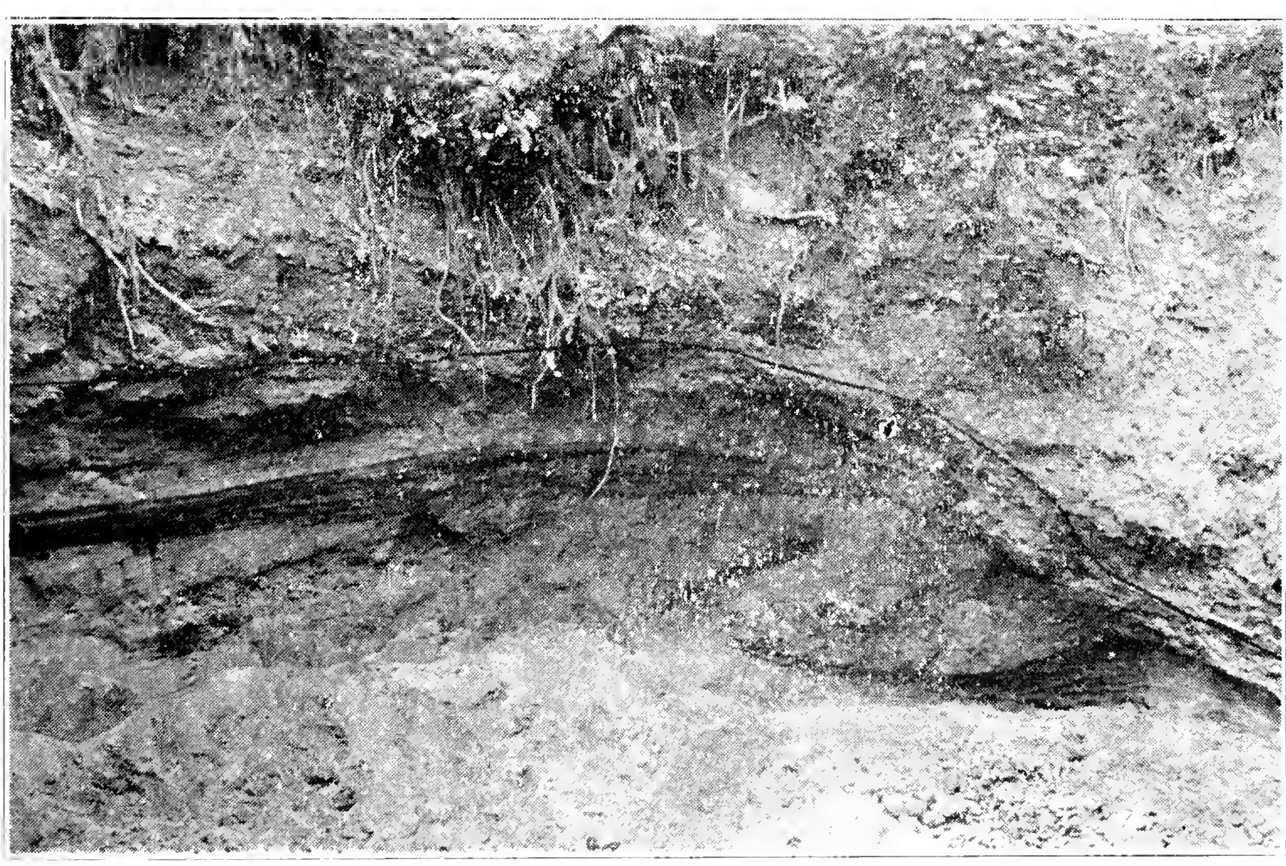
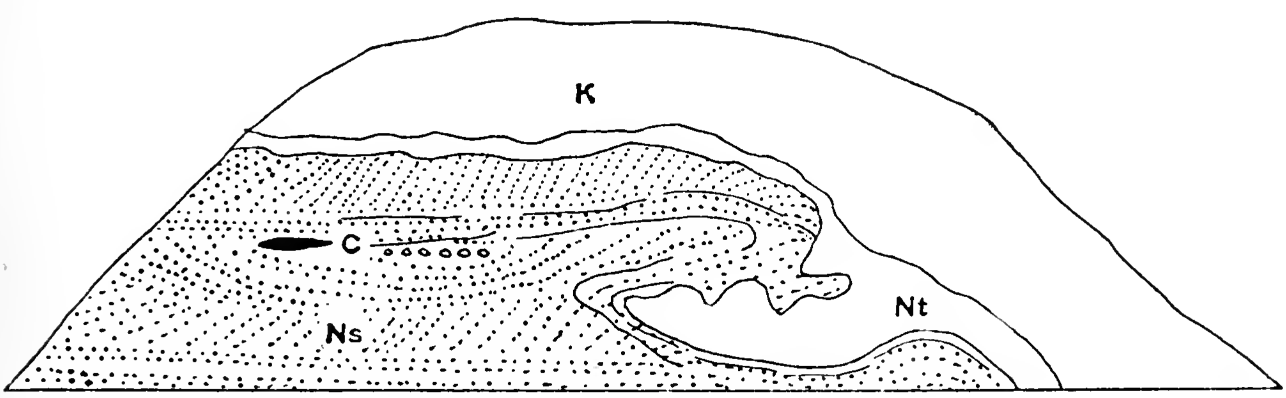


FIG. 6.—Photograph of cut bank exposure sketched in figure 7. The boundary between the Kansan and Nebraskan tills is marked by a line.

Sand, noncalcareous, light buff, somewhat cross-bedded; foreset beds dip east; includes several lens-like masses of weathered coal	2	
Gravel, noncalcareous, lenticular	1	
Sand, noncalcareous, to base of cut	4	
Till, noncalcareous, brownish; exposed by digging; may be lenticular		6

Between the cut described above and the lower end of the ravine there are several remnants of terrace deposits, formed during the early Wisconsin glacial stage, and consisting of finely laminated fossiliferous silts and sands.



K Kansan till, calcareous
Nt Nebraskan till, concalcareous
Ns Nebraskan cross-bedded sand, non-calcareous, with iron stains
C Coal, weathered

FIG. 7.—Diagram of cut bank on southwest side of ravine in SW. ¼ SE. ¼ sec. 32, T. 4 N., R. 3 E. (Isabel), showing unoxidized calcareous Kansan till overlying oxidized non-calcareous till and cross-bedded sand. Figure 6 is a photograph of this cut bank.

Comparison of the Illinoian, Kansan and Nebraskan Tills.

In the absence of striated surfaces on the bed rock and lack of systems of morainic ridges, the most satisfactory data on the direction of advance of an ice sheet may be obtained from a study of the rock fragments incorporated in the till. A pebble count is made by lining out an area of one or two square feet and picking up all pebbles larger than the size of a pea within this area. This gives representative proportions of the different kinds of rocks incorporated in the till.

Fresh till in this region is calcareous. A noncalcareous till has been leached of all of its limestone and dolomite pebbles and many sandstone and shale pebbles have also become disintegrated, hence its pebbles consist principally of the rocks which are most resistant to weathering, such as quartz, chert, and igneous and metamorphic rocks.

Pebble counts were made from the Illinoian and Kansan tills in the first ravine and from all three tills in the second ravine. The pebble count from the Nebraskan till can not be closely compared with those from the other tills because the Nebraskan is noncalcareous where the pebble count was made, whereas the other tills are calcareous. The percentages of rocks in the Illinoian and Kansan tills were recalculated excluding the limestone and dolomite pebbles from consideration, to permit a comparison of these tills with the noncalcareous Nebraskan till.

TABULATION OF PEBBLE COUNTS FROM ILLINOIAN, KANSAN AND NEBRASKAN TILLS.

(Figures are percentages of total number of pebbles.)

	Illinoian Ravine (1) Calcareous	Illinoian Ravine (2) Calcareous	Kansan Ravine (1) Calcareous	Kansan Ravine (2) Calcareous	Nebraskan Ravine (2) Noncalcareous
Quartz	4.2	4.4	2.1	3.9	14.7
Chert, gray	5.7	10.5	12.8	9.4	14.7
Chert, brown	0.4	2.2	6.4	11.7	13.1
Shale or clay	2.3	1.6	0.0	14.0	0.0
Shale, fissile	0.0	2.7	4.2	0.0	0.0
Coal	0.4	0.6	2.1	3.9	8.2
Sandstone	7.6	5.0	12.8	19.5	3.3
Ironstone concretions	7.2	4.4	4.2	2.3	1.6
Limestone	32.7	29.8	31.9	15.6	0.0
Dolomite	26.2	25.4	10.6	3.9	0.0
Granite and syenite	1.6	2.2	6.4	3.1	8.2
Diorite and gabbro	2.0	0.0	2.1	0.8	0.0
Rhyolite and quartz porphyry	0.0	0.0	0.0	0.8	1.6
Basalt	7.2	9.4	2.1	7.0	22.9
Quartzite and graywacke	1.6	1.6	2.1	3.1	3.2
Gneiss	0.4	0.0	0.0	0.0	0.0
Jasper	0.0	0.0	0.0	0.8	4.9
Orthoclase	0.0	0.0	0.0	0.0	3.3
Hematite	0.8	0.0	0.0	0.0	0.0

The small number of counts given here makes it impossible to draw final conclusions regarding general differences in the characters of the three drift sheets, or regarding the direction of advance of the Nebraskan ice over this region. The following characteristics of the tills, as shown by pebble counts, are worthy of mention:

The Illinoian till contains on the average more dolomite and basalt than the Kansan.

The Kansan till contains more chert, more shale, and much more sandstone than the Illinoian, and nearly as much limestone.

The Nebraskan till has lost all limestone and dolomite, and much of its shale and sandstone through weathering. Its pebbles consist mostly of quartz and chert, and basalt and other igneous and metamorphic rocks. The percentage of these rocks in the Nebraskan till exceeds those in either of the other tills, even when the limestone and dolomite pebbles in the Kansan and Illinoian tills are excluded from consideration.

Sources of the Three Tills.

The Illinoian glacier came from the Labradorean center of glaciation and locally advanced southwest, down the broad valley of Illinois River. The dolomite fragments which are abundant in, and characteristic of this drift, were derived largely from the Ordovician (Galena dolomite) and Silurian (Niagaran dolomite) areas of northern Illinois.

The Kansan glacier is believed to have come from the Keewatin lobe, and to have spread eastward into Illinois from north central Missouri and southern Iowa. Its numerous fragments of shale, sandstone and coal (Pennsylvanian) were probably picked up locally, as there are widespread exposures of such rocks within a distance of a few miles. Numerous fragments of compact limestone in the Kansan drift may have come from the Mississippian (Salem and St. Louis) limestones, west and southwest of this area.

The Nebraskan glacier may have come from either the Labradorean or Keewatin center of glaciation, so far as the pebble count made here affords information. The abundance of rounded quartz and chert fragments in the Nebraskan till probably points to the wide surface distribution of these materials in Tertiary concentrations before the time of the first glaciation.

Evidence of Nebraskan Age of the Oldest Till.

The youngest till in the area investigated is known to be Illinoian in age because of its position below calcareous Peorian loess and noncalcareous Sangamon loess, materials which overlie the Illinoian till in extensive areas of western Illinois.

In the first ravine described, a second till is identified by its separation from the Illinoian till by an interglacial, fossiliferous loess, and an old soil profile on the till below the loess. A third till is here distinguished by the complete oxidation of masses of till which were later incorporated in the second till, and are now surrounded by unoxidized or unweathered till.

In the second ravine described the second till is separated from the Illinoian by an interglacial unfossiliferous loess and by 15 feet of oxidized and leached gravel, and is further distinguished by darker color, and the inclusion of fragments of old soil, fossiliferous loess, noncalcareous till, and logs, and by its contorted structure. The third till is again distinguished from the second by its complete leaching and oxidation and its position directly below the calcareous, unoxidized, second till.

The second till resembles the buried Kansan of many other exposures in western Illinois in character, and in its position below a compacted fossiliferous Yarmouth loess, the fauna of which contains a few species known to be characteristic of the Yarmouth epoch.

The third and oldest till is therefore assigned to the only known glacial epoch previous to the Kansan, the Nebraskan epoch, which has not heretofore been recognized in western Illinois.

GLACIAL ORIGIN OF BEAVER CREEK, BOONE COUNTY.[1]

George E. Ekblaw, Illinois State Geological Survey, Urbana, Illinois.

A considerable part of the north portion of Boone County, Illinois, comprises the basin of Beaver Creek, which flows south and southwest to join Kishwaukee River about four miles west of Belvidere. The course of Beaver Creek is roughly parallel to that of Piscasaw Creek a few miles farther east.

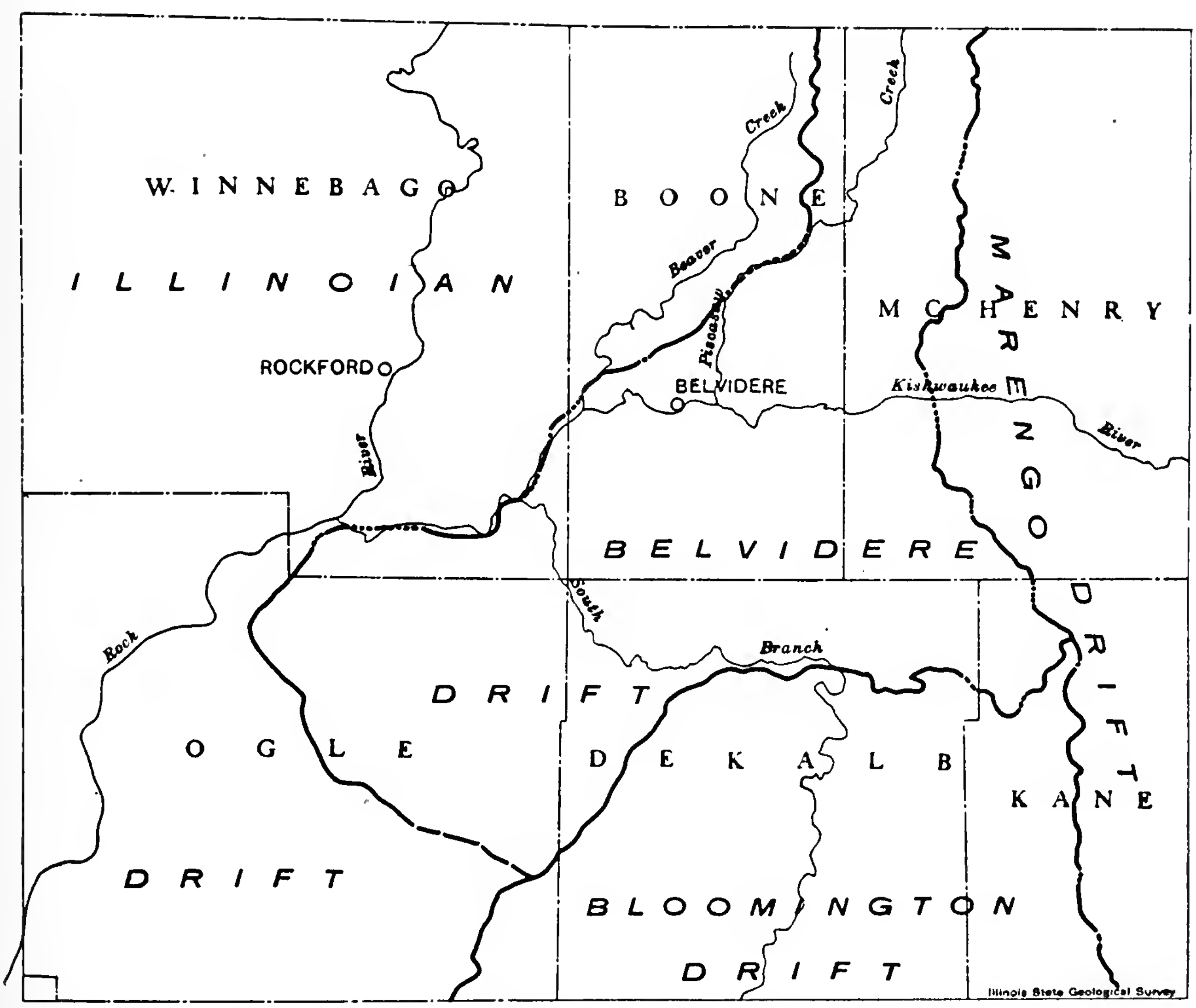


FIG. 1.—Outline map of central northern Illinois showing relations of Belvidere and adjacent drifts. (After Leighton.)

It has been recently demonstrated[2] that the glacial drift on the northwest side of Beaver Creek is Illinoian in age and that most of the drift on the southeast side, designated as Belvidere drift of early Wisconsin age, is much younger. Thus Beaver Creek practically demarcates the boundary between the older Illinoian drift and the younger Belvidere drift north of Belvi-

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[1] Published by permission of the Chief, Illinois State Geological Survey

[2] Leighton, M. M., The differentiation of the drift sheets of northwestern Illinois: Jour. Geol., vol. 31, pp. 265-276, 1923.

dere. The Belvidere drift was deposited from a northwestward lobate protrusion of the Michigan lobe of the Wisconsin glacier at a time that is believed to have been contemporaneous with the deposition of the Champaign moraine.

It has been stated that "the protrusion of the Belvidere ice-lobe from the main Michigan lobe blocked the valley of Piscasaw Creek and diverted its waters temporarily westward across the divide into Beaver Creek."[3] It now appears that there was not only an actual temporary diversion of Piscasaw Creek but that an entirely new line of drainage was formed at that time and now remains as the valley of Beaver Creek.

At the time of its maximum advance, which is recorded by the White Rock moraine that lies between Piscasaw and Beaver creeks, the Belvidere ice covered Piscasaw Creek and blocked the southeastward flowing tributaries. The water from the melting ice filled the valley of each tributary to the level of the lowest point by which it might escape. Due to a regular southwesterly regional slope, the water in each valley escaped to the one next southwest by way of a col across the divide between the valleys, and due to the normal development of the valleys the selected col was the one nearest the ice-front. Consequently the glacial waters escaped by a southwesterly course which followed the ice-front rather closely and which is now the course of Beaver Creek.

As the glacier receded from its maximum expansion, parts of the upper portion of Piscasaw Valley were freed before the entire valley was reopened. Fore-glacial lakes formed in the open portions of the valley between the White Rock moraine and the ice-front and overflowed through sags into Beaver Creek Valley. Such a lake appears to have existed in secs. 28, 29, 32, and 33, T. 45 N., R. 4 E., and adjacent areas and overflowed into Beaver Creek Valley through the sag in secs. 29 and 30. After the Belvidere ice had receded so far that the whole Piscasaw Valley was again open, the morainic deposits in the lower portions of the former tributaries were so thick and the interfluves between the tributaries had been so deeply incised by glacial Beaver Creek that the tributaries could not rejoin Piscasaw Creek but remained permanently diverted into a new course now known as Beaver Creek. The following physiographic features are due to and are evidence of this diversion.

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[3] Idem, p. 276.

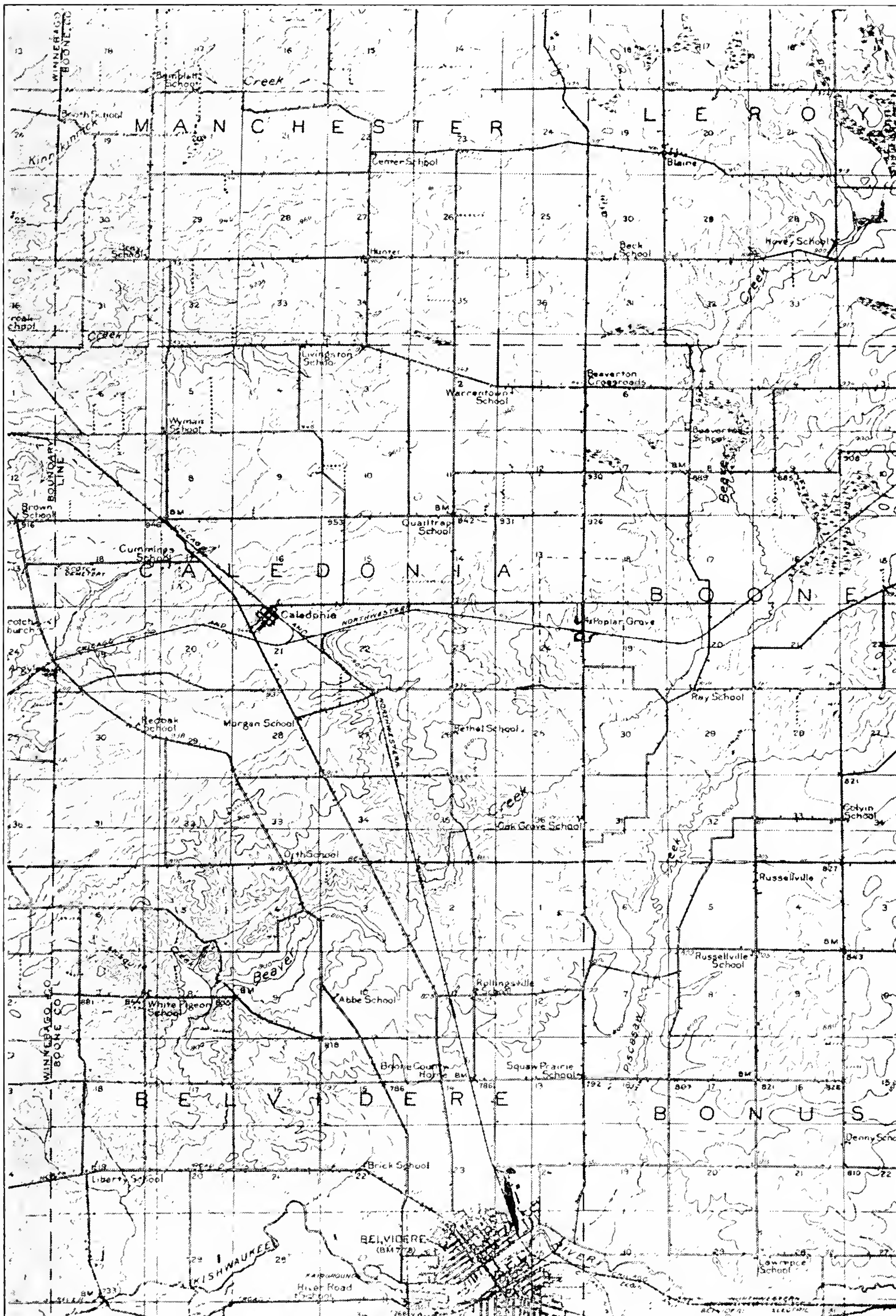

FIG. 2—Reproduction of a portion of the topographic map of Belvidere quadrangle showing the physiographic features discussed.

1. The large number and the considerable length of the streams and the size and development of the valleys of the tributaries on the northwest side of Beaver Creek are in striking contrast to those on the southeast side and are in themselves good evidence of the difference in age between the Illinoian drift, in which they are developed, and the Belvidere drift.

2. The streams join Beaver Creek at quite or nearly right angles, which is abnormal and quite at variance with the regional habit, as most streams join at acute angles pointing downstream.

3. The lower part of the valley of Beaver Creek is alternately broad and narrow. The broad parts occur at the junction of the tributaries and are believed to represent the former valleys of the tributaries, partly filled by fine alluvium when the valleys were ponded during the Belvidere glacial stage. The narrow parts represent gorges cut through the interfluves between the tributaries. Excellent examples of these narrows occur in sec. 35, T. 45 N., R. 3 E.; sec. 8, T. 44 N., R. 3 E.; and sec. 19, T. 44 N., R. 3 E. It may be noted that each of these narrows occurs just above the junction of a large tributary and Beaver Creek.

4. Terraces occur along the lowest part and in the broader expanses of the valley of Beaver Creek and are doubtless the remnants of the glacial fills, below whose level Beaver Creek has entrenched itself headward as far as Ray School, southeast of Poplar Grove.

5. Sags across the White Rock moraine, some of which are occupied by short tributaries of Piscasaw Creek, occur opposite the tributaries on the northwest side of Beaver Creek and are believed to represent the former extensions of these tributaries, partly filled by morainic deposits. Specific examples occur in sec. 21, in sec. 29, and in sec. 30, T. 45 N., R. 4 E.; and in sec. 11, in sec. 10, in sec. 16, and in sec. 20, T. 44, N., R. 3 E. The sag in sec. 21 is low and broad and may represent the former course of Piscasaw Creek when the headwaters of Beaver Creek were the headwaters of Piscasaw Creek; the sag in sec. 29 is probably the continuation of the streams east of Poplar Grove; the sag in sec. 30 may be the continuation of the streams west of Poplar Grove; the sag in sec. 11 is the logical continuation of the tributary followed by Northwestern Railway; the sag in sec. 10 may be the former course of the tributary which now joins Mosquito Creek; and either the sag in sec. 16 or that in sec. 20 may be the former course of pre-Belvidere Mosquito Creek.

6. The marshy flats along the headwaters of Beaver Creek are probably fills of fine glacial outwash from the Belvidere ice, which have not yet been drained or entrenched by headward development of Beaver Creek.

7. Low broad cols across sec. 13 and across the south edge of secs. 35 and 36, T. 46 N., R. 3 E., are probably temporary spillways by which some of the water from the melting Belvidere glacier escaped westward instead of down glacial Beaver Creek.

8. The tributary of Mosquito Creek in sec. 8, T. 44 N., R. 3 E., was apparently diverted from a southward course across the southeast corner of sec. 5. This diversion was probably accomplished when the valley was first blocked by the Belvidere glacier and filled with the water from the melting ice.

A STUDY OF THE PLEISTOCENE MOLLUSCA COLLECTED IN 1927 FROM DEPOSITS IN FULTON COUNTY, ILLINOIS.*

Frank Collins Baker, Curator, Museum of Natural History, University of Illinois, and Pleistocene Invertebrate Paleontologist, Illinois State Geological Survey, Urbana.

During the Summer of 1927, the Illinois Geological Survey carried on extensive field operations in Fulton County, Illinois, during which time the Pleistocene formations were carefully examined and a large amount of material collected which contained a considerable fauna of this period. All of the interglacial intervals are represented, but two of these are of a very limited character. To summarize, there is one collection from the Aftonian, five from the Yarmouth, one from the Sangamon, eleven from the Peorian, eight from the Early Wisconsin and one of Late Wisconsin strata. The absence of large collections from the Sangamon is noteworthy, indicating that this interval is not well represented in this county. The Aftonian is also very unsatisfactorily represented. The Yarmouth, Peorian, and Early Wisconsin collections are among the best that have been studied by the writer, and their contents have made clear many points in the relationship of Pleistocene molluscan life.

In a previous paper in these transactions (Vol. XX, pp. 269-292) a resume is given of the knowledge of the Pleistocene molluscan life of the State of Illinois as it was known at the time of writing that communication. The material from Fulton County has changed opinions held concerning the status of some of the variations of species therein recorded, necessitating the diagnosis of six varieties and species as new to science, and the addition of at least one species new to the fauna of Illinois. (See The Nautilus, Vol. XLI, p. 133, for descriptions of these new forms). The general statements in the paper in volume XX stand practically as there published, with very slight variation. Several additional species show considerable variation in size and form and may eventually be distinguished as peculiar Pleistocene varieties of recent species. Not enough material is avail-

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* Contribution from the Museum of Natural History, University of Illinois, No. 52.

able to settle this point in a satisfactory manner. These suggested changes are indicated under each species in the following pages.

A study of the tables at the end of this paper bring out several interesting facts. In the table of land species, it will be observed that as a whole, the fauna of the Illinois Pleistocene contains 31.5 per cent of extinct forms and of the 68.5 percent of living forms, 11.5 per cent are now found outside of the state boundaries, mostly far removed. Among the fresh water gastropods, 29.5 per cent are extinct and of the 70.5 per cent of living forms 8.5 per cent now live north of Illinois. Among the Sphaeriidae, the distribution is practically unknown, because of the absence of material from earlier formations. Dr. Sterki, however, finds little change from Pleistocene to recent, but this may be due to lack of material as well as, perhaps, a conviction that the differences found in the gastropods are not sufficiently important for recognition among the Sphaeriidae. While this is largely true as regards the recent fauna, it is only by the study of these small and apparently trivial variations from interval to interval that we can learn of the effect of the Ice Age on molluscan life.

When material of ample proportions from all of the intervals has been critically examined it will be possible to trace the ancestry of many of our common recent species. This has been possible in a limited manner from the material already at hand, which has shown that a Pleistocene variation grades into the recent form, usually in the Early Wisconsin stage. In at least one extinct species there has been observed a change from Aftonian to Peorian intervals. In several varieties, the two forms, recent and extinct, are seen to overlap in their distribution in a single interval. This is indicated on the tables by solid lines.

In some of the exposures examined, the material represents flood plain deposits gathered during flood periods, the fauna being of a mixed character, fluviatile and terrestrial. Such are very perplexing unless the manner of their formation at the present time is kept in mind. While they represent the fauna of the interval, they do not represent actual living conditions as does a deposit formed in situ at the bottom of a river or lake or in a true land deposit, as the loess. Care must also be used in interpreting the presence of fluviatile species among true land species, as in loess formations where a valve or two of Pisidium may be present. Many extraneous agencies may carry such material from flood plain or shore to uplands of pure land habitats. The presence of such genera as Pomatiopsis and Fossaria in true loess formations is to be accounted for by the fact that these groups contain species which live on wet mud, often away from true water bodies, in tracts of land subject to overflow or water accumulation during spring and early summer but dry during the remainder of the year. Such deposits are usually formed on partly abandoned flood plains or in hollows. Loess accumulates during the dry seasons, which accounts for the mixture of faunas. Typical upland loess does not usually contain these amphibious species.

It may be of value to describe typical outcrops of each interval and indicate the association of life in each (data by Dr. Wanless.)

Aftonian Interval

Locality: Second ravine north of road in NW ¼ SE ¼ sec. 32, T. 4 N., R 3 E., Isabel Twp., about ¾ mile west and ¼ mile north of Enion.

Material: Dark gray or brownish gray soil and fossiliferous silt or loess including wood and some logs several feet long incorporated in lower portion of Kansan till in bed and banks of deep, steep-walled ravine. About one hundred feet downstream the contact between calcareous Kansan till and weathered Nebraskan till is exposed.

Molluscan Life:

Vertigo loessensis, rare.
Hendersonia occulta, rare.
Goniodiscus macclintocki angulata, rare.

Yarmouth Interval

Locality: Along northwest bank of ravine near center of NE. ¼ sec. 5, T. 3 N., R. 3 E., Kerton Twp. One-half mile west and one quarter mile south of Enion.

Material: Hard, dark brownish gray loess-like silt with abundant fossils. At east end of this outcrop may be seen Kansan till and rolled fragments of Nebraskan till.

Molluscan Life:

Succinea ovalis pleistocenica, common.
Succinea grosvenori gelida, rare.
Succinea retusa fultonensis, rare.
Polygyra monodon peoriensis, rare.
Polygyra multilineata wanlessi, rare.
Gonyodiscus macclintocki angulata, common.
Zonitoides arborea, rare.
Glyphyalinia indentata, rare.
Pisidium abditum, 4 valves.
Circinaria concava, rare.
Strobilops virgo, rare.
Hendersonia occulta, common.
Vertigo loessensis, rare.
Vertigo modesta, rare.
Gastrocopta pentodon, rare.
Pomatiopsis scalaris, rare.
Fossaria parva tazewelliana, rare.
Pisidium concinnulum, 2 valves.

The life is a typical loess fauna of almost pure land mollusks. Pomatiopsis and Fossaria live in places that might become loess-covered. The presence of the two species of Pisidium, a typical fresh water genus of small mussels, can be accounted for only by accidental intrusion. Of the above gastropods 10 or 62.5 per cent are extinct, at least to varieties.

Peorian Interval

Locality: Cut on private road in upper part of Illinois River bluff, in Se. ¼ SE. ¼ sec. 31, T. 5 N., R. 4 E., Liverpool Twp.

Material: Characteristic Peorian loess.

Molluscan Life:

Succinea ovalis pleistocenica, common.
Succinea grosvenori gelida, common.
Polygyra multilineata wanlessi, common.
Polygyra hirsuta yarmouthensis, common.
Polita hammonis electrina, common.
Carychium exile canadense, rare.
Fossaria parva tazewelliana, common.
Vertigo loessensis, common.
Gonyodiscus anthonyi, common.
Gonyodiscus macclintocki, common.
Circinaria concava, rare.
Polygyra monodon, common.
Vallonia gracilicosta, rare.
Hendersonia occulta, common.
Euconulus fulvus, rare.
Columella hasta, rare.
Columella alticola, common.

Locality: Cut in private road in upper part of bluff of Illinois River in SW. ¼ SW. ¼ sec. 14, T. 5 N., R. 4 E., Liverpool twp.

Stratigraphic Horizon: Peorian loess. Fossils occurred in beds in upper and lower part of loess, separated by about ten feet; upper loess grayer than lower loess.

Molluscan Life:

Upper Part.	Lower Part.
Succinea ovalis pleistocenica, rare	*Succinea ovalis pleistocenica*, common.
Succinea grosvenori gelida, common.	*Succinea grosvenori gelida*, common.
Gonyodiscus anthonyi, common.	*Gonyodiscus anthonyi*, rare.
Vallonia gracilicosta, rare.	....
Polygyra monodon, common.	*Polygyra monodon*, rare.
Vertigo modesta, rare.	*Vertigo modesta*, rare.
Polygyra multilineata wanlessi, common.	*P. multilineata wanlessi*, rare.
Fossaria parva tazewelliana, rare.	*Fossaria parva tazewelliana*, common.
....	*Polita hammonis electrina*, rare.
....	*Hendersonia occulta*, common.
....	*Columella alticola*, rare.
....	*Vertigo loessensis*, rare.

Early Wisconsin Interval

Locality: High terrace cut bank on southeast side of East Creek about 200 yards east of center of north line of sec. 11, T. 4 N., R. 3 E., Waterford Twp., about three miles south and one mile east of Lewistown.

Material: Terrace cut shows upper gray silt, probably loess, middle laminated silts, and lower red clay. Fossils numerous in two upper layers but scarce or absent from lower red clay.

Molluscan Life:

Laminated Layer.	Upper Gray Loess.
Water Breathers.	
Valvata tricarinata, common.	....
Valvata tricarinata perconfusa, common.	....
Pisidium compressum, rare.	....
Pisidium variabile brevius, rare.	....
Amphibious.	
Pomatiopsis scalaris, common.	*Pomatiopsis scalaris*, common.
Fresh Water Pulmonates.	
Fossaria obrussa decampi, rare.	....
Fossaria parva tazewelliana, common.	*F. parva tazewelliana*, common.
Stagincola caperata, common.	....
Gyraulus altissimus, rare.	....
Land Pulmonates.	
Polygyra multilineata wanlessi, rare.	....
Polygyra hirsuta yarmouthensis, rare.	*P. hirsuta yarmouthensis*, rare.
Polita hammonis electrina, rare.	*P. hammonis electrina*, rare.
Succinea retusa fultonensis, rare.	*S. retusa fultonensis*, rare.
Succinea grosvenori gelida, rare.	*S. grosvenori gelida*, rare.
....	*Circinaria concava*, rare.
....	*Polygyra monodon*, rare.
....	*Gonyodiscus cronkhitei anthonyi*, rare.

The lower deposit as well as the middle deposit evidently represent fluviatile conditions during the early part of Early Wisconsin time, the common species being of a strictly aquatic character, the admixture of land forms being so rarely represented that they are to be considered as material washed into the stream, which frequently happens in recent times. In the upper deposit, while land forms are relatively rare, the aquatic forms are those which live on mud flats where loess-like silt would accumulate. The two species represented are almost uniformly found in loess deposits in Fulton County. This cut is an excellent example of exposures and included life in this county.

Exposures of Late Wisconsin strata are rare, since the territory is far beyond the limits and the decissive influence of the last Wisconsin glaciation. One exposure is believed to be of this age, containing a characteristic recent fauna, differing in nature from that of the Early Wisconsin of other places in the county.

My thanks are due Dr. M. M. Leighton, Chief of the Illinois State Geological Survey for the opportunity of studying this very interesting collection. Acknowledgment is due Dr. Harold R. Wanless of the Department of Geology, University of Illinois and Associate Geologist of the Illinois Survey, for the careful field notes accompanying the material. Dr. Wanless was in charge of the Pleistocene work in this county. Associated with Dr. Wanless in the collection of the material were Mrs. Wanless, and Mr. A. W. Waldo and Mr. H. B. Willman, the last two graduate students at the University of Illinois. Dr. V. Sterki has very kindly looked over the Sphaeriidae and his findings are reported under each species. The material upon which this paper is based is preserved in the Paleontological collection of the Museum of Natural History of the University of Illinois.

Discussion of Species Represented.

Land Mollusca

Family HELICIDAE

Polygyra monodon (Rackett)

Occurred in five exposures of Peorian age and in six exposures of Early Wisconsin age. The monodon of the middle and later Pleistocene is similar to the recent form as found in several localities in Illinois. It differs from the typical aspect of the species in having a higher and more dome-shaped spire, a more convex base, and a smaller parietal lamella which is not as deeply notched at the columella region. The umbilicus is also smaller than in many recent specimens. As this type of shell also occurs living in widely separated localities it cannot be considered a peculiarly formed Pleistocene species, though the typical form with low spire and wide umbilicus is to be considered a descendent of the high-spired, narrow umbilicated form.

Polygyra monodon peoriensis F. C. Baker.

A single specimen, rather larger than the type, occurred in loess of Yarmouth age in one exposure. Peoriensis appears to abound in the Yarmouth interval and to live into the Peorian interval, where it disappears, its place being taken by the large form described above. The two forms evidently overlap in the Peorian interval. None have been seen from the Sangamon interval.

Polygyra hirsuta (Say)

Typical hirsuta apparently first appears in Early Wisconsin time. The large form with huge parietal lamina descending below the basal lip was found in one exposure in Early Wisconsin strata and in one exposure in Late Wisconsin strata.

Polygyra hirsuta yarmouthensis F. C. Baker

Throughout almost the entire period of Pleistocene time this small form of hirsuta persists. It occurred in one exposure of Yarmouth strata, four exposures of Peorian strata, and five exposures of Early Wisconsin strata. It is also known from Sangamon strata in other places in Illinois and it is thus represented in all intervals excepting the Aftonian and further researches will doubtless find it in this interval. Some specimens from Peorian strata are larger than typical yarmouthensis and approach the typical hirsuta, though having the small parietal lamina of the variety.

Polygyra multilineata wanlessi F. C. Baker. (See Nautilus, Vol. 41, p. 132.)

This new variety of multilineata occurred in one exposure of Yarmouth age, ten exposures of Peorian age, and three exposures of Early Wisconsin age. A single specimen was found in an exposure believed to be of late Wisconsin age. None have been seen from the Sangamon interval, but a very large variety, altonensis F. C. Baker, has been described from this interval. Wanlessi probably occurs in the Sangamon but no specimens have yet been seen. The nearest relative of wanlessi in the recent fauna is variety algonquinensis Nason, the type locality being Algonquin, McHenry County, Illinois. The fossil variety differs in having a deeply impressed umbilical region and in being frequently widely perforate, characteristics lacking in the recent variety. The fossil form ranges both larger and smaller than algonquinensis, but is on the whole somewhat larger and in many examples has a more depressed spire. Algonquinensis is without doubt the lineal descendant of wanlessi. The large recent form may have descended from variety altonensis.

Polygyra clausa (Say)

Observed in one exposure each of Early and Late Wisconsin strata. Only a few specimens obtained and they are typical of the species as it is found recent.

Polygyra thyroides (Say)

Associated with clausa in Early and Late Wisconsin strata. The Early Wisconsin form has a parietal denticle but the Late Wisconsin form is without a denticle. Does not differ from the recent form. It is noteworthy that neither of these species have been seen in Early Wisconsin deposits in Illinois.

Family PUPILLIDAE

Columella hasta (Hanna)

One specimen from exposure of Peorian age. The specimen measures 4.5mm. in length and has eight whorls. This species was originally described from Pleistocene deposits at Long Island, Phillips County, Kansas (see Hanna, Proc. U. S. Nat. Mus., Vol. 41, p. 372, 1911) and the Illinois specimen indicates that it had a wider distribution during mid-Pleistocene time. The Illinois example is somewhat smaller than the type specimen from Kansas but much larger than any alticola recent or fossil. Additional material from Pleistocene deposits will be looked for with interest.

Columella alticola (Ingersoll)

Alticola was more or less abundant in five exposures of Peorian loess and in two exposures of Early Wisconsin loess. It was most abundant in several Peorian deposits. The Illinois species measures 2.8 mm. in length and 1.3 mm. in width and has from 6½ to 7 whorls. It is known as a fossil in Phillips Co., Kansas, associated with the large *Columella hasta.* Alticola is extinct as far as Illinois is concerned, but is known living from Canada, British Columbia, Wyoming, Colorado, New Mexico, and Arizona. As a fossil it is known from the Peorian and Early Wisconsin intervals but has not been found in Yarmouth or Sangamon (see Pilsbry, Manual Conch., Series II, Vol. XXVII, p. 243, 1926.)

Gastrocopta armifera (Say)

Early and Late Wisconsin, one exposure each. Typical of the species as in the recent fauna. Armifera has not been seen from the Yarmouth interval, but is known from Sangamon and Peorian.

Gastrocopta contracta (Say)

Early and Late Wisconsin. Not yet observed in earlier deposits in Illinois.

Gastrocopta pentodon (Say)

This species is apparently rare in Pleistocene deposits, at least in Illinois. A single specimen, with parietal, columellar, and, two palatal teeth, was collected from Yarmouth deposit; and a single specimen with parietal, columellar, and five palatal denticles was collected in a Late Wisconsin deposit. Typical specimens have been seen from New Harmony, Indiana, in loess supposed to be of Peorian age.

Vertigo loessensis F. C. Baker (see Nautilus, Vol. 41, p. 135.)

A common loess fossil found in one Aftonian, seven Yarmouth, and three Early Wisconsin exposures. Its absence from the Sangamon probably indicates that it has been overlooked. Loessensis is related to gouldii and was at first listed as that species. Its wider shell and differently shaped aperture, separates it from the gouldii of the recent fauna. It has been referred to *Vertigo elatior* Sterki, but that species has a strong palatal callus which is absent in loessensis. Immature and broken specimens were previous referred to ventricosa in papers on Illinois Pleistocene mollusks, but all are doubtless variations of the present species. It appears to be the most abundant and widely distributed of the small pupoids in the Pleistocene.

Whether the species reported by Iowa geologists as gouldii is really that species or loessensis cannot at present be determined for lack of material from that state. It is apparently the same as the gouldii reported by Hanna from a Pleistocene deposit in Phillips County, Kansas (Kansas Science Bull. VII., p. 120, pl. xviii, fig. 4)

Vertigo modesta (Say)

Yarmouth interval, one exposure; Peorian interval, four exposures; Early Wisconsin interval, two exposures. Most abundant in the Peorian interval. Not yet observed from the Sangamon interval.

In two lots from the Peorian of Fulton County, this species shows considerable variation in the number and position of the denticles in the aperture. In one lot the basal denticle varies greatly in size. In the other lot, there was one specimen without parietal denticle, and two specimens with two denticles on outer lip. Modesta is known in the recent fauna from Maine to British Columbia. It is locally known in Connecticut and Vermont, but is absent from the Middle West. It apparently survived to Early Wisconsin time, but was rare. During the Pleistocene it was abundant in Illinois and Iowa and as far south as Phillips County, Kansas.

Strobilops labyrinthica (Say)

One specimen from Early Wisconsin strata. This species has not been seen from strata earlier than Early Wisconsin.

Strobilops virgo Pilsbry

Found in three exposures of Yarmouth, and one exposure each of Late and Early Wisconsin time. It is known from Peorian time in other parts of Illinois. Virgo appears to be the common Strobilops of Pleistocene time. The Fulton County material is perhaps somewhat lower in spire than in most recent specimens but is otherwise typical.

Family VALLONIIDAE

Vallonia gracilicosta (Reinh.)

Found at two exposures of Peorian strata. This fine-ribbed form appears to be the dominant Vallonia of the Pleistocene. In Illinois it is not yet known earlier than the Peorian interval.

Family CIRCINARIIDAE

Circinaria concava (Say)

In Fulton County this species occurred in one Yarmouth exposure, seven Peorian exposures, three exposures of Early Wisconsin age, and one of Late Wisconsin age. In no exposure was it abundant.

As has been noted before, the loess concava differ uniformly in size from the recent forms. The largest specimen seen measured, 12.5 mm. in diameter and 5.5 mm. in height. The whorls appear to be more tightly coiled with smaller nuclear whorls, and with 4½ to 5 whorls. This type of shell is not found later than Early Wisconsin time, the Late Wisconsin specimens being large and like the recent form. As there is a possibility that these may not be full grown the question of their distinction from recent concava must await the examination of additional material. The same form occurs in loess deposits at New Harmony, Indiana, possibly of Peorian age.

Family ZONITIDAE

Zonitoides arborea (Say)

Yarmouth interval, one exposure, Peorian interval, two exposures, Late Wisconsin interval, one exposure. It is also known from the Sangamon in Illinois. The Pleistocene arborea differs somewhat from the recent species. It is smaller, with usually four whorls, the spire depressed and the sculpture finer than in recent forms. Curiously enough, it is like the species as it occurs in Arizona, both in size and in the depressed spire. Measurements of the several forms are as follows:

Recent, Illinois:	H:3.2; 3.2; 2.6 mm.;	D: 5.8; 5.6; 5.1 mm.
Recent, Arizona:	H:2.1; 2.1; 2.0 mm.;	D: 5.0; 4.9; 4.1 mm.
Fossil, Illinois:	H:2.0; 1.5; 1.5 mm.;	D: 4.0; 3.6; 3.5 mm.

As in the case of other species, much more material is needed before safe conclusions may be drawn, but the evidence at presence indicates that the Pleistocene form is uniformly smaller and with a more depressed spire.

Striatura milium (Morse)

One specimen from Late Wisconsin strata. Apparently typical. This species has not been found in earlier deposits in Illinois.

Pseudovitrea minuscula (Binney)

Three specimens from a Peorian loess exposure appear to be typical minuscula, although the sculpture is finer than in recent specimens and approaches *P. laeviuscula* Sterki. The shape of the shell is that of minuscula, however. Also known from strata of Early Wisconsin age.

Retinella hammonis electrina (Gould)

Peorian interval, seven exposures, Early Wisconsin, two exposures. Not seen from Sangamon or Yarmouth deposits. The electrina of the loess differs from the species as it is found in Illinois today in being uniformly smaller and in having but 3½ whorls. The aperture, also, is ovate and not as round as in living specimens. In size and number of whorls it is like northern forms from Vermont, Maine, and Canada. Measurements of each form are shown below: Maine: H:1.6; D:3.4 mm. 3⅓ whorls. Vermont: H:1.1; D:3.7 mm. 3½ whorls. Illinois: H:2.0 and 2.4; D:4.1 and 4.8 mm. 4 whorls. Fossils: H:1.6; 1.5; 1.5; 1.7; 1.8; 1.9; mm. D:3.2; 3.3; 3.1; 3.5; 4.0; 4.0 mm. 3¼ to 3½ whorls. Here again the fossil form is slightly smaller than the species as found in the local recent fauna.

Glyphyalinia indentata (Say)

Collected from three Yarmouth intervals, two Early Wisconsin intervals, and one Late Wisconsin exposure. The Pleistocene specimens are on the whole a trifle smaller than recent specimens, but not enough material has been available for examination. Fossil specimens measure height 1.9, diameter 4.1 mm., and the largest recent specimens from Illinois 2.5 mm. in height and 5.8mm. in diameter. The fossil specimens have a slight indication of a perforation, resembling in this respect some examples of *G. umbilicata* (Ckll.) from Texas and Arizona.

Euconulus fulvus (Müller)

Two exposures each in Peorian and Early Wisconsin strata. None have been seen in earlier strata than Peorian. The specimens are like those living in Illinois today.

Family ENDODONTIDAE

Anguispira alternata (Say) Variety

Two exposures in Peorian interval; one exposure in Early Wisconsin. The Pleistocene alternata is uniformly smaller than the species as it occurs living in Illinois, and the whorls are not as high or the periphery as rounded. They are more like specimens from Michigan and farther north. The largest fossil specimen seen measured 12 mm. in height and 19 mm. in diameter. Recent shells measure 16 mm. in height and 23 mm. in diameter, both forms having the same number of whorls. The Pleistocene form is abundant from Sangamon time onward but has not yet been observed in Yarmouth strata.

Anguispira alternata (Say)

Late Wisconsin strata. The specimens from this late period appear to be referable to the typical form.

Anguispira solitaria (Say)

One exposure each in Early and Late Wisconsin strata. These do not differ in any way from the species as it is found in Illinois at the present time. It was more abundant in Late than in Early Wisconsin strata. This species has not been observed instrata earlier than Early Wisconsin time.

Gonyodiscus macclintocki F. C. Baker. (See Nautilus, Vol. 41, p. 133.)

This new species was found in six exposures of Peorian loess. It is very uniform in characteristics, varying only a trifle in height of spire. A single specimen in one deposit resembles the variety angulata. Macclintocki has been confused with shimekii but is quite different in size, form, and sculpture, as noted in the diagnosis in the paper quoted. It is widely distributed, occurring in St. Clair, Bureau, Adams, and Warren counties, in loess.

Gonyodiscus macclintocki angulata F. C. Baker (Nautilus, Vol. 41, p. 134.)

Observed in four exposures of Yarmouth strata, and one of Aftonian strata, Angulata is the earliest form of this species, having a depressed spire and angulate periphery. In the Peorian interval the spire is high and the periphery flatly rounded. As no examples of perspectiva have been found in Illinois Pleistocene, it is presumed that macclintocki may be the ancestral form, since it does not occur in strata older than Peorian.

Gonyodiscus cronkhitei anthonyi (Pilsbry)

Occurred in three exposures of Early Wisconsin strata, in eight exposures of Peorian strata, and is known elsewhere from Late Wisconsin deposits.

Helicodiscus parallelus (Say)

Observed in three Peorian exposures, four exposures of Early Wisconsin age, and one of Late Wisconsin age. As has been previously stated, the Pleistocene parallelus differ somewhat from the species as it occurs in Illinois today. They are somewhat smaller, the spire is more depressed, causing the shell to be more orbicular, and the umbilicus is wider and has a 'reamed out' appearance, the umbilical region not being sunk below the coil of the last whorl. The aperture is smaller and more distinctly lunate. The largest fossil specimen seen had but 4½ whorls while recent forms have five full whorls. Sizes are as follows:

Recent, Illinois:

Height 1.5 and 1.5 mm.; diameter 4.1 and 4.5 mm.

Early Wisconsin:

Height 1.4 and 1.4 mm.; diameter 3.5 and 3.6 mm.

Yarmouth:

Height 1.3 and 1.2 mm.; diameter 3.8 and 3.4 mm.

Peorian:

Height 1.2 and 1.2 mm.; diameter 3.4 and 3.5 mm.

Parallelus is known from the Yarmouth interval to the present. It is uniformly smaller with depressed spire up to Early Wisconsin time, when it becomes mixed with the higher spired recent form, and in Late Wisconsin the form is entirely like the recent form. Among recent specimens, the fossil form more nearly represents the aspect of the species as it occurs in the north, specimens from Minnesota being similar, though not quite like the fossils of Yarmouth and Peorian time.

Family SUCCINEIDAE

Succinea ovalis Say

The typical form of this species occurred in one deposit of Late Wisconsin age. In two exposures of Early Wisconsin age a form was found which varied toward pleistocenica.

Succinea ovalis pleistocenica F. C. Baker

This variety of ovalis occurred abundantly in five exposures of Yarmouth age, seven exposures of Peorian age, and one of Early Wisconsin age. In the latter there was evidence of variation toward typical ovalis. All were from typical loess deposits. Pleistocenica varies in form but retains the peculiar rounded form of aperture which is characteristic of the fossil form of this large Succinea. It occurs in the Yarmouth, Sangamon, Peorian, and Early Wisconsin intervals, but has not been seen from the Aftonian interval, though it doubtless also occurs here.

Succinea grosvenori gelida F. C. Baker

This small Succinea occurred in two exposures of Yarmouth age, ten exposures of Peorian age, and eight exposures of Early Wisconsin age. It varies greatly in the height of spire and in the size of the aperture. It disappears from Pleistocene deposits in Early Wisconsin time. It is one of the most abundant species of Pleistocene.

Succinea retusa fultonensis F. C. Baker (Nautilus, Vol. 41, p. 136.)

Collected from two exposures of Yarmouth age, one of Peorian age, and four of Early Wisconsin age. This race resembles the variety decampii Tryon, but is much smaller and has a longer spire and shorter aperture. Though no specimens have as yet been seen from Sangamon strata, the form no doubt has a continuous history from Yarmouth to Early Wisconsin time. None have been seen from deposits later than Early Wisconsin. In a previous paper (Trans. Ill. State Acad., XX. p. 269-292) this form was referred to both retusa and decampi, from both of which it is distinct.

Family HELICINIDAE

Hendersonia occulta (Say)

Occulta occurs abundantly in five exposures of Yarmouth age, eight exposures of Peorian age, and four exposures of Early Wisconsin age. A single broken specimen occurred in strata believed to be of Aftonian age. As it is also known from the Sangamon it has a continuous range geologically from Aftonian to Early Wisconsin time. There appears to be a size variation among most of the fossils examined. The present lot indicates that this is an individual variation and cannot be correlated with any interval. In many lots small and large specimens occur associated together. In others, the specimens will be all large or all small indicating colonies of local distribution. The largest specimen seen measured, height 5.6, diameter 7.4 mm., and the smallest specimen, height 4.0, diameter 6.0 mm. A specimen from Quincy measured but 5.1 mm. in diameter.

Hendersonia occulta rubella (Green)

Two specimens from a Late Wisconsin deposit have a slight carina and are of large size and appear to be referable to the living form. Typical occulta apparently died out in late Early Wisconsin time and was replaced by the carinated form called rubella.

Family AURICULIDAE

Carychium exiguum (Say)

Several specimens occurred in strata of Early and Late Wisconsin age. It is also known from strata of Yarmouth age.

Carychium exile canadense Clapp

Peorian loess, three exposures, Early Wisconsin, two exposures. It is also known from the Yarmouth interval. The fossil and recent specimens are similar. Carychium apparently had the same species, exiguum, exile, exile canadense, in the Pleistocene as in the recent fauna and the same amount of variation was present.

FRESH WATER PULMONATES

Family LYMNAEIDAE

Stagnicola palustris elodes (Say)

Material apparently referable to this wide-spread species was collected from three exposures of Early Wisconsin time.

Stagnicola caperata (Say)

Observed in one exposure of Yarmouth age, one of Sangamon age, one of Peorian age, and four of Early Wisconsin age. Most of the Pleistocene caperata differ from the recent form as found in Illinois in being somewhat smaller, with a more obese body whorl, hence a wider shell, with an erect, wide, smooth inner lip which emargines the umbilical region leaving a conspicuous chink. Specimens from the Yarmouth interval measure as follows:

Height 10.5; diameter 6.0; aperture height 4.7; diameter 3.0 mm.
Height 11.1; diameter 7.0; aperture height 5.0; diameter 3.1 mm.
Height 9.0; diameter 5.0; aperture height 4.1; diameter 2.0 mm.

The Pleistocene form resembles more closely specimens from Colorado than those from the Mississippi Valley. It is thought best at the present time to merely call attention to these differences. A few specimens from an Early Wisconsin deposit more nearly resembled the recent form indicating a change in this direction.

Fossaria parva (Lea)

Observed in three exposures of Early Wisconsin age. All of this material varies toward the variety listed below, indicating a transition toward the typical recent species.

Fossaria parva tazewelliana (Wolf)

Collected from one Yarmouth, one Sangamon, ten Peorian, seven Early Wisconsin exposures and one Late Wisconsin exposure. In many deposits it is very abundant and the dominant lymnaeid. Tazewelliana differs from the recent parva in having a longer spire, with usually one more whorl, rounder whorls, deeper sutures, a more obese body whorl, and a wider umbilicus. Specimens from Yarmouth to Peorian intervals are slightly smaller than those from Peorian and Early Wisconsin exposures. One lot from Late Wisconsin strata appeared to be referable to tazewelliana being very high of spire, and measuring 10 by 4.6 mm. Specimens from earlier strata measure as follows:

Yarmouth:	Height 5.8;	diameter 3.1 mm.
Sangamon:	Height 5.5;	diameter 2.9 mm.
Peorian:	Height 6.5;	diameter 3.3 mm.
Peorian:	Height 8.0;	diameter 3.5 mm.
Early Wisconsin:	Height 9.1;	diameter 4.2 mm.
Early Wisconsin:	Height 10.0;	diameter 4.6 mm.

From the material at hand there appears to be a progressive variation toward the large, short-spired recent form. An average recent form measures height 9.0; diameter 4.0 mm.

Fossaria modicella (Say)

A single rather characteristic specimen was found in material from an Early Wisconsin exposure. A similar specimen has been seen from silt of Peorian age. This species, very abundant in the recent fauna, appears very rare in Pleistocene deposits.

Fossaria obrussa decampi (Streng)

Observed in three exposures of Early Wisconsin strata. The Pleistocene decampi differ conspicuously from the form of the recent fauna in having a narrower shell, the body whorl more compressed and straighter, the spire whorls flat with a distinct and sharp shoulder, the sutures deep, and the base distinctly umbilicated. Late Wisconsin specimens are like the recent form.

Measurements are:

Height 11.0;	dia. 5.9;	Aper. height 6.0;	dia. 2.9 mm.	Fossil.
Height 9.0;	dia. 4.4;	Aper. height 4.5;	dia. 1.4 mm.	Fossil.
Height 9.2;	dia. 4.1;	Aper. height 4.5;	dia. 1.5 mm.	Fossil.
Height 11.6;	dia. 6.4;	Aper. height 6.6;	dia. 2.8 mm.	Recent.
Height 11.0;	dia. 5.9;	Aper. height 6.0;	dia. 2.5 mm.	Recent.

Family PLANORBIDAE

Planorbula crassilabris (Walker)

Two specimens in strata of Sangamon age The fossil specimens are smaller than some of those from the recent fauna but appear otherwise typical. The comparative measurements of the fossil and recent forms are as follows:

Sangamon:	Height 2.5;	diameter 5.5 mm.
Sangamon:	Height 2.4;	diameter 5.0 mm.
Recent:	Height 3.0;	diameter 7.5 mm.

This is the first record of this species from Pleistocene deposits and its discovery in strata of other ages will be awaited with interest. As a living species it is known from Michigan, Iowa, and Indiana.

Gyraulus altissimus (F. C. Baker)

Collected from one exposure of Early Yarmouth age and eight exposures of Early Wisconsin age. There is considerable variation among the different specimens in the deflection of the aperture and in the depth of the sutures. On the whole it is very uniform, however. Its absence from the intervals between the Yarmouth and Early Wisconsin is noteworthy. It is known from the Late Wisconsin in many places in Wiconsin, Michigan, Illinois, and Indiana.

Gyraulus urbanensis (F. C. Baker)

A single specimen of this small species was found in material from one exposure of Early Wisconsin time. Urbanensis is of uncertain affinities, appearing related to Tryon's circumstriatus. Until more material is available it will be treated as a species.

Gyraulus crista (Linn.)

Two specimens of this small and characteristic species occurred in one exposure of Early Wisconsin silt. The fossils are somewhat larger than the recent specimens at hand for comparison and the lateral costae are not as heavily marked. Recent specimens are 1.3 and 1.4 mm. in diameter while the fossil specimens are 1.5 and 1.7 mm. in diameter. The number of specimens is too small for generalizations.

Family PHYSIDAE

Physella integra (Haldeman)

This species occurred in two exposures of Early Wisconsin strata and in one of Late Wisconsin strata. The largest specimen measured 12.8 mm. in length and 7.0 mm. in diameter. They are like recent specimens from Illinois. Physella appears to be rare in Early and middle Pleistocene time.

Fresh Water Pectinibranchiates

Family POMATIOPSIDAE

Pomatiopsis lapidaria (Say)

Typical forms of this species were found in three exposures of Early Wisconsin strata.

Pomatiopsis scalaris F. C. Baker

This long-spired, widely-umbilicated species occurred in one exposure of Yarmouth age, two of Peorian age, and six of Early Wisconsin age. The earlier forms are typical of scalaris, but some of the Early Wisconsin forms show some variation toward the recent lapidaria. Scalaris is ancestral to lapidaria and might perhaps be considered simply a race of that species.

Family VALVATIDAE

Valvata tricarinata (Say)

This striking species was observed in one exposure of Yarmouth age, and in two exposures of Early Wisconsin age. They do not differ from the species as found in the recent fauna.

Valvata tricarinata perconfusa Walker

Observed in two exposures of Early Wisconsin strata.

Valvata tricarinata simplex (Gould)

One specimen observed in Early Wisconsin deposit.

Valvata lewisii precursor F. C. Baker (Nautilus, Vol. 41, p. 136.)

Young specimens were observed in strata of Early Yarmouth age. It is very abundant in exposures of Early Wisconsin age and must have been a dominant species of the streams of that time. It differs from the recent lewisii in its higher spire, showing four whorls in front profile while lewisii usually shows but three. The absence of this form in the intervals between Yarmouth and Early Wisconsin is noteworthy.

Class Pelecypoda

Small Fresh Water Mussels

Family SPHAERIIDAE

Sphaerium striatinum (Lam.)

Two valves of this species (immature) occurred in an exposure of Sangamon age, associated with *Planorbula crassilabris* and other fresh water species.

Sphaerium tenue (Prime)

Several odd valves of this species occurred in an exposure of Early Wisconsin age.

Pisidium compressum (Prime)

This characteristic species occurred in exposures of Yarmouth, Peorian, and Early Wisconsin age. As but a few odd valves are represented in many cases they may have been carried to the spot by outside agencies.

Pisidium pauperculum crystallense Sterki

A few specimens in strata of Early Wisconsin age. The original habitat of this variety is a lake.

Pisidium noveboracense (Prime)

A few valves from strata of Early Wisconsin age.

Pisidium abditum Hald

A single valve of this species was found in Yarmouth slit, evidently an accidental intrusion as the deposit is loess-like and contains a large fauna of land snails.

Pisidium concinnulum Sterki

Occurred in one exposure of Yarmouth age (one specimen evidently of accidental intrusion), two exposures of Early Wisconsin age, and one exposure of Late Wisconsin age. In none of these was it common, and most strata represent flood plain deposits.

Pisidium walkeri Sterki

One deposit of Early Wisconsin age, a few specimens.

Pisidium scutellatum Sterki

Found in three deposits of Early Wisconsin age, and common in but one exposure.

Pisidium tenuissimum Sterki

Occurred in two deposits of Early Wisconsin age.

Pisidium medianum Sterki

A single valve occurred in one exposure of Early Wisconsin age.

Pisidium rotundatum (Prime)

Three valves were found in one exposure of Early Wisconsin age.

Pisidium vesiculare Sterki

Three valves from Early Wisconsin strata are referred to this species by Dr. Sterki.

Pisidium variabilis cf brevius Sterki

A single valve of a Pisidium is referred to this variety by Dr. Sterki. It was found in silt of Early Wisconsin age.

The Pisidia of the Pleistocene are insufficently known as regards species represented and variation due to glacial conditions. The few valves represented do not differ particularly from the species of the recent fauna. *Pisidium abditum* of the Yarmouth interval is somewhat smaller than specimens from the recent fauna.

Notes on Tables.

The starred names at the left indicate extinct varieties or species. The dagger indicates that the species is not now found in Illinois in the recent fauna. The geological intervals are in order, Aftonian, Yarmouth, Sangamon, Peorian, Early Wisconsin, Late Wisconsin. Illinois indicates that the species or variety is now living in the state. The exotic column indicates that the species is not living in Illinois at the present time but is living in some other part of the country. The solid lines indicate the extent of the range of each species or variety as it relates to the geological interval indicated.

DISTRIBUTION OF PLEISTOCENE FRESH WATER MOLLUSCA IN FULTON COUNTY

	Aft.	Yarm.	Sang.	Peor.	E.Wis.	L.Wis.	Illinois	Exotic
Stagnicola palustris elodes					—	......	—	—
* Stagnicola caperata,Var	—	—	—	—	—			
Stagnicola caperata					-	—	—	—
Fossaria parva					-	—	—	—
* Fossaria parva tazewelliana		—	—	—	—	-		
Fossaria modicella					—	—	—	—
Fossaria obrussa decampi						—	—	—
* Fossaria obrussa decampi,Var					—	-		
' Planorbula crassilabris			—					—
* Gyraulus altissimus		—			—	—		
* Gyraulus urbanensis					—			
Gyraulus crista					—		—	—
Physella integra					—	—	—	—
Pomatiopsis lapidaria					—	—	—	—
* Pomatiopsis scalaris		—		—	-			
Valvata tricarinata		—			—	—	—	—
V.tricarinata perconfusa					—	—	—	—
V.tricarinata simplex					—	—	—	—
* Valvata lewisii precursor		—			—			
Sphaerium striatinum			—				—	—
Sphaerium tenue					—			—
Pisidium compressum		—		—	—	......	—	—
P.pauperculum crystallense					—			—
Pisidium noveboracense					—		—	—
Pisidium abditum		—					—	—
Pisidium concinnulum		—						—
Pisidium walkeri					—		—	—
Pisidium scutellatum					—		—	—
Pisidium tenuissimum					—		—	—
Pisidium medianum					—		—	—
Pisidium rotundatum					—		—	—
Pisidium vesiculare					—		—	—
P.variabilis brevius					—			—

DISTRIBUTION OF PLEISTOCENE LAND MOLLUSCA IN FULTON COUNTY

Species	Aftonian	Yarmouth	Sangamon	Peorian	E.Wis.	L.Wis.
Polygyra monodon				-------	------	------
P.monodon peoriensis		--------		-------		
Polygyra hirsuta					------	------
P.hirsuta yarmouthensis		--------	....	-------	--	
P.multilineata wanlessi		--------		-------	------	--
Polygyra clausa					------	------
Polygyra thyroides					------	------
Columella hasta				-------		
Columella alticola				-------	------	------
Gastrocopta armifera			.... ..	....	------	------
Gastrocopta contracta					------	------
Gastrocopta pentodon		--------		....		------
Vertigo loessensis	--------	--------		....	------	
Vertigo modesta		--------		-------	------	
Strobilops labyrinthica					------	------
Strobilops virgo		--------		....	------	------
Vallonia gracilicosta				-------		
Circinaria concava		--------	....	-------	------	------
Zonitoides arboreus		--------	....	-------		------
Striatura milium						------
Pseudovitrea minuscula				-------	......	
Retinella hammonis				-------	------	
Glyphyalinia indentata		--------			------	------
Euconulus fulvus				-------	------	
Anguispira alternata,Var.			....	-------	------	
Anguispira alternata,Typ.						------
Gonyodiscus anthonyi		--------		-------	------	.....
Gonyodiscus macclintocki				-------		
G.macclintocki angulata	--------	--------				
Helicodiscus paralellus				-------	------	------
Succinea ovalis					---	------
S. ovalis pleistocenica		--------	....	-------	------	
S. grosvenori gelida		--------		-------	------	
S. retusa fultonensis		--------		-------	------	
Hendersonia occulta	--------	--------	....	-------	------	
Carychium exiguum					---	------
Carychium exile canadense		....		-------	------	

ON SOME OF GURLEY'S UNFIGURED SPECIES OF CARBONIFEROUS BELLEROPHON.*

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In 1883 and 1884 Mr. William F. E. Gurley, at one time state Geologist of Illinois, privately published two small bulletins describing but not illustrating new Carboniferous fossils. As stated in a preface to Bulletin 1, these descriptions were intended merely as preliminary notice of new forms and it was the author's intention to republish the descriptions with figures at some later time. This however was never done. At present paleontologists are almost totally unacquainted with Gurley's species both on account of the rarity of his bulletins and the fact that it is almost impossible to identify specimens from a short description alone.

In connection with some of my work, I have recently had occasion to look up certain of Gurley's types of Bellerophon which are preserved in the collections of the Walker Museum at the University of Chicago. It has occurred to me that, as most of these species were established upon Illinois specimens, it would not be unappropriate to reestablish in the Transactions of the State Academy those which are valid as well as assign those which are not to their proper places in our paleontological synonymy. Gurley's original descriptions are presented below together with remarks upon the present status of his species.

"*Bellerophon Harrodi* (sp. nov.)[1] (Plate I, Figures 6a, 6b.)

"Shell commonly attaining a growth above the medium size, outer or body whorl, broadly and regularly expanding; aperture reniform.

"Dorsal margin not reflexed, but conforming to the direction of the growth of the body whorl. Lateral margins rapidly thickening and slightly reflexed, forming a stout flat lip, which, in joining the volution, entirely closes and conceals the umbilicus.

"Dorsum regularly rounded, full semi-circular in section, with a sharp prominent mesial or longitudinal nodose ridge, the nodes being developed by the continuation across the ridge of a series of transverse costæ or undulations extending to the um-

* By permission of the Chief, Illinois State Geological Survey.
[1] Bulletin 1, p. 5.

bilicus. These undulations are quite prominent toward the back of the shell, but gradually become faint and indistinct along the last quarter of the outer volution, which is regularly marked by distinct lines of growth that occasionally thicken up, forming slight indications of undeveloped costæ or undulations, extending around the shell at irregular intervals.

"Inner lip callous and in mature specimens it frequently swells out and thickens laterally, being quite prominent.

"This species resembles *B. percarinatus,* Conrad, but is easily distinguished from that form by being less compressed and not having the lateral nodose ridges which so strongly characterize that form. Again, this species shows more clearly the close relation existing between the concentric lines of growth along the latter portion of the body whorl, and the undulating lateral costæ which ornament the shell back of the last quarter.

"The specific name is given in honor of Dr. S. H. Harrod, of Canton, Indiana, an untiring worker, and one to whom palaeontologists are indebted for many new and interesting forms.

"*Position and Locality:* Upper Coal Measures, near Oakwood, Vermilion County, Illinois."

Remarks: Three names have been applied to a series of Coal Measures Bellerophons characterized by a prominent nodose median ridge. These are *B. percarinatus* Conrad 1842, *B. tricarinatus* Shumard 1858 and *B. harrodi* Gurley 1883. All specimens, however, that have been figured have been referred to Conrad's species. The original figures are not very good and the description is extremely brief, being as follows:[2]

"Subglobose; back with a sharp, elevated, waved carina; sides with distant transverse acute ribs and intermediate minute striæ; volutions concealed."

Shumard's description of *B. tricarinatus* is as follows:[3]

"*Shell* rather large, elongated, expanding rather gradually from beak to front; *aperture* elongate, subpentagonal; *dorsum* marked by three carinæ, which are rather strong towards the front and become obsolete posteriorly; central one most prominent, rounded; lateral ones broadest and subangular; *sides* descending obliguely from the carinæ to the base, flattened or slightly concave before and rounded posteriorly.

[2] Acad. Nat. Sci. Phil., Jour. Ser. 1, Vol. 8, 1842, p. 268, pl. 16, Fig. 4.
[3] Acad. Sci. St. Louis, Tran. Vol. 1, 1858, p. 204.

"The specimen from which the description has been drawn is deprived of the test and no surface markings are preserved."

In spite of their many defects the above descriptions seem to indicate quite clearly that the specimens under consideration represent the two extremes of the *B. percarinatus* series. The specimen figured by Norwood and Pratten[4] and referred to Conrad's species is, however, clearly of the tricarinatus type and subsequent authors, including Meek, followed their example with the result that the tricarinated form came to be considered the typical *B. percarinatus*. Gurley erred in comparing his specimen with descriptions and illustrations other than the original. His form is clearly conspecific with Conrad's and his name is therefore a synonym.

There may be some question as to the advisability of retaining two forms of full specific rank within the *B. percarinatus* series as almost complete intergradation is known to occur. Although my collections contain specimens from the same locality which vary considerable in the prominence of the latteral nodes, I have not as yet observed the association of the two extremes. It may, therefore, be best for the present to retain *B. tricarinatus* in full specific rank bearing in mind, however, that in the future it may be necessary to reduce it to a variety of *B. percarinatus*.

Girty has established the genus Pharkidonotus upon *B. percarinatus* as its type species. *B. harrodi* Gurley will therefore take its place in the synonymy under *Pharkidonotus percarinatus* (Conrad.)

"*Bellerophon textiliformis* (sp. nov.)[5] (Plate I, Figures 7a, 7b, 8.)

"Shell medium size, subglobose, body whorl rapidly expanding, slightly embracing; aperture broad, ovate reniform with the lips thin and sharply reflexed laterally, joining the whorl in a thin raised reflexed plate and gradually becoming obsolete as it follows the curvature of the umbilicus, which is thereby partially concealed.

"The dorsal margin of the lip conforms to the general direction of the growth of the shell, not being reflexed, but is divided by a deep slit, which is equal in width to the narrow band passing around the shell.

"Shell ornamented by fine longitudinal raised striæ, there

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[4] Acad. Nat. Sci. Phil., Jour. Ser. 1, Vol. 3, 1854, p. 74, pl. 9, fig. 4.
[5] Bulletin 1, p. 6.

being about fifteen on each side of the mesial band, and increasing by implantation with the growth of the shell.

"The mesial band consists of a flattened carina about twice as broad as the lateral striæ and bounded on either side by a shallow depression, each being about the same width as the carina.

"On each side of the shell there are raised transverse costæ, which extend from the umbilicus, following the lines of growth and gently curving backward as they join the mesial band, where they become quite obsolete. They are separated by a rather deep space, equal to about three times the breadth of the costa.

"These transverse costæ and longitudinal striæ regularly cross each other, giving the surface a fine and even imbricate appearance.

"This species is quite distinct from any of the known Upper Carboniferous forms, and strongly resembles *B. textilis,* Hall, from the St. Louis division of the Sub-Carboniferous series, but differs from that form in having fewer and less prominent longitudinal striæ, stronger and more clearly defined lateral costæ, which in that species are barely developed beyond well marked lines of growth.

"The slit in the dorsal margin is a feature not mentioned by either Hall or Whitfield as being a characteristic of *B. textilis*, and it is hardly possible that its presence would have escaped their observation.

"*Position and Locality:* Upper Coal Measures, Kansas City, Missouri, collected by Mr. David H. Todd."

Remarks: Unfortunately, the type specimen of *B. textiliformis* has been mislaid. The figures of this species presented herewith and the remarks concerning its affinities are based upon a series of specimens in the Gurley collection which were also obtained from Kansas City and on account of these reasons there can be little doubt but that they are representative of the same form.

This species has never been figured. On the basis of the description alone Ulrich[6] and later Girty[7] have referred it to the genus Patellostium. An examination of the specimens in the Gurley collection show conclusively that such a reference is in error as *B. textiliformis* lacks both of the most important charac-

[6] Pal. Minn., Vol. 3, pt. 2, 1897, p. 854.
[7] U. S. G. S., 19th An. Rpt. pt. 3, 1899, p. 589.

ters of Patellostium, i. e., the greatly expanded aperture and the peculiar callosity such as is present in *B. patulus,* Hall. The callosity of *B. textiliformis* is thickest in its median portion and greatly accentuated the convexity of the interior whorl at the aperture. It also differs greatly from *B. montfortanus,* Norwood and Pratten, our common Coal Measures Patellostium in the nature of its transverse markings. In *B. textilliformis* these are simply prominently developed lines of growth while in Norwood and Pratten's species they are produced by a folding of the shell and are plainly represented on interior casts.

On account of its revolving longitudinal markings and otherwise similarity to Bellerophon, *B. textiliformis* must be classed as *Bucanopsis textiliformis* (Gurley.)

"*Bellerophon incomptus* (sp. nov.)[8] (Plate I, Figures 9a, 9b).

"Shell thick, rather below the medium size, subglobose; body whorl, embracing, regularly and moderately expanding; aperture lunulate, strongly arcuate, reniform. Lip thin, becoming quite stout where it joins the inner volution, entirely closing and concealing the umbilicus. The margin of the lip conforms to the general direction of the growth of the outer whorl, showing slight indications of becoming reflexed a short distance from the umbilicus. The lip is divided by a central depression, formed by each side of the margin slightly and regularly curving backward to the mesial band.

"The surface is quite smooth, being entirely destitute of any ornamentation beyond a narrow, smooth mesial band, which on either side is separated from the lateral portions of the shell by a fine, sharp groove. There are numerous fine lines of growth at irregular intervals being more clearly defined close to the umbilicus, with an occasional line extending across the shell and curving gently backward as it approaches the carina. These lines of growth are not prominent and do not interfere with the smoothness of the surface.

"This form closely resembles *B. sublaevis,* Hall, in its globose shape, smooth unornamented surface, closed umbilicus and emarginated lip; it is, however, slightly more embracing, shows fewer lines of growth, and is at once distinguished by its narrow carina, bounded on either side by a fine, sharp groove.

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[8] Bulletin 2, p. 9.

"*Position and Locality:* From the black roof shales of coal No. 7, Danville, Illinois."

Remarks: The specimens upon which Gurley based this species are completely pyritized, much broken and considerably compressed. This was poor material upon which to base a new species and in spite of having been preserved in oil the types have somewhat disintegrated during the intervening years.

B. incomptus apparently differs from all other described Coal Measures Bellerophons with the exception of *B. crassus wewokanus,* Girty, in having its umbilici closed so solidly that it must possess a continuous imperforate columella. From this species it differs in having its mesial band much narrower and not raised above the shell upon either side and in consequence this feature is rather insignificant.

I am inclined to consider that the distinguishing characters of *B. incomptus* are not of specific rank and therefore propose that it be reduced to a variety of *B. crassus* Meek and Worthen and be referred to as *Bellerophon crassus* var. *incomptus*, Gurley.

"*Bellerophon nodocostatus* (sp. nov.)[9] Plate I, Figures 1, 2).

"Shell medium size, subglobose, moderately expanding body whorl, slightly embracing. Aperture subovate, robust, reniform. Margin of lip thin, conforming to the general direction of the growth of the outer whorl, slightly recurved as it joins the inner volution close to the umbilicus, which is distinct and partially concealed by the thin, raised, reflexed termination of the lip.

"Surface ornamented by fine revolving striæ, extending around the shell to the margin of the lip, there being about nine on either side of the mesial band, and increasing by implantation with the growth of the shell.

"There are numerous prominent, regularly arranged transverse costæ, which extend from the umbilicus across the shell with a gentle backward curve as they approach the center, and crossing the mesial band in a thin, sharply raised ridge, which is not in the same line as the costa but alternates with the lateral furrows on either side. The revolving striæ and transverse costæ in crossing each other become nodulose at the junction, developing small rather prominent nodes which assume a regularity in arrangement and give the surface a fine cancelled appearance, presenting a form readily distinguished from any of the known

[9] Bulletin 2, p. 9.

forms of this genus. The mesial band is narrow and the imbrication of the sharp transverse costæ and the few revolving striæ give it the fine nodose appearance possessed by the lateral portions of the shell.

"*Position and Locality:* Upper Coal Measures, near Oakwood, Vermilion County, Illinois."

Remarks: This species was based upon a number of cotypes from a band of very impure limestone. The matrix adheres tenaceously to the rough surfaces of these shells and although the character of the markings may be clearly observed it is exceedingly difficult to obtain them in all their details in a photograph. Consequently the figures of this species upon the accompanying plate, which are the first illustrations of this form to be published, are not as expressive as might be desired.

Ulrich[10] and later Girty[11] have referred *B. nodocostatus* to Patellostium but such a reference is totally unwarranted for the same reasons as were mentioned in the discussion of *B. textiliformis.* These two species are quite similar in form but differ greatly in their markings, those of *B. nodocostatus* being much coarser. The transverse costæ of this species are quite different from those of the other in that they do not represent prominent lines of growth but are produced by a folding of the shell similarly, but to a smaller degree, to *Patellostium montifortiantum. B. nodocostatum* is easily distinguished from this latter species by its unexpanded aperture, coarser and more widely spaced revolving striæ, less prominent transverse costæ and the presence of sharply upraised crescentic ridges which cross the mesial bend and correspond to the transverse costæ.

The surface markings of *B. nodocostatus* appear to be intermediate between those characteristic of Bucanopsis and Patellostium as represented by *P. montfortianum.* Lacking, however, the greatly expanded aperture and peculiar callosity of Patellostium this species should probably be referred to Bucanopsis.

It seems probable that Gurley's species may prove to be identical with *B. kansasensis,* Shumard, which was described as follows:[12]

"Shell of small size, subglobose, very rapidly expanding at the front; aperture very transverse, short, reniform, the sides becoming much thickened, extended and gently recurved poster-

[10] and [11] Op. cit.
[12] Op. cit.

iorly, where the volution is covered by a smooth and thick callosity; umbilicus small, round, sometimes partially hidden by the thickening of the lip; surface ornamented with from twenty-two to twenty-four transverse, rounded ribs, which are gently arched forward on either side of the dorsal sinus and become nearly obsolete before reaching the umbilicus; these are decussated on each side of the sinus by from ten to twelve revolving thread-like lines, distinct on the dorsum, but becoming indistince towards the umbilicus; at the points of intersection of the transverse and revolving lines there is a thickening which gives to the surface a very beautiful subgranulose appearance; dorsal band narrow, rather strongly depressed anteriorly, becoming shallow posteriorly, bounded on either side by a thread-like line, and marked by the transverse furrows, which are backwards.

''Dimensions: Length, .44; height, .32; width of aperture, .40; length of same, about .19.

''There is in the collection a specimen which is double the size of that from which the above proportions were taken.''

Until Shumard's species becomes better known, however, it it would be well to consider it as being distinct and Gurley's form may therefore be termed *Bucanopsis nodocostata* (Gurley.)

''*Bellerophon tenulineatus* (sp. nov.)[13] (Plate I, Figures 4, 5a, 5b)

''Shell medium size, subglobose, body whorl, moderately expanding; aperture broadly subovate, reniform, arcuate; umbilicus distinct, partially concealed by the thin, recurved extremity of the lip, which along the greater portion of the margin conforms to the general direction of the growth of the shell; the lateral margins of the lip gradually curve backward to the mesial band, where they join each other with a sharp backward curve, thereby forming a shallow sinus, which distinctly divides the lip into two parts.

''Surface marked by fine, closely arranged longitudinal striæ, which continue, without interruption to the margin of the lip, there being about thirty-five on each side of the shell and seven on the mesial band. The mesial band is small, slightly depressed, and barely distinguishable from the rest of the shell, being bounded on either side by a fine raised line which is somewhat heavier than those on the lateral portions of the shell. Regularly arranged, faint transverse lines of growth cross the shell,

[13] Bulletin 2, p. 10.

with a moderate backward curve in the same direction as the margin of the lip; they are not sharp or prominent and do not interrupt the evenness of the revolving striæ.

"This shell bears a strong resemblance to *B. marcouanus*, Geinitz in its ornamentation, but does not possess the broad, flattened lip of that form, and also differs materially in the form of the mesial band, which in that species is distinctly elevated in the center, whilst in this form it is depressed.

"*Position and Locality:* Same as the preceding."

Remarks: Girty has referred this species to *B. meekianus*, Swallow[14]. In doing so he is possibly correct although there is some doubt because of Swallow's statement in regard to the expanded aperture and carination. Neither Gurley's type specimen nor the other from his collection which is figured herewith show any dilation of the aperture except in the vicinity of the umbilicus, nor is there the slightest indication of carination. Swallow's originatal description is as follows[15]:

"Shell small, gibbous, broadly rounded on the dorsal margin, carinated near the aperture, ornamented with fine, crowded, longitudinal striæ and very minute transverse lines; aperture very much expanded, reniform, transverse, much modified by the preceding whorl, lip thickened and reflected over the umbilicus, with a linear callosity extending back from the points of junction on to the adjacent whorl; volutions concealed; umbilicus shallow, distinctly modified by the thick reflexed lip.

"Diameter, 0.77; width of aperture 0.60; length of aperture 0.35."

On account of the discrepancies between Swallow's description and Gurley's specimens which have been pointed out above, it seems to me to be inadvisable at this time to class *B. tenuilineatus* as a synonym of Swallow's species, which is by no means well established. Gurley's description and specimens characterize a distinct and easily recognizable species and recognition should be given to his name. It is, however, entirely possible that future investigation will prove beyond a reasonable doubt that *B. tenuilineatus* and *B. meekianus* are synonyms. Two other names that may also fall into the same category are *B. marcouianus* Geinitz and *B. perlatus* Conrad.

On account of its longitudinal markings Gurley's species has

[14] U. S. G. S., Bull. 544, 1915, p. 169.
[15] Acad. Sci. St. Louis, Tran. Vol. 1, 1858, p. 204.

been removed from Bellerophon and is now to be known as *Bucanopsis tenuilineata* (Gurley.)

"*Bellerophon rugopleurus* (sp. nov.)[16] (Plate I, Figures 3a, 3b.)

"Shell rather large, outer volution greatly expanding, forming a broad, rounded lip, which is slightly depressed toward the margin. Umbilicus moderately small, open and distinct. Aperture large, transversely reinform; inner margin of aperture callous, being quite elevated and prominent. Lip thin along the center, thickeneing up laterally and becoming very stout and callous at its junction to the inner whorl; distinctly divided in the center by a shallow sinus formed by the lip abruptly curving backward as it approaches the center.

"Mesial band consisting of a narrow shallow groove with rounded margins.

"Surface marked by small rather closely arranged, more or less prominent and irregular transverse costæ or undulations which vary in size from a prominent ridge to a mere line of growth, being more closely and regularly arranged on the body of the shell and becoming less prominent, and in many instances obsolete, near the margin. The transverse costæ extend from the umbilicus, with a gentle backward curve, around the shell to the margin of the mesial band, where they entirely disappear, the mesial band or furrow being uninterrupted by any traces of these ridges.

"Towards the margin of the shell there are faint traces of closely arranged, fine longitudinal striæ which are for the most part obsolete upon the transverse costæ along the body of the shell, but are quite distinct where they cross the transverse furrows between the more prominent ridges.

"This species has the general form of *B. marcouanus,* Geinitz, being one of those rapidly expanding forms with a small body whorl and a broad, dilated lip. The ornamentation is so entirely different that any comparison is unnecessary.

Locality and Position: Same as preceding."

Remarks: A careful examination of the type of this species and comparison with the types of *B. nodocostus* have lead me to the conclusion that these are conspecific. The type of *B. rugopleurus* is a large individual nearly twice the size of any of the

[16] Bulletin 2, p. 11.

cotypes of *B. nodocostatus.* Its proportions are somewhat different but this may be the result of compression. This shell is obviously much water worn and the details of the surface markings are largely obliterated but those which remain agree well with the smaller forms. The types of both species were collected from the same locality and when this is considered in connection with their other similarities there can be little doubt as to their identity. The outer lip of the larger shell is broken away and the prominent callosity is revealed to a greater degree than in any of the smaller specimens.

As *B. nodocostatus* was described upon a page preceding the description of *B. rugopleurus* this latter species will take its place in the synonymy under *Bucanopsis nodocostata* (Gurley).

Explanation of Plate

Note: All figures are enlarged two diameters.

1. *Bellerophon nodocostatus*—cotypes WM 6328.
   Anterior view of a small specimen.
2. *Bellerophon nodocostatus*—cotype WM 6328.
   Side view of a larger somewhat crushed specimen.
3. *Bellerophon rugopleurus*—type WM 6326.
   a. Anterior view.
   b. Side view. The outer lip is broken away showing the callosity.
4. *Bellerophon tenuilineatus*—type WM 6329.
   Anterior view of the type specimen.
5. *Bellerophon tenuilineatus*—WM 11639.
   a. Side view of another specimen in the Gurley collection from Kansas City, Missouri.
   b. Anterior view of the same.
6. *Bellerophon harrodi*—type WM 6319.
   a. Side view of the type specimen.
   b. Anterior view of the same.
7. *Bellerophon textiliformis*—WM 11624.
   a. Side view of a specimen in the Gurley collection from Kansas City, Missouri.
   b. Anterior view of the same.
8. *Bellerophon textiliformis*—WM 11624.
   Anterior view of a larger somewhat crushed specimen from the same locality, also in the Gurley collection.
9. *Bellerophon incomptus*—cotype WM 6325.
   a. Side view of a crushed pyritized specimen.
   b. Anterior view of the same.

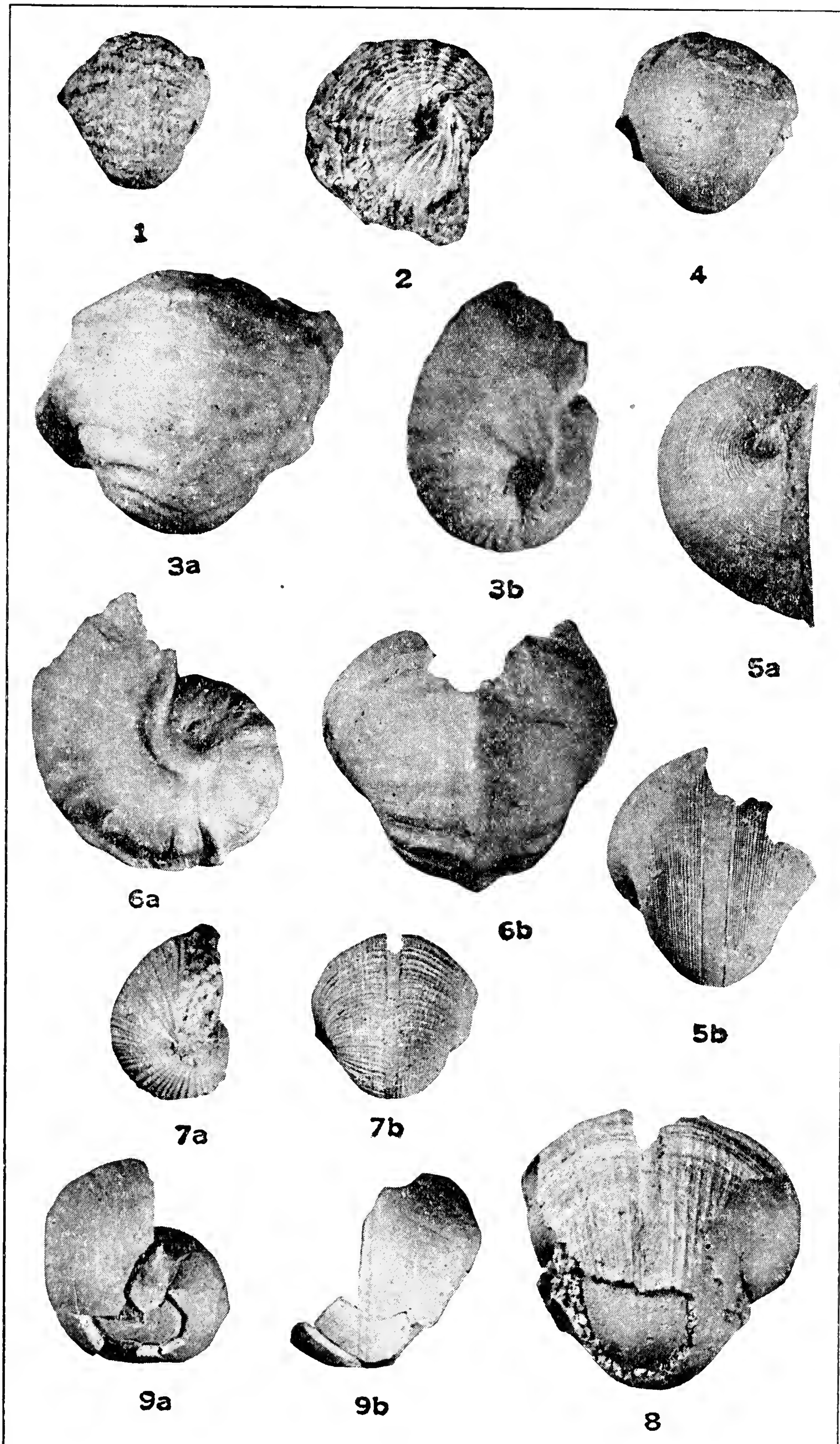

PLATE I.

THE SILURIAN FAUNAS OF SOUTHEASTERN MISSOURI.*

JOHN R. BALL, NORTHWESTERN UNIVERSITY.

For several years study of certain Silurian faunas of Southeastern Missouri has been in progress. Part of the investigation has been completed, but the work continues because recent additions have been made to the collections.

Silurian strata outcrop discontinuously between Ste. Genevieve and Cape Girardeau, Missouri. The fossils were collected chiefly in localities near each of these cities. Until early in the summer of 1927 the work had been under the direction of the late Stuart Weller. Richard Flint of Yale University and Josiah Bridge of the Missouri Bureau of Geology and Mines have contributed much assistance in connection with their own work in the same region.

Faunal Summary.

That part of the faunas studied includes 151 species. Illustrations of 147 of the species have been prepared for publication, and descriptions of 124 species have been written or rewritten. Of the described forms 58 species are new and 27 individuals either have been referred provisionally to certain genera or compared with closely related forms. This makes the aggregate of new species practically 85.

The species are distributed as follows:

Corals	18	Bryozoans	6	Gastropods	13
Graptolites	1	Brachiopods	55	Cephalopods	6
Echinoderms	22	Pelecypods	7	Trilobites	20
Vermes	1				
Stromatoporoids	1				

One coral, very common in the collections, of general Auloporoid habit, was placed in a new genus of the Auloporidae.

Formations.

In addition to the faunal aspect thus indicated, the study has developed some additional facts concerning the number of Silurian formations represented in Southeastern Missouri.

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Formerly, but one formation, the Bainbridge limestone was recognized in the area. The collections include, however, *Triplecia ortoni* a brachiopod, *Phaenopora multifida,* a bryozoan, *Illaenus daytonensis,* a trilobite, and three other forms highly characteristic of the Brassfield limestone, a lower Silurian formation of Kentucky, Ohio and Indiana. Equivalent strata also are in Illinois as Savage has indicated[1]. Ulrich, Reeds, and others have reported the occurrence of the Brassfield farther south and west as well. The presence of the Brassfield in this part of Missouri, therefore, extends the domain of that Early Silurian sea to this region as well as to the others above mentioned. Recently, Flint has recognized the Edgewood formation, another member of the Alexandrian Series, in this area. The Silurian succession, as now known, therefore, is as follows:

Niagaran	Bainbridge limestone
	(Unconformity)
	Brassfield limestone
	(Unconformity)
Alexandrian	Edgewood limestone
	(Unconformity)
	Girardeau limestone

Correlation.

Another matter considered in the investigation has been the correlation of the Bainbridge formation with Silurian strata elsewhere in the United States. The most obvious correspondence of the Bainbridge fauna is with that of the Brownsport beds of southwestern Tennessee. This locality is about 150 miles distant. Of seventeen Bainbridge species, sixteen appear in, and nine are restricted to the Brownsport beds. The Waldron beds of Indiana is a classic locality for Niagaran or Middle Silurian fauna. The Bainbridge fauna includes individuals that have interesting affinities with the Waldron forms. The two faunas possess some ten or eleven species in common, but only one of this number is restricted to the Waldron beds. Several Bainbridge species are strongly suggestive of characteristic Waldron forms but yet are not identical. Such instances are seen in two of the new species of the Bainbridge which have been named *Camarotoechia indianoidea* and *Camarotoechia neglectoidea* because of their striking resemblance to the well-known

[1] T. E. Savage "Stratigraphy and Paleontology of the Alexandrian Series in Illinois and Missouri." Illinois State Geol. Survey Bull. Vol. XXIII (1917).

Waldron species, *Camarotoechia indianensis* and *Camarotoechia neglecta.*

With the fauna of the Silurian limestone in the vicinity of Chicago the Bainbridge has still less in common. Eight instances, some of doubtful identity, are recognized, but in several cases the fossils are of wide areal distribution, almost ubiquitous in Silurian strata. One peculiar coincidence, however, is in the presence of *Pisocrinus quinquilobus,* formerly reported only from the Brownsport and Chicago regions. This fossil also is quite abundant in the Missouri Bainbridge. The peculiarity of the Chicago occurrence is that the fossil has not been noted in place in the limestone. Where found, the crinoid, well silicified, has been washed into clay pockets in the bedrock along the Des Plaines River below Lemont. Mr. Slocom, of Walker Museum, who has discovered the fossils in such position, has not observed them elsewhere in place.

For both of the Missouri Silurian formations, then, mentioned especially in this paper, the conclusion seems possible that their faunas have their closest affinities with those in strata of the same age, particularly to the east, but to some extent west, also, of the Mississippi River.

SIGNIFICANCE OF CONGLOMERATES IN INTERPRETING THE MESOZOIC HISTORY OF THE NORTHERN ROCKY MOUNTAINS.

ARTHUR BEVAN, UNIVERSITY OF ILLINOIS.

Foreword.

During field work on the western Great Plains and in the adjacent front ranges of the Rocky Mountains in Montana and northwestern Wyoming prominent conglomerates were observed in certain Mesozoic formations. As these conglomerates obviously afford considerable significant data for interpreting the contemporaneous geography and physiography of that portion of the Rocky Mountains in which they occur, as well as of portions of the source province, a study of the literature was begun in order to outline the problem of their distribution and origin.

Conglomerates have been observed by many geologists in this region, but the nature of most of the field investigations did not permit particular attention being given to them. As a result they are generally briefly described without interpretations; in some cases they are only mentioned as part of the general section. However, all reports that contain much stratigraphic data on the Mesozoic formations at least mention them. A few workers in other parts of the Rocky Mountains, especially Mansfield in southeastern Idaho, have recently suggested or made interpretations of some of the Mesozoic conglomerates.

This article is a brief preliminary summary of some of the data with partial interpretation of them. It is not an exhaustive treatment, as much study of the literature and considerable field work will be necessary to treat the subject in a comprehensive manner. The purpose of this paper is to emphasize the value of most conglomerates in deciphering the paleophysiography of extensive regions, to stress the need of more thorough field study and more complete description of significant conglomerates, and to summarize some of the numerous facts about Mesozoic conglomerates that are scattered through the extensive literature of the northern Rocky Mountains. Although equally significant conglomerates are present elsewhere in the Cordilleran region they are not considered at this time. More complete discussion will be given in a subsequent paper.

Distribution and Range.

Conglomerates are somewhat numerous and widespread in the Mesozoic formations of the Rocky Mountains and even in the larger Cordilleran region. Some are local but a few are remarkably persistent. They are present along the western Great Plains and in the ranges of the Rocky Mountains in Montana and Wyoming wherever extensive Mesozoic sections exist. Some have been reported as far north as northwestern Canada and others as far southwest as the Plateau region of Utah and Arizona. Their east and west limits are not definitely known, but the conglomerates seem to be more common in the eastern part of the northern Rocky Mountains and on the adjacent plains. In places they occur as far west as do the Mesozoic formations, and no doubt once extended much farther west. This vast area is not covered by one or more continuous sheets of conglomerate; with, perhaps, one notable exception, the conglomeratic zones are markedly discontinuous.

The principal conglomerate horizon in the northern Rocky Mountains is the lower part of the Lower Cretaceous (Comanchean), mainly the Kootenai formation or its approximate equivalents. This conglomerate has attracted most attention because of its persistence and thickness, and it has been interpreted by a few geologists. Conglomerates are present in other Mesozoic formations, chiefly in the Ellis formation (upper Jurassic) and in members of the Colorado and Montana groups (upper Cretaceous). The overlying Lance and Fort Union formations also contain conglomerates which seem to antedate the main Laramide orogeny that caused much coarse detritus to be supplied to post-Fort Union basins.

The Pennsylvanian and Permian of Western Montana and adjacent states contain some conglomerates that are somewhat similar to those in the Mesozoic formations. Conglomerates of this age extend as far west as the east side of the Sierra Nevada. These older strata will not be discussed at this time.

Triassic conglomerates are very widespread and persistent in the Plateau region of the Southwest. They have been treated in some detail by numerous workers in that province.

Character and Relations.

Much of the coarse material in the Mesozoic conglomerates is chert. It is mainly in the form of small black pebbles, but other colors are rarely present. Pebbles of quartzite and limestone are moderately abundant in places, and pebbles of sandstone and shale are reported from a few localities. Igneous pebbles occur locally in some formations, chiefly in the Fort Union. Black chert pebbles form prominent beds at some horizons in the Cretaceous of central Montana and northwestern Wyoming. As the formations weather these pebbles are strewn in considerable abundance along gentle dip slopes.

Most of the chert and quartzite pebbles are subangular to rounded. Highly angular fragments seem to be scarce except at a few localities in Wyoming and in parts of Idaho. The black chert pebbles in the Cretaceous of Montana generally have smooth, somewhat polished surfaces. Hence, much of this material is travel-worn.

The pebbles are as a rule less than one inch in diameter. Some beds are without pebbles larger than one-half inch. Some chert cobbles rarely as large as one foot have been reported. Insufficient data are at hand to state definitely the distribution of size grades, but it appears that the size increases rapidly westward from the plains and front ranges.

The thickness of the conglomerate zones is variable. In many places the beds are lenticular, varying from several inches to several feet in maxium thickness. The Kootenai conglomerate is persistently a few tens of feet in thickness, and in places becomes almost 100 feet thick. Mansfield[1] reports two conglomerates in the Lower Cretaceous (?) of southeastern Idaho to be each about 1,000 feet thick.

In addition to the well-defined conglomerate zones some of the typical standstones are highly arkosic. Many of the Cretaceous sandstones are conspicuously peppered with small grains of black chert.

Some of the conglomerates or conglomeratic standstones which are remarkably persistent are almost certainly basal conglomerates. Many of the other zones may be found to represent a decided break in sedimentation. Some of the conglomerates are intraformational and probably indicate nothing more than temporary changes in the conditions of sedimentation.

[1] Mansfield, G. R., Geography, geology, and mineral resources of part of southeastern Idaho: U. S. Geol. Survey Prof. Paper 152, pp. 103-104, 1927.

General Interpretations.

These Mesozoic conglomerates and conglomeratic sandstones suggest several things about the late Plaeozoic and Mesozoic physiography and conditions of sendimentation in the northern Rocky Mountains. The chert pebbles and grains are particularly significant because they best survived the stress of erosion in the source area and of transportation to the final site of deposition. Furthermore, they can in many cases be more confidently traced to parent formations.

The source of most of the chert is Paleozoic limestones. Scattered nodules and discontinuous seams of chert are common in some of the Carboniferous limestones, and nodules are present in Devonian and Ordovician limestones. Unfortunately, too little study has been made of these limestones and especially their cherts to trace the pebbles to their sources in as much detail sa may be done in the future. Fossils have been discovered in the cherts in a few sections, but such occurrences are rare.

The quartzite pebbles appear to have been derived mainly from Proterozoic formations, such as the Beltian series in Montana, but some may have come from Paleozoic strata. Igneous pebbles and feldspathic grains may have been supplied by rocks of widely variable age, but the pebbles in the Cretaceous conglomerates, including the Fort Union horizons, probably came mostly from pre-Cambrian terranes. Some of the granitoid pebbles are in places certainly of this origin. The limestone, sandstone, and other pebbles are more or less local, having been derived from Paleozoic and early Mesozoic formations that were exposed near the sites of sedimentation.

The abundance of chert pebbles and grains in conglomerates and standstones and the wide distribution of these sediments indicate a total mass that is very large. Since chert constitutes only a small per cent of any source formation the conclusion is warranted that great decay and disintegration of Paleozoic limestones occurred during Mesozoic time. Hence, these limestone must have formerly extended far west of their present outcrops.

This extensive and deep erosion indicates that the land mass west of the Mesozoic Rocky Mountain geosyncline was elevated considerably during the Mesozoic era. As a result the Paleozoic limestones were removed probably from large areas. The extent of the uplift, the height of the land mass, and the relative rate of elevation are interesting problems, but more data are necessary before even useful suggestions can be made. A detailed study of the chert conglomerates would probably afford much information in regard to the paleotopography of the region and the conditions of piedmont and flood-plain sedimentation during the Mesozoic.

The general uplift of the region west of the main basin of early Cretaceous sedimentation has been recognized by some students, but its importance has commonly not been sufficiently stressed. Schuchert has recently shown the general conditions on paleophysiographic maps.[1] Mansfield has given an excellent interpretation of Cretaceous conglomerates in southeastern Idaho. The significance of other conglomerates, especially those of more restricted distribution and of older age, and has not been so well recognized. Much work remains to be done before their paleogeographic bearings are fully deciphered. The several conglomeratic horizons and the repeated recurrence of chert pebbles and sand grains may signify cyclic conditions, either of a diastrophic or climatic character, in the source region.

[1] Historical Geology, 2nd edition, p. 511, 1924.

PAPERS IN GEOGRAPHY

A PRIMITIVE INDUSTRY IN SOUTHEASTERN ILLINOIS.

CLARENCE BONNELL, HARRISBURG, ILLINOIS.

The first white men coming to Southeastern Illinois found the Shawnee Indians already in possession. Shawneetown, an Indian village, lay on the north side of the Ohio River a few miles above the mouth of the Saline River and twelve miles below the mouth of the Wabash.

Many things indicate that the village site had been for a long time the natural distributing point up and down the rivers from the salt springs ten or twelve miles up the Saline River. The mounds in and about Shawneetown were rich in relics of prehistoric men. The great abundance of broken pottery fragments over the territory between Shawneetown and Equality near the old salt springs leads to the belief that the making of pottery as containers for salt and for evaporating salt water was connected with activity in collecting salt and possibly trading it for other things of value from afar. Some of the trinkets found about Shawneetown are of materials brought from a distance.

The early white trappers and traders and, later, the early settlers, were attracted to the sources of salt supply. The most extensively worked salt wells used by the white men were those just southwest of Equality where traces of that early industry still remain. Another spring which later must have been opened out into a well and walled with heavy timbers some of which yet remain, is located about three miles southeast of Equality, a few hundred feet from the south bank of the Saline River and just at the foot of a high range of hills. A dirt road runs parallel to the hills and crosses a little stream bed just south of this spring which lies in the stream. In times of flood, backwater covered the road making travel difficult or impossible. Just to the east of the well and north of the road there is a small field of less than an acre which is generally level but lies above the high water mark. The soil is black in contrast to the clay of the surrounding hills and stream banks, due to the remains of charcoal which was used in evaporating salt, during the time of the early white man in this region. I had known of this for a number of years and at times had picked up small bits of pottery. It is known that negro slaves were used and that a great deal of activity centered here. The owner of the land tells me that he has plowed up several whole pieces of pottery and two or three skeletons. He and others tell me of stone walled graves, supposedly of Indians, on the high hill top just to the southeast, which are said to have been robbed of what ever they contained many years ago. Only rough slabs of stone and sunken places remain.

The brackish water from the well which always overflows contains about 1.3% of salt by weight.

Concerning this region, I quote from A. T. Norton's History of the Presbyterian Church in the State of Illinois, published in 1879. "The eastern settlements in 1813 extended thirty miles up the Wabash and forty down the Ohio. They include the United States saline where a considerable number of people are employed in manufacturing salt. This is twelve miles back from Shawneetown, near the present town of Equality. Shawneetown, on the Ohio twelve miles below the mouth of the Wabash, contained about one hundred houses. Shawneetown derives its name from a band of the Shawnee Indians, located there from 1735 to 1760. It contained a few straggling houses from 1805. It was the nearest point to the salt wells, twelve miles west. It was laid out by the United States Government in 1813-1814, that point being chosen on account of its continguity to the United States salines."

Late last autumn, Mr. Lafayette Justice, then road commissioner of Equality township, began the construction of a fill across the stream bed above the spring to make the road passable in flood time. Dirt for the fill was taken from the banks of the old roadway mostly from the east side of the stream. The plow and scraper unearthed many fragments of pottery from these banks which were cut down to a depth of four feet in some places and revealed in the fresh cuts successive layers of yellow clay, charcoal, burned clay, etc., all mixed with mussel shells, pottery fragments, and small pieces of bone. At one point at a depth of four feet or more a skeleton was found. A workman drove his pick through the skull and the bones were scattered and carried away by the curious. I obtained a few fragments that had been saved in the neighborhood. There is probably nothing significant about these skeletons as they may have been those of white or black laborers who died and were buried in the most convenient place.

The earthenware fragments are of special interest because of their composition and apparent method of construction which, however, is common to many of such specimens in this region and further south; but the great size that some of the vessels must have had is more remarkable. Using a rim as the arc of a circle I estimated that one of them must have been forty-six inches in diameter. A large number of fragments were about as large, and must have been from containers that large or nearly so. I gathered quite a large number of these, and others had been carried away before I arrived on the scene which was several days after the discovery of the skeleton.

The pottery appears to be made of clay and finely broken bits of mussel shells. The marks or patterns on the outer surfaces indicate that basket like vessels were woven then plastered on the inside with the clay and shell mixture. A few pieces only are smooth on the outside as well as on the inside and these seem to be of the smaller sizes. Some whole pieces of small size found at Shawneetown are smooth without as well as within. The largest whole piece found there held fourteen gallons and the design on the outside was conventional in contrast to the rather irregular prints of the coarsely woven support of the pieces from larger vessels.

The thin layers of charcoal and burned clay together with the large numbers of mussel shells and earthenware fragments extending to a total depth of nearly four feet in some places point to successive generations of men who must have made these huge containers and used them in the salt industry long before the white man came. At the surface, I found some fragments of iron kettles which were evidently the work of the early white men who continued this prehistoric industry.

A closer examination of the undisturbed banks of the roadway on both sides of the stream reveals shells and pottery fragments projecting from the clay, all of which makes it apparent that there may be an area of an acre or more immediately surrounding this old well where many generations, beginning back before Illinois history is recorded, camped and labored at the salt making industry up to within the memory of some now living.

ANOMALOUS PANAMA.

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University of Chicago.

A new treaty between the United States and Panama, signed but not yet ratified, has raised a storm of disapproval in Europe and Latin America. The treaty provides that Panama shall consider itself at war whenever the United States is at war, and that military operations throughout the Republic of Panama shall be under the control of the United States. Even in time of peace American troops shall have access to any part of the nation, and the United States shall have jurisdiction over radio stations and aviation routes.

These provisions have been construed as an extension of American control beyond the Canal Zone to include the whole Republic of Panama. Europe and Latin America have been aroused at this as an encroachment on an independent member of the League of Nations.

Surprise and disappointment over the treaty would be justified if it marked a real American advance from the Canal Zone to the Republic of Panama and if the significance of the advance could be measured in square miles, from the little Canal Zone, 10 miles wide, to the Republic, 70 times as large.

But nations are not to be judged by square miles of land marked off by boundary lines any more than men are to be judged by their shadows on the wall. We have been under the spell of common maps. From maps we imagine that Brazil is a huge nation occupying the heart of South America and that Chile is a narrow strip of country along the Pacific coast, when as a matter of fact these two nations are quite similar in form from the viewpoint of their national structure. The Amazon lowlands and the interior savannahs are merely appendages, and the real Brazil is in the highlands along the Atlantic Coast, as Chile is along the Pacific.

Many nations, particularly new and underdeveloped nations in Latin America, are not understandable as homogeneous areas but rather as active organism, each consisting of a relatively populous and productive nucleus extending its influence over relatively weak, unattractive, and sparsely populated outlying districts. At the outset boundaries are unimportant, lying somewhere in the unoccupied territory between two nuclei, reached by an equally tenuous influence on either side. It is the heart of the nation that is significant and not the fringes.

It is of little significance that the Republic of Panama has an area of 32,000 square miles extending from the territory of Colombia on the one hand to that of Costa Rica on the other. The boundaries are in districts practically uninhabited and inaccessible and so remote from the centers of the nations concerned that they have not yet been exactly fixed. Most of the area of the country is unoccupied, unproductive, and almost valueless at the present time. Parts of it are held by intractable Indian tribes in complete independence. Only a few communities of secondary importance occupy moderately favorable districts. The country is not remarkable either for production or for natural resources.

The heart of the nation is not a productive district; it is the crossing place of the Isthmus. This crossing place became a center of activity in the early days of the Spanish colonial empire. In the 16th, 17th, and 18th centuries a large proportion of the trade of Spain's chief mining districts in the Andes passed across the Isthmus. Pack animals were succeeded by the railway in the 19th century, and activity was renewed with the passage of Californian traffic during the gold rush. The 20th century sees the trade of the Pacific with the North Atlantic pasing through the canal.

The only important district in Panama is that near the canal. The Canal Zone is not merely 436 square miles in a nation of 32,000; it is the heart of the country, the one great asset. The two chief cities of the country are at the two ends of the crossing, so close to the canal that they are excluded from the Canal Zone by explicit agreement and form enclaves within it. It is natural that they should be excluded, since they are the only real cities Panama has and one of them is the capital. It is also natural that they should be included under the potential control of the canal authorities, in view of their relation to the canal, which is their source of life.

That the United States controls the greatest asset of the nation is not a cause for resentment by the people of Panama. Unlike some natural resources, this asset cannot be removed. The economic results would not be more satisfactory for Panama if the canal were controlled locally. The inhabitants of the country have been unable to develop their asset, and are glad to have someone else do it. Whatever truth there may be in the charge that President Roosevelt fomented revolt in Panama against Colombia, there is no doubt that the Panamanians were ready for revolt, or anything, to bring about the one event that would save them from oblivion.

This exposes the fact that the Isthmian crossing place is not merely the nucleus of the Republic of Panama. It has become an outlying district of the great nucleus or cluster of nuclei in the United States. Unlike other cases where two nations are interested in the same territory, there is no conflict here. The interests are different and supplementary. Panama has very little use for the canal but has great interest in its construction, maintenance, and use by others. The United States has more use for it than any other nation. The canal carries more traffic between eastern and western United States than between any other regions of the world.

It is evident that the United States has a natural if not pardonable interest in the canal and adjacent land. It is also evident that the extension of the American control to include not only the Canal Zone and the neighboring cities but the whole republic is a less significant change than the ordinary map would indicate. Much more significant is the fact that the United States has from the outset controlled the very heart of the country under circumstances which preclude real independence for Panama.

The new treaty makes Panama a manifest anomaly as a member of the League of Nations. But in the light of fundamental facts, Panama in the League has always been an anomaly and could not be anything else. The treaty does not produce but reveals the anomaly.

The senate of Panama has failed to ratify the treaty and is said to desire better terms. Perhaps the failure to ratify is due to the disapproval of other nations. But it is significant that the changes desired by Panama are not in the terms which called forth foreign disapproval. Panama is not concerned with American military occupation now any more than formerly. On the contrary what it desires is more participation by the United States in the building of roads and other public improvements, subjects touched upon in the treaty but passed over as unimportant by foreign critics.

What has this analysis to do with diplomacy or with international rights and wrongs? Should the new treaty have been signed? Should it be modified? Should the United States have dug the canal? What should be the policy of the United States with respect to Latin American sensibilities, the Monroe Doctrine, and the League of Nations? Perhaps these are not questions for geographers to answer. Geography may reveal only some of the roots from which the answers spring.

MALARIA AS A FACTOR IN ITALIAN ENVIRONMENT.

W. O. Blanchard, University of Illinois.

Italy has long been the classic land of malaria. From whence it came or when introduced is not known but that it was well established in the Peninsula long before the Christian era, is certain. For at least twenty-five centuries it has taken a heavy annual toll of life,[1] and the economic loss through decreased efficiency of labor and reduced utilization of areas subject to the disease have been enormous.[2] Even today one-third of the total area and 40% of the population of the entire Kingdom are in communes officially "malarial." The number actually living in the infected parts of such communes is about 12% of that of Italy or about four million people. The number of cases "officially reported" annually runs over two hundred thousand and it has directly or indirectly affected the social and economic welfare of the whole population.

In the centuries following its introduction into Italy devasting wars both civil and foreign, by discouraging agriculture and especially by their destruction of the irrigation and drainage systems, caused much of the cultivated land to revert to pasture and marsh, thus providing favorable conditions for the spread of malaria. Extensive deforestation by aggravating the flood problem added to the difficulties. It is well known that certain sections of south Italy which, in the eighth century, were sites of large and prosperous communities have since been rendered desolate and barren by the ravages of malaria. The increase in the area affected in the southern part of the Peninsula since 1860 has been extraordinarily rapid. In 1880 only six of the sixty-nine provinces of Italy were entirely free from the disease; in 1885 there were only two; in 1902-5 there were eleven and in 1923, seventeen.

The close connection between malaria and marshes was early recognized; indeed, long before the relation of the disease to the mosquito was known. The name itself (mal-bad; aria-air) owes

[1] However, the death rate in recent years from measles, from typhoid or from tuberculosis is larger than that from malaria. The mortality from tuberculosis in 1923 was over sixteen times that from malaria.

[2] It has been suggested as an important contributing factor in the national decadence of Spain and in the fall of Greece and Rome. See Regnault, Dr. Felix;—The Role of Depopulation, Deforestation and Malaria in the Decadence of Certain Nations, Annual Report, Smithsonian Institute, 1914, pp. 593-7.

its origin to the common belief that the foul air from swamps carried the infection. Naturally the first measures of protection undertaken involved the drainage or filling of overflow lands or, failing in this, the abandonment of the vicinity as a human habitation, at least during the summer season. At this time of the year drought turns many streams into chains of stagnant pools which with the high temperatures then prevailing, provide the optimum conditions for mosquito breeding.

Remedial Measures—The reclamation of poorly drained land has always been in Italy one of the two most important lines of attack on the malarial problem. When Italy became a united Kingdom in 1870 there were over 4½ million acres of land with drainage so bad as to be a menace to health. A vigorous campaign of state reclamation begun in 1880 has to date restored to use about one-half of this acreage. Of the total which required improvement over ⅗ was in north Italy, although the warmer central and southern parts of the Peninsula and the islands have always been the worst infected with malaria. Agricultural development has quickly followed the completion of the government drainage projects in the north; in the central and south it has lagged. The reclamation work has not only reduced the breeding of anopheles but by improving living standards it has increased the physical well being and resistance of the people to malarial attack.

A second and no less effective measure in the antimalarial campaign has been to make quinine, the principal specific, available to all. Though the virtues of this drug had been known since the 17th century it was not until the government took over its manufacture and distribution as a state monopoly in 1902 that it was placed within the reach of even the poorest peasant. Its distribution free or at small cost has been a tremendous boon to rural Italy and the enforcement of the "quinine laws" have been marked by sharp declines in the malarial death rate.

The real modern anti-malarial campaign in Italy dates from the beginning of the present century. The discovery of the role played by the anopheles mosquito as the transmitter of the malarial parasite gave a tremendous impetus to the fight and high hopes were entertained for the speedy elimination of the disease. Needless to say, they have failed of realization. True, the discovery placed additional weapons at the disposal of the campaigners. The oiling of stagnant waters, the introduction of mosquito-eating fish, the screening of dwellings, all came to be a part, though a minor part, of the campaign. The major credit for the reduction of the malarial menace still rests upon the drainage and quinine measures.

The Campagna. The work of "bonification" or improvement, by which the malarial districts are being gradually re-

FIG. 1.

claimed may be illustrated by the Roman Campagna, for centuries one of the most notorious of malarial districts.

The Campagna is a vast plain about the capital city, underlain by impervious clays. The soil is fertile, the climate good, and the presence of an excellent market in the capital seemed to furnish all the requisite conditions for a prosperous agricultural region. Indeed, in ancient times, this section supported a dense population, but for centuries it has been desolate and all but forsaken.[3] Less than 10% has been under cultivation. Without forest, towns or permanent homes it has been inhabited in winter by scattered herdsmen but even these retreated with their charges to the mountains in summer. For the past half century the government has repeatedly tried to colonize the region but until recently with little success. Of late the prospects have been more promising. In addition to general reclamation works and quinine legislation various economic inducements have been included, e. g. the building of roads, introduction of electric power, extension of long time loans to settlers, exemption of buildings from taxation, and the providing of agricultural experts as teachers. From 1900 to 1906 the proportion of the inhabitants affected by malaria was reduced from 32% to 4% and the agricultural revival is changing the whole appearance of the Campagna.

Distribution. The distribution map of malarial zones, Fig. 1 shows a striking resemblance to the physical map. The dependence of the disease upon the anopheles mosquito as the carrier naturally confines it largely to the plains region where favorable conditions for the propagation of mosquitoes exist. This is especially unfortunate for Italy since with a dense population still chiefly agricultural it needs every acre of soil available for food production, doubly so since the area of lowland is so limited. It is estimated that for Italy as a whole only one-fifth of the surface is plains, the remainder being equally divided between mountain and hill land. Assuming that the mountain areas are free from malaria, this means that more than one-half of the plains and hills, the most productive of Italy's lands, are malarial zones.

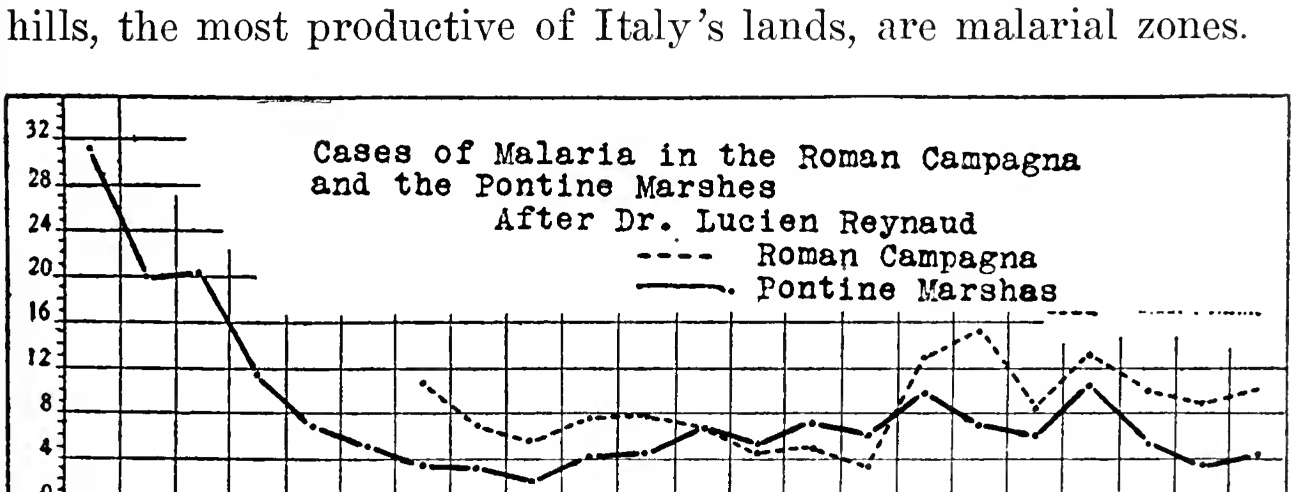

Fig. 2

[3] Depopulation that set in with the fall of the Empire apparently reached its lowest stage in the 17th and 18th and first half of the 19th centuries. Ashby, T. The Roman Campagna in Classical Times, London, 1927.

In north Italy the Po valley and north Adriatic coast, in central Italy, the low lying coastal plains, are favorable malarial areas. The mountain streams checked in their descent from Alps and Apennines, deposit their silt, clog up their lower courses and provide extensive overflow lands. Dunes aid in lagoon formation along the coast and even in the hill and mountain country, open quarries and crater lakes have been prolific centers of infection. In south Italy and on the islands the infected area includes considerable upland as well as the valleys and coastal plains. Here the higher temperatures and more marked seasonal irregularity of the river regime are more favorable for mosquito breeding. It is in this southern portion of Italy that the disease carries with it a large proportion of fatalities while in the north it is very mild. Thus Basilicata in the extreme south had from 1901 to 1905 an average malarial death rate in proportion to the number of inhabitants, fifty times that of Lombardy in the north. Malaria may well be charged with a considerable share of the responsibility for the retarded development of this southern part of the Peninsula and the Island.

Figure 3 shows the decline in death rate. The decrease is most striking. Thus from 1887 to 1902, the period preceding the quinine legislation, the mortality averaged 15,000 annually; from 1903 to 1905 with the enforcement of the malarial laws, the average fell to about one-half that figure. Fluctuations are of course to be expected, partly in response to climatic differences, partly as a result of human activities. The latest recrudescence, it will be noted, came during the war period when the exposure of vast numbers of men and their movements from place to place were bound to spread the disease. In addition war activities not only interrupted the antimalarial campaign but actually destroyed vast irrigation and drainage systems, thus releasing the check upon mosquito breeding.

The number of deaths is of course only a part—and but a small part—of the total loss and suffering caused. From 1919 to 1923 inclusive, there were officially reported an average of 56 cases of illness for every death. How many malarial attacks were never officially reported is, of course, unknown, but the number must have been large. A disease so common and one in which the standard specific—quinine—may be administered by anyone, together with the fact that many of those affected live in isolated sections would indicate that the numbers officially reported are far under the real figures.[4] Prof. B. Goss estimates that the average annual death rate of 15,000 from malaria between 1903

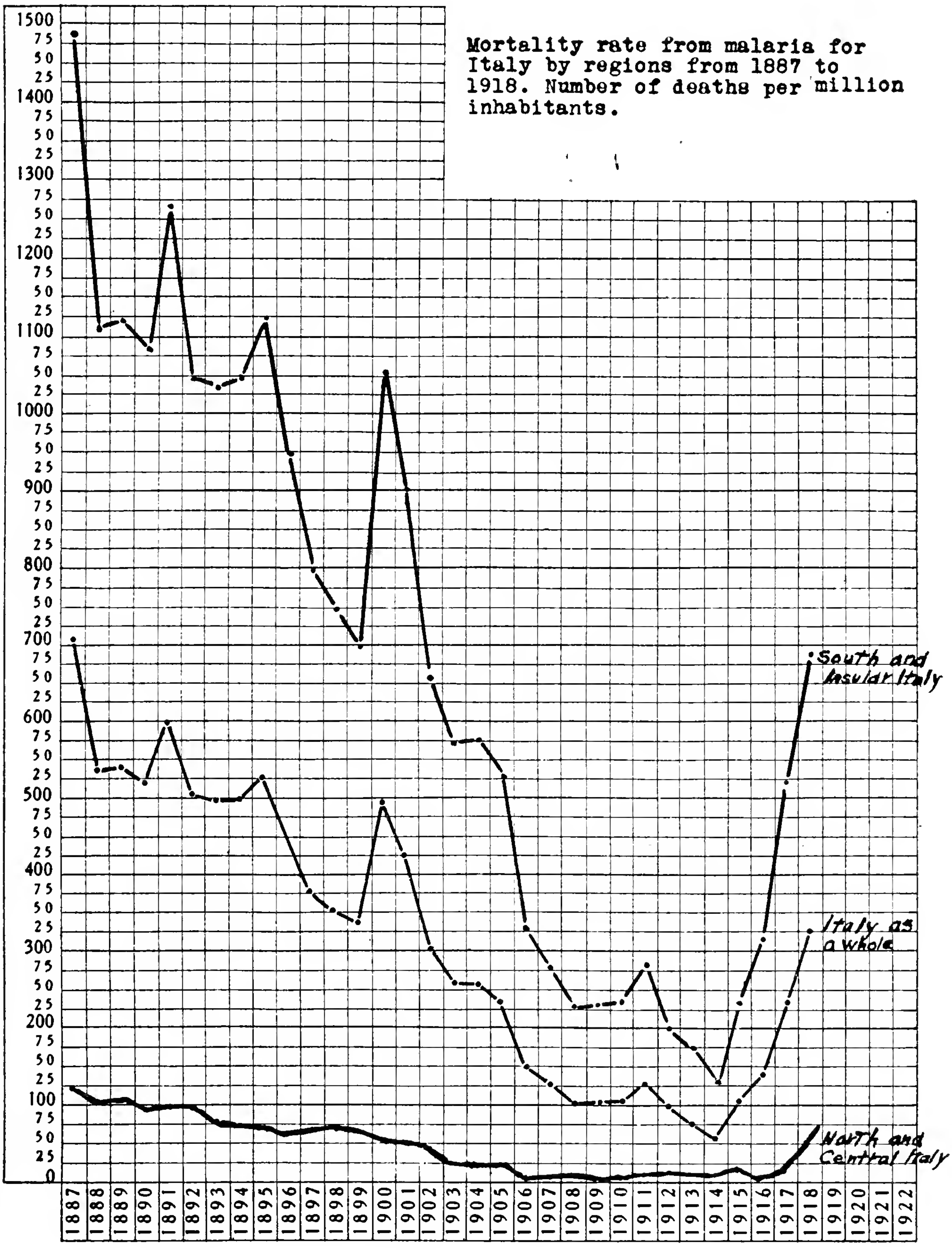

FIG. 3.

and 1905 represented some two million cases, or a ratio of one death to one hundred thirty-three attacks.

In addition to the marked success of the anti-malarial meas-

[4] Malarial illness began to be officially reported in 1902. After reaching a high point of 323,000 in 1905 they declined and in recent years have usually been less than 250,000.

ures in saving life there have been notable economic results. The national government spent in the work from 1900 to 1920 about $100,000,000. The improved land has an estimated value of $400,000,000. It is of course recognized that the accomplishment

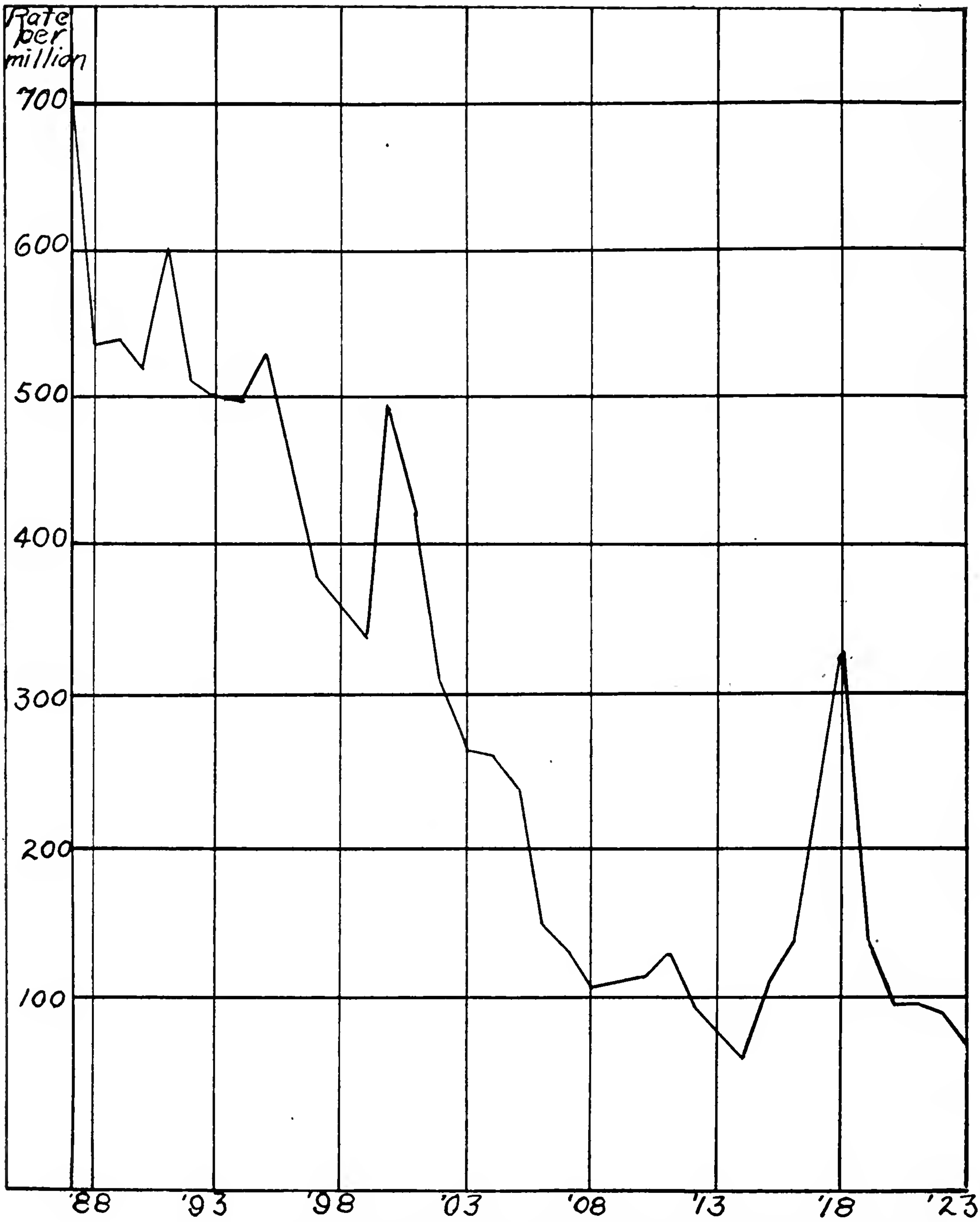

FIG. 4.—Death rate from malaria and malarial conditions in Italy. From Commission du Pauldisme "Rapport sur Son Voyage d'Etude dans Certains Pays d'Europe en 1924."

in stamping out the disease has not been everywhere satisfactory or commensurate with the cost.

The most common effect of malarial infestation has of course been depopulation and the reversion of land to waste or to pastoral use. This change in the type of land utilization has resulted in a modification of agricultural methods, of land ownership, of population distribution, and of emigration. For example, since the anopheles works at night and chiefly in summer, the agriculturist must spend that part of the day or season in the hills. This has favored the grouping of the population into towns in the uplands, rather than in scattered rural homes on the cultivated land. Thus in south Italy where malaria is at its worst, though a non-industrial region, the percentage of the inhabitants, in towns is greater than in the industrial north. As a consequence of such an arrangement much labor is lost through the workers having to walk long distances to and from their fields. Intensive agriculture, favored by a dense population is correspondingly handicapped. Latifundia and absentee landlordism have been fostered and a strong impetus given to the emigration of the hungry population to more favored lands. Thus though primarily a rural or agricultural problem its effects are directly or indirectly felt throughout the whole social and economic scheme.

AGRICULTURAL PRODUCTION IN CHINA*

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Data dealing with land utilization and crop distribution in China have never been numerous nor easily available to the geographer who has been interested in agricultural problems of the Far East, however, it would appear that satisfactory statistics may be obtained from the "Statistical Tables of Agriculture and Commerce," Pekin 1922, as that publication has served as the basis for the following preliminary analysis.

The total area of China[1] is 2,440 millions of acres, of which 1,146 millions of acres are too arid for crop production, 64 millions too cold, 488 millions of acres too mountainous, and 36 millions so lacking in fertility that crop production is impossible. There remains, therefore, 706 millions of acres which may be classified as arable land, however, only 176 millions of acres are actually cultivated. To recapitulate, it is evident from this analysis that approximately one-fourth (¼) of the total area of China is arable, but the Chinese are cultivating only ¼ of their cultivable land.

If the acreage of cultivated land be divided by the total population (176,000,000÷475,000,000) the area of cultivated land per person is roughly 0.40 acres. If China proper be considered, the average is somewhat lower, being 0.38, whereas in the United States the average area of cultivated land per capita was 3.4 acres.

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* Worked in cooperation with O. E. Baker and E. G. Foscue.

[1] "Agricultural Production in China" (Economic Geography, Vol. III, No. 3). (A special set of maps to serve with these data given here.)

TABLE I.

PRELIMINARY ESTIMATE OF AREA OF CULTIVATED LAND IN 1918—NUMBER OF FARMS, 1918, AND TOTAL POPULATION, 1923
(P. O. ESTIMATE.)

(Based mostly on Statisticai Table of Agriculture and Commerce Department of Agriculture and Commerce, Peking, 1922.)

Province or District	Cultivated Land (acres)	Number of farm (families)	Cultivated Land per farm (acres)	Population	Popula-tion per farm	Cultivated Land per capita
Capital District	2,446,000	635,000	3.85	34,187,000	7.2	0.47
Chihli	13,625,000	3,985,000	4.20			
Shantung	15,983,000	5,350,000	2.98	30,803,000	5.8	0.52
Honan	16,700,000	5,325,000	3.14	30,832,000	5.8	0.54
Shansi	7,353,000	1,530,000	4.82	11,081,000	7.3	0.60
Shensi	5,333,000	1,308,000	3.62	9,436,000	7.3	0.56
Kansu	3,000,000	854,000	3.48	5,928,000	7.0	0.51
Kiangsu	13,833,000	4,542,000	3.03	33,786,000	7.4	0.41
Anhwei	6,833,000	2,873,000	2.38	19,833,000	7.0	0.34
Chekiang	5,531,000	3,340,000	1.67	22,044,000	6.6	0.27
Kiangsi	6,383,000	3,800,000	1.68	24,467,000	6.4	0.26
Hupeh	7,500,000	3,636,000	2.07	27,167,000	7.5	0.28
Hunan	6,166,000	3,831,000	1.59	28,444,000	7.4	0.25
Szechwan	20,833,000	6,038,000	3.45	49,783,000	8.2	0.42
Fukien	2,960,000	1,621,000	1.82	13,158,000	8.1	0.22
Kwangtung	8,734,000	5,310,000	1.68	37,168,000	7.0	0.24
Kwangsi	2,951,000	1,771,000	1.67	12,258,000	7.0	0.24
Kweichow	2,716,000	1,482,000	1.67	11,115,000	7.5	0.24
Yunnan	1,016,000	1,300,000	1.47	9,839,000	7.6	0.20
China Proper	151,016,000	58,531,000	2.58	414,012,000	7.1	0.365
Fengtien	7,631,000	1,736,000	4.40	12,487,583	7.4	0.61
Kiren	7,480,000	589,000	12.68	5,511,406	9.3	1.41
Heilungkiang	6,478,000	336,000	19.30	4,000,000	12.?	1.62
Manchuria	21,589,000	2,661,000	8.11	22,083,000	8.2	0.98
Jehol	2,714,000	620,000	2.73	....	....	......
Charhar	944,000	116,000	8.13	....	....	......
Suiyuan	913,000	67,000	13.67	....	....	......
Mongolia Inner	4,571,000	803,000	4.45	....	....	......
Sin Kiang	2,004,000	460,000	4.36	2,491,000	5.4	0.8
China and Dependencies.	170,180,000	62,455,000	2.85	442,046,000	7.1	0.4

There appears to be, therefore, about ten times as much cultivated land per person in the United States as in China. Furthermore, the American citizen has access to the world markets, whereas the buying range of the Chinese peasant is limited to a half day's walk or approximately an area with a diameter of fifty miles.

The three food crops, rice, wheat and the sorghum-millets occupy 69 per cent of the cultivated land. Very little of the land is used for fiber and forage crops, because the returns from the food products yield a greater return, therefore, the most valuable land must be reserved for its growth—an economic principle which makes itself felt in our own cornbelt.

Rice, the most important crop, is cultivated primarily in the southern provinces as indicated by these data:

TABLE II.

Province	Acres	Percent of Cult. Land.
Chihli	246,000	17%
Shantung	253,000	2%
Honan	1,260,000	8%
Shansi	827,000	11%
Shensi	340,000	6%
Kansu	73,000	2%
Kiangsu	5,000,000	36%
Anhwei	3,500,000	51%
Chelziang	3,817,000	69%
Kiangsi	4,650,000	70%
Hupeh	4,750,000	64%
Hunan	4,396,000	71%
Szechwan	6,981,000	34%
Fulzien	2,100,000	70%
Kwangtung	6,200,000	70%
Kweichow	1,852,000	69%
Yunan	1,230,000	68%
		64%
China Proper	49,572,000	32.8% Total
Fengtien	180,000	2%
Kirin	109,000	1%
Heilunglziang	8,000	....
Manchurio	357.000	1.7% Total
Jehol	3,000	....
Charhas	90,000	10%
Suivan	....	....
Mongolia	93,000	.... Total
Sinkiang	88,000	4.4% Total
China and Dependencies	50,110,000	28.0% Grand Total

Wheat is the leading crop in northern regions. About one-fifth of the total cultivated land is devoted to wheat, whereas in the provinces of Kansu 50% of the cultivated land is sown to wheat. The yields per acre are somewhat lower than in the United States.

TABLE III.

Province	Wheat		Sorghum and Millets	
	Acres	Percent of Cult. Land	Acres	Percent of Cult. Land
Chihli	2,905,000	21%	966,000	39%
Shantung	6,028,000	37%	5,340,000	40%
Honan	5,961,000	36%	5,255,000	33%
Shansi	2,159,000	29%	5,833,000	35%
Shensi	2,473,000	26%	1,833,000	25%
Kansu	1,500,000	50%	362,000	7%
Kiangsu	4,061,000	29%	367,000	12%
Ankurie	1,645,000	24%	2,114,000	15%
Chekians	650,000	11%	603,000	9%
Kiangsi	250,000	4%	116,000	2%
Hupeh	900,000	%12	19,000	..
Honan	608,000	5%	594,000	8%
Szechewan	4,166,000	20%	40,000	1%
Fulzien	287,000	10%	2,100,000	10%
Kwangtung	....	....	....	..
Kwangsi	100,000	4%	....	..
Kweichow	125,000	5%	50,000	2%
Yunnan	200,000	10%	100,000	5%
China Proper	34,318,000	22.7%	26,697,000	17.7%
Fengtien	221,000	3%	4,465,000	58%
Kirin	1,048,000	14%	2,414,000	32%
Heilung Kiang	153,000	18%	2,025,000	31%
Manchuria	2,422,000	11.2%	8,904,000	41.2%
Jehol	103,000	4%	2,226,000	83%
Charhar	612,000	65%	174,000	18%
Suiyuan	159,000	18%	416,000	46%
Mongolia	874,000	19.1%	2,816,000	61.6%
Sinkiang	801,000	40.0%	72,000	3.6%
China and Dependencies	38,415,000	21.6%	37,489,000	21.0%

Sorghum and millets as indicated in the above table, play an important part in the agriculture of China. These crops are being crowded out by the soy-bean.

TABLE IV.

Number of Livestock in China

(From Statistical Tables of Agriculture and Commerce, 1918, Division of Statistics, Department of Agriculture and Commerce, Peking, 1922. except that estimates were necessary for Hunan and Szechewan, Kwangtung, Kwangsi, Kweichow, Yunnan. Sheep data for these provinces are from Chinees Economic Monthly, Nov., 1924.)

Province or District	Horses	Mules and Asses	Cattle	Swine	Sheep	Poultry
Capital District	225,459	74,618	31,210	152,014	56,335	1,138,000
Chihli	311,181	514,407	516,711	2,995,591	1,032,800	8,258,000
Shantung	184,795	937,506	974,726	2,145,203	788,493	16,672,000
Honan	263,704	670,510	945,160	1,230,683	1,016,261	12,005,000
Shansi	97,058	314,983	304,330	391,853	3,335,401	2,321,000
Shensi	191,915	179,995	519,363	845,953	1,000,389	2,610,000
Kansu	236,620	383,116	455,841	529,410	5,235,065	2,770,000
Kiangsu	39,274	268,523	1,209,411	4,868,897	865,432	33,555,000
Anhwei	127,380	472,492	1,345,726	4,926,986	888,689	31,595,000
Chekiang	1,406	5,368	577,184	1,942,192	743,888	18,702,000
Kiangsi	30,675	7,411	1,409,083	3,372,642	94,755	18,778,000
Hupeh	154,619	142,352	1,604,544	4,868,910	874,716	23,870,000
Hunan	40,000	9,000	1,450,000	4,000,000	702,948	23,000,000
Szechewan	280,000	230,000	3,600,000	10,000,000	2,780,987	45,000,000
Fukien	8,804	2,027	370,547	1,828,137	367,891	12,882,000
Kwangtung	5,000	1,000	1,700,000	5,000,000	385,463	40,000,000
Kwangsi	5,000	1,000	600,000	1,800,000	311,722	13,000,000
Kweichow	30,000	7,000	600,000	1,600,000	77,874	9,000,000
Yunnan	40,000	20,000	500,000	1,100,000	1,006,140	8,000,000
China Proper	2,110,279	4,241,308	18,713,836	53,598,471	21,564,849	323,156,000
Fengtien	808,734	343,543	475,239	4,574,610	611,674	8,458,000
Kirin	616,742	113,695	506,557	1,401,553	219,839	4,535,000
Heilung Kiang	764,775	70,619	259,623	1,074,839	235,884	2,817,000
Manchuria	2,190,251	527,857	1,241,419	7,051,002	1,067,397	15,810,000
Jehol	160,136	124,321	182,759	394,969	582,642	2,016,000
Charhar	51,710	12,753	104,528	207,043	552,125	458,000
Suiyuan	61,606	28,290	104,407	90,300	498,786	167,000
Mongolia Inner	273,452	165,364	391,694	692,312	1,633,553	2,641,000
Sinkiang	166,218	305,253	508,291	23,477	4,324,818	3,080,000
China and Dependencies	4,702,200	5,239,782	20,355,240	61,365,262	28,590,617	344,687,000

Horses are relatively scarce, and are concentrated primarily in the northern states. This appears to be due to climatic conditions which favor the water buffalo in the south.

Mules and asses are relatively numerous though poor of quality, a condition characteristic of most of the livestock in China.

Cattle are used primarily for draft purposes. It appears as if the soy-bean serves as an excellent substitute for dairy products.

Swine are as numerous as in the United States, but there is no meat packing industry in China analagous to that in this country.

Sheep thrive in the semi-arid states and offer a potential source of great wealth.

Poultry are commonly found on nearly every Chinese farm and this industry serves as a basis for a lucrative export trade.

THE CLEVELAND INDUSTRIAL DISTRICT OF ENGLAND.

An Area of Specialized Industry—Iron and Steel.

JOHN B. APPLETON, UNIVERSITY OF ILLINOIS.

The Cleveland Industrial District is located along the lower reaches of the River Tees around Middlesbrough in northeast Yorkshire. It is interested primarily in the production and fabrication of iron and steel, and is one of the chief producing areas in the United Kingdom. (Fig. 1.)

The relative importance of the Northeast Coastal Area, of which the Cleveland District is the most significant part, so far as iron and steel production is concerned, is shown in Figures 2 and 3. In 1924, it was the leading producer of pig iron in Great Britain and ranked second to South Wales in the making of steel. In 1913, its position was still more dominant. Approximately 30% of the pig iron and 20% of the steel output of the country is produced normally in the Northeast Coastal Area. This industry is concentrated largely in the Cleveland District, where 80% of the blast furnaces and the most up-to-date steel mills are located. (Fig. 4.)

The production of iron and steel like all the major manufacturing industries of Great Britain is concentrated on the coalfields, and particularly on those adjacent to the coast where good harbors provide easy access to the sea. Generally speaking, blast furnaces rather than steel mills predominate in the coastal areas where the local supply of iron ore, so frequently associated with British coalfields, can be supplemented easily by imported ores. (Fig. 1.)

The outstanding advantages offered by the Cleveland District, where practically all the most up-to-date iron and steel plants in the country are located, are (1) nearness to abundant supplies of high grade coking coal, to the Cleveland ironstone deposits upon which the industry was based originally, and to limestone deposits suitable for flux, (2) tidewater sites along a navigable waterway accessible to large vessels, (3) the accessibility to supplies of foreign ores carried in returning colliers which can be unloaded directly on the wharves of many of the blast furnace plants, (4) cheap and abundant shipping facilities

FIG. 1.—The coalfields of Great Britain. The Cleveland District lies near the southern edge of the Durham coalfield around Middlesborough.
Courtesy of the "Manchester Guardian."

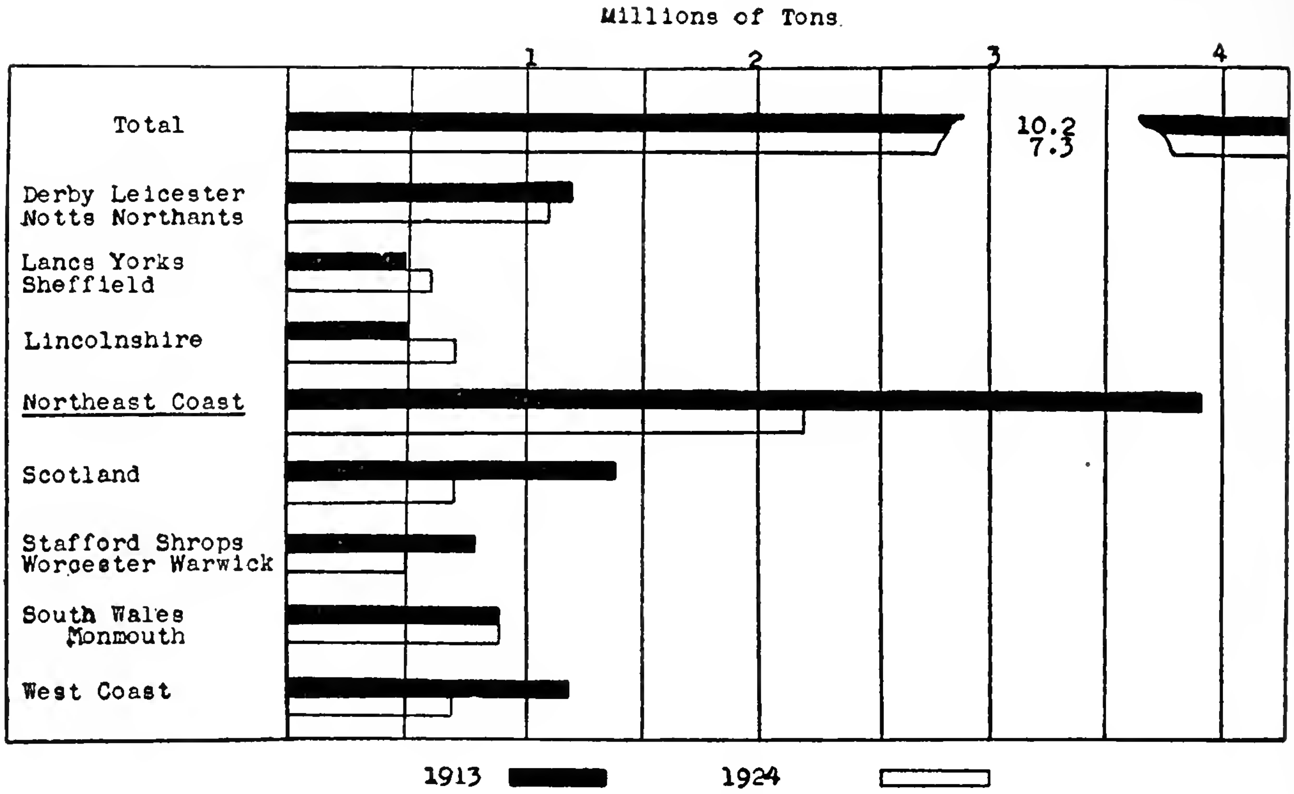

FIG. 2.—The chief Pig Iron producing areas in Great Britain. From data published by "The National Federation of Iron and Steel Manufacturers," London, 1926.

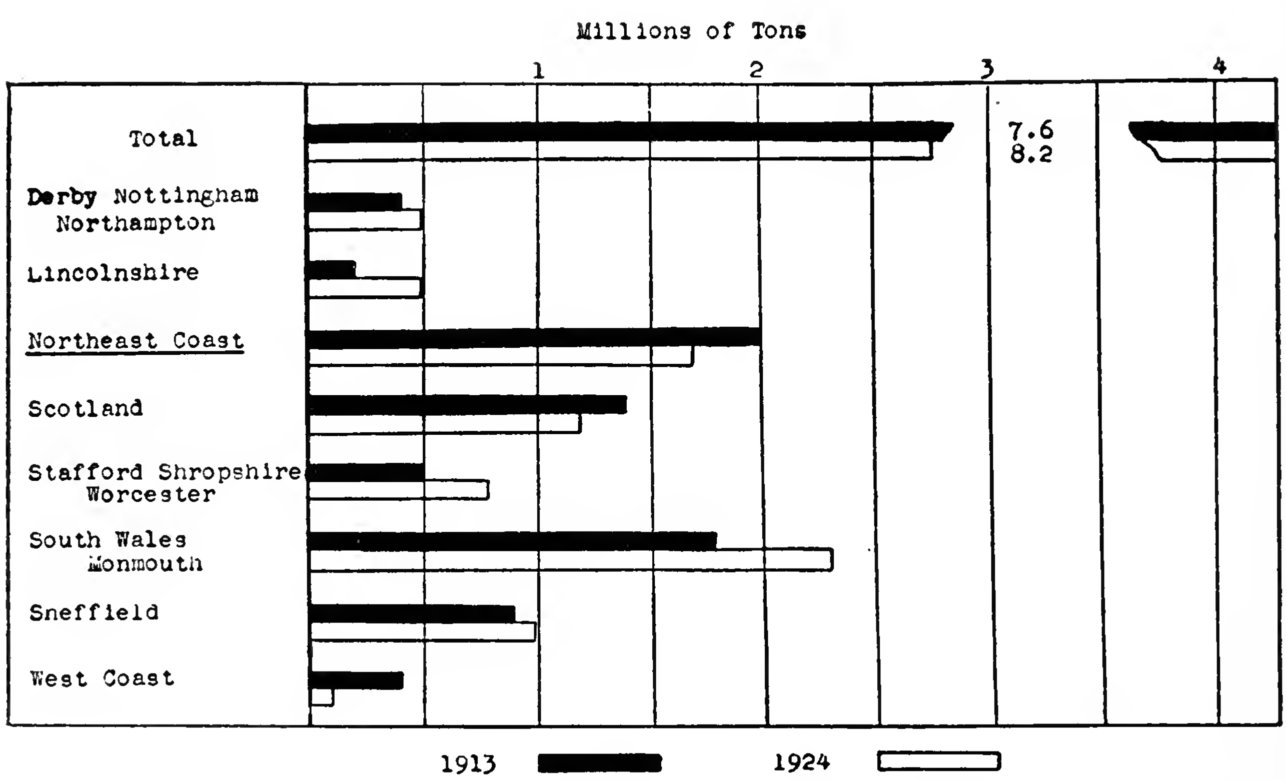

FIG. 3.—The chief Steel producing areas in Great Britain. From data published by "The National Federation of Iron and Steel Manufacturers," London, 1926.

offering direct communication with all parts of the world, (5) excellent railroad communications with all parts of Britain, and (6) abundant space well suited to the needs of this type of industry.

Location of the Area with Reference to Raw Materials.

Iron Ore: The chief source of iron ore in the United Kingdom is the oolitic escarpment which stretches from the Severn to the Tees. This low upland belt terminates in the Cleveland Hills a few miles south of the Tees estuary in an abrupt north-facing scarp along which the iron stone out-

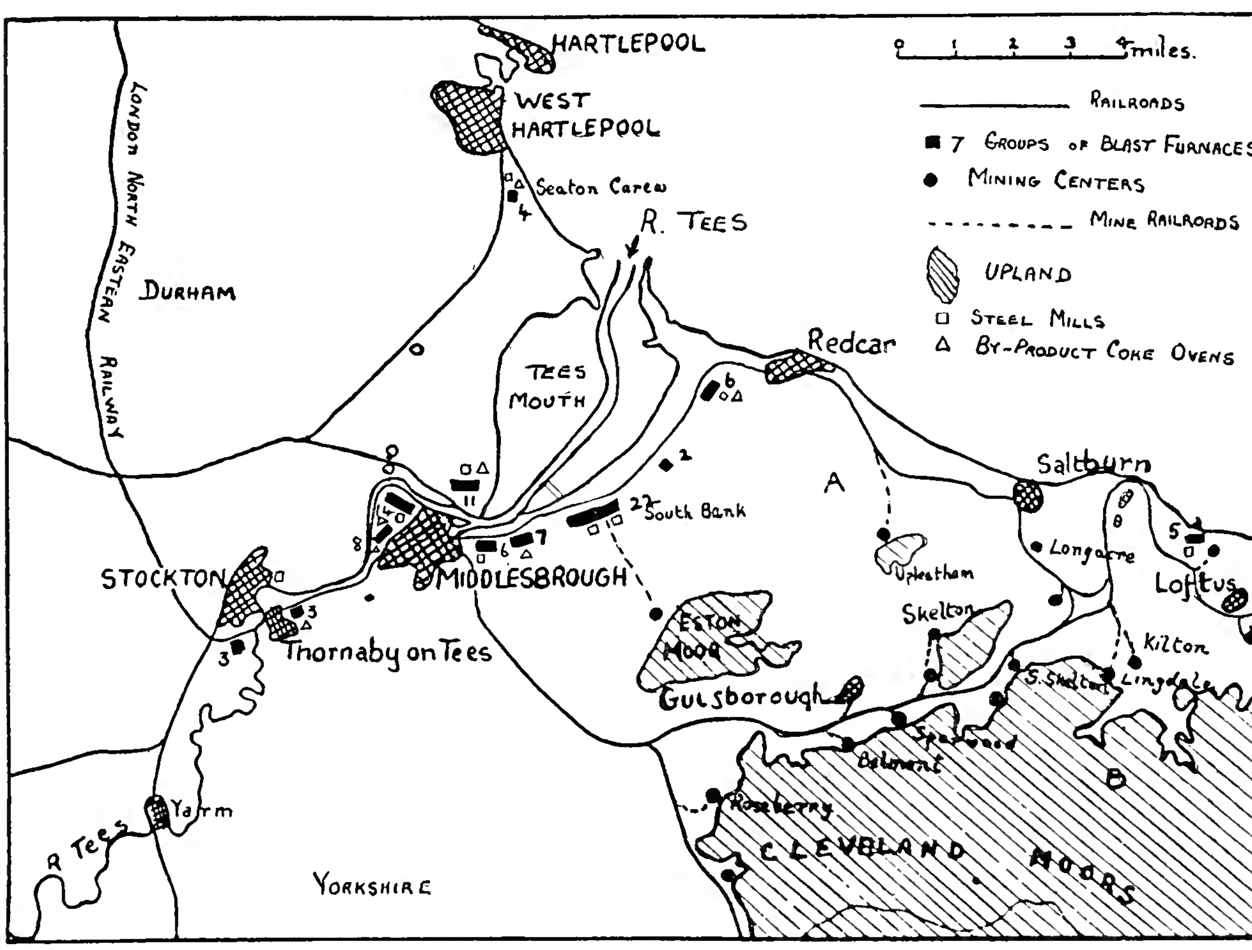

FIG. 4.—The Cleveland Industrial District showing the distribution of Blast Furnaces and Steel Mills and their relation to the R. Tees and the Cleveland Iron mines.

Adapted from Ll. R. Jones, "North England," p. 41.

crops. Figure 4 shows the chief mining centers and their relation to Tees-side. Owing to the rather dissected character of the upland, the iron is relatively near the surface in many places and quite frequently drift mining methods can be employed. The main seam varies from 5 to 12 feet in thickness. Figure 5 shows a cross section of the area from northwest to southeast and indicates the relation between the iron stone and the surrounding rocks.

It was the proximity of this supply of iron stone to the mouth of the River Tees, necessitating only a very short haul, mainly down grade, together with nearby supplies of coal, that encouraged the beginning of iron smelting there in the middle of the nineteenth century. The low cost of assembling these commodities at the mouth of the Tees offset the low grade of the iron stone.

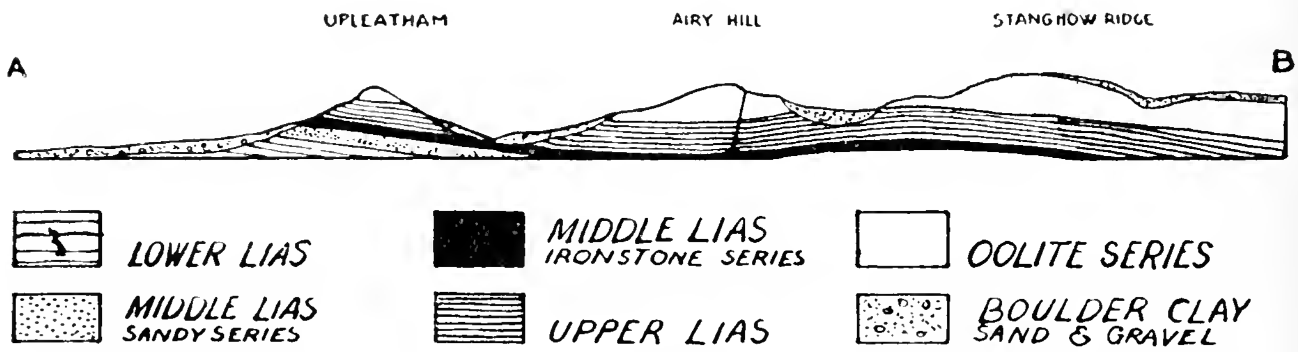

FIG. 5.—A cross-section from northwest to southeast across the Cleveland District to show the relations of the iron stone to the surface features and to the Geologic structure.

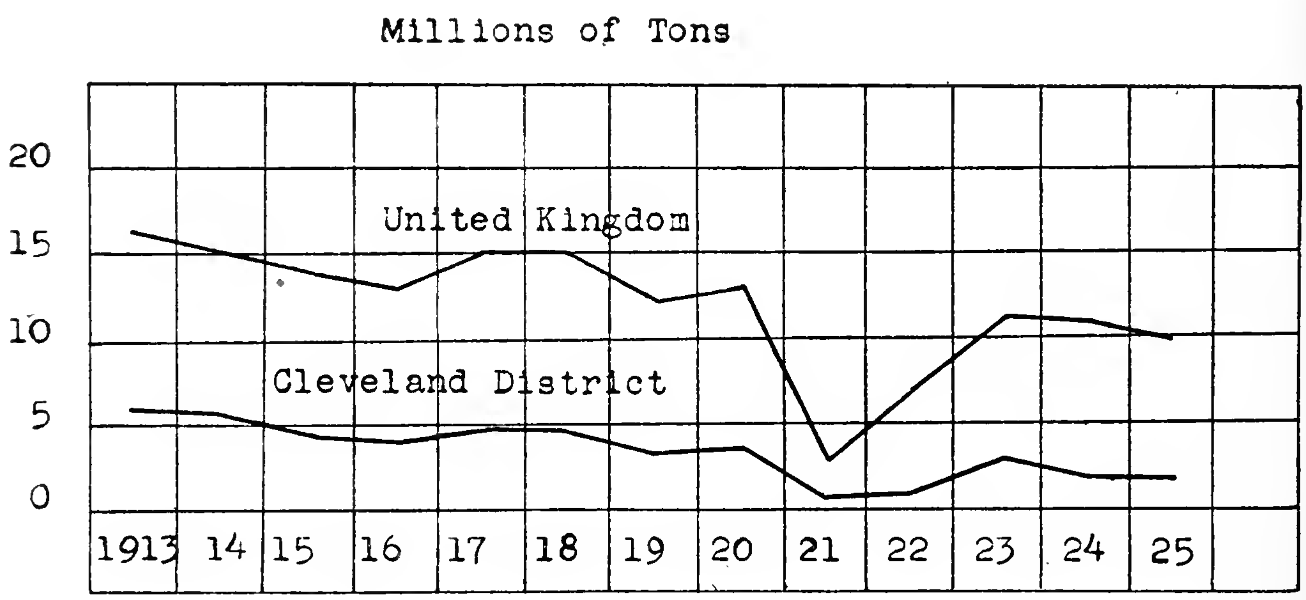

FIG. 6.—The production of Iron Ore in the United Kingdom, 1913-1925, and the output of the Cleveland mines during the same period. From data published by "The National Federation of Iron and Steel Manufacturers," London, 1926.

At the present time the more accessible and higher grade iron stone in the Cleveland District has been exhausted. The average distance from the mines to the riverside furnaces is less than twenty miles although formerly it was much less. The iron content is slightly below 30%. In 1924, the production amounted to 2,200,000 tons, only one-third that of 1913 when 6,000,000 tons were mined. (Fig. 6.) The mining industry there provides employment for some 4,000 men. The present production is inadequate for the needs of the Cleveland

District and economic conditions make the use of higher grade ores imperative. In 1924, almost 2,000,000 tons of foreign ores were imported by Tees-side smelters, practically one-third of the total British importation. (Fig. 7.) Some plants use foreign ores almost exclusively.

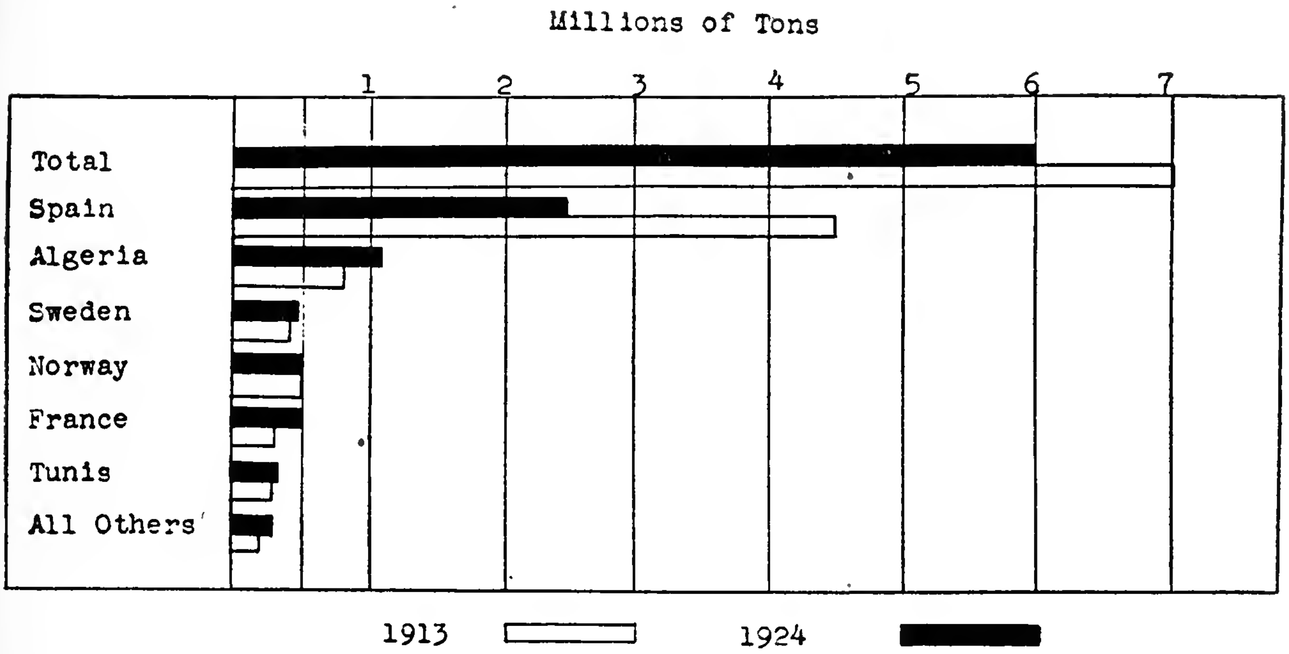

FIG. 7.—The tonnage and sources of Iron Ore imported into Great Britain. The Cleveland District receives approximately one-third of these ores. From data published by "The National Federation of Iron and Steel Manufacturers," London, 1926.

The trend in the production of Cleveland ore is shown by the graph in Figure 6. Although production has declined steadily since 1913, the tonnage of imported ore has remained more or less constant, indicating the increasing importance of foreign ores to the British iron and steel industry.

The sources of the imported ores are shown in Figure 7. Spain, Algeria, Sweden, and Norway supply the largest quantities. Present indications point to a great increase in the consumption of Algerian and Tunisian ores in the Cleveland District. These are of almost equal quality to the Rubio ores of Spain, but offer a slight advantage in price and freight. The extensive use of these foreign ores is practicable mainly because of (1) cheap water transportation, (2) the tide-water location of the furnace groups, (3) the higher iron content, and (4) the relatively low price of the ores.

Coal: The Cleveland Industrial District is adjacent to the southern edge of the Durham coalfield which produces a high grade coal suitable for making metallurgical coke. The rail haul from the mines to the blast furnaces averages only 25 miles. The seams average from three to five feet in thickness.

The largest as well as the deepest mines are located within easy reach of good harbors, where coastwise shipping is available to move the coal to the great industrial centers of northeastern England which utilize much of the iron and steel produced in the Cleveland District, and to foreign countries. (Fig. 1.)

Formerly much of the coal was coked in beehive furnaces at the mines, but in recent years modern by-product ovens have been installed adjacent to the blast furnace groups. The change has resulted in the production of large quantities of by-products which were formerly wasted. Some of these, particularly tar and coal gas, are employed in the various processes of steel manufacture in place of other fuels. This change has been necessitated by the increased costs of production and by foreign competition.

Limestone: Adequate supplies of limestone suitable for fluxing purposes are also within easy reach of the Cleveland District. Large exposures of Carboniferous limestone occur in the valley of the River Wear. In addition there are exposures of magnesian limestone in which beds of almost pure limestone occur. The chief producing areas are around Darlington and Sunderland. Owing to the high phosphorous content of the Cleveland ores the furnaces yield a highly phosphatic slag. This, when ground fine, makes an excellent fertilizer and is widely used. Slag bricks are also manufactured on a large scale and constitute another important by-product of the steel industry.

Local Conditions Favor Iron and Steel Production.

Sites Adjacent to a Waterway: Owing to the bulky and heavy nature of the commodities that are handled, all the processes of iron and steel manufacture are confined to single storied buildings. Consequently, the area required for a complete installation is large. The abundance of vacant, flat, and often marshy land, much of which consists of reclaimed tidal marshes, fronting the river, affords excellent sites for iron and steel plants and has encouraged their concentration there. (Fig. 4.)

In order to make the Tees estuary accessible to large vessels and thereby foster industrial growth, extensive harbor improvements have been made. The entrance was blocked originally by a sand bar which was covered by only three and a half feet of water at low tide. The river followed three winding channels through extensive mud flats which were exposed at low tide. Navigation, therefore, was hazardous and restricted to small boats. The Tees Conservancy Commissioners have dredged a deep waterway and provided numerous deep-water berths with a minimum depth of 25 feet at low water. The steel companies have their own wharves adjacent to their plants and can receive ore and ship iron and steel products with a minimum of delay. In addition a 26 acre dock has been provided at Middlesbrough to handle the world wide commerce of the Cleveland District.[1] In carrying out these improvements large areas of tidal foreshore have been reclaimed for industrial purposes.

Labor Conditions: As a result of the industrial development of the district a great urban development has taken place. From a sparsely populated agricultural district the area has become a densely populated urban area with some 400,000 people living in a number of thriving cities. Middlesbrough, the chief industrial and commercial center, has a population of 140,000, and some 84,000 live in the twin cities of Stockton and Thornaby. A very large proportion of this population is engaged in the local iron and steel trades. Excellent railroad communications link the district with the densely populated industrially developed northern counties as well as with all parts of Britain. Consequently, there is an abundant supply of labor assured at all times. The urbanized belt is largely confined to the southern side of the estuary and extends from Tees-Bridge to Redcar. Middlesbrough, Stockton, Thornaby, South Bank, and Redcar are the most important centers. North of the river there are fewer cities because there has been less industrial growth there. West Hartlepool and Seaton Carew, near the mouth of the Tees, have also developed as a result of their iron and steel industries which are based almost entirely at the present time on imported ores. (Fig. 4.) As in most industrial areas the population has expanded into the surrounding country-side where living conditions are much more pleasant. Consequently, there is a large suburban development which has been facilitated by the extensive railroad and street car net.

Products and Marketing Aspects.

The Cleveland District normally produces a large surplus of pig iron and steel for shipment to other parts of England,

[1]T. A. Bulmer & Co., Middlesbrough Shipping Facilities, pp. 23-32.

to Scotland, and to foreign countries. The location of the plants at the mouth of the Tees, adjacent to deep water, readily permits the shipment of a large tonnage of these bulky products by water. The railroads handle the bulk of the distribution to inland centers, chiefly Sheffield and the Midlands. The Clyde District is the largest market for Cleveland pig iron.

In 1924, from a total production of 2,000,000 tons of pig iron the Cleveland District shipped approximately one-fifth or 443,000 tons. Of this 170,000 tons were shipped coastwise or by rail to other centers in the United Kingdom and 273,000 tons were exported. In 1913, the total shipments were much greater, being 1,247,000 tons, or about one-third of the output. The marked decline in shipments was due to the general stagnation of the industry, to foreign competition, and to the increased local consumption.[2]

Much of the Hematite pig iron that is produced from imported ores is sent by rail to the Sheffield District for manufacture into special high grade steels which are used chiefly for tools, alloy products, cutlery, guns, and naval equipment. A small tonnage is sent to South Wales.

In recent years there has been a greater utilization than formerly of both pig iron and steel within the Cleveland District itself for the manufacture of more finished products. Approximately four-fifths of the total pig iron production in 1924 was converted into steel and used in the local rolling mills. The specialties of the district are, plates and other shipbuilding material, structural steel of all kinds, steel rails and other railroad equipment, sheets, and tubes.

The shipbuilding industry is without doubt the most important single user of Cleveland products. This is carried on locally at Stockton and West Hartlepool. Newcastle and Sunderland are, however, the great shipbuilding centers of Northeastern England, normally producing about half the total tonnage launched in the country. Marine engineering and boiler making are subsidiary industries along the Tees.

The great engineering industries of Northeastern England constitute a very large nearby market for a wide range of manufactured and semi-manufactured products of the Cleveland District. The chief manufacturing centers are located along the

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[2] U. S. Dept. of Commerce, Iron and Steel Division, Report No. 209121, pp. 41-42.

lower Tyne from Newcastle to the sea forming one continuous industrial area, and at Sunderland at the mouth of the River Wear. These can be conveniently supplied by coastwise steamers from Tees-side plants. Numerous inland centers such as Darlington, largely interested in engineering can receive their requirements readily by rail since the London and North Eastern Railway serves the whole area.

Intensive mining operations throughout the northeast create a demand for machinery, pipes, and tubes, which are made in considerable quantities in the Cleveland District.

Only slightly more distant are the other great manufacturing areas of Northern England. The Sheffield and Midland districts are primarily interested in the making of iron and steel products. The manufacture of machinery there is associated with the great textile industries of Yorkshire and Lancashire and much of the material is supplied from Cleveland plants. Throughout the whole region there is a large demand for all kinds of structural steel, mining equipment, and railroad material. This extensive and varied market can be reached readily from Middlesbrough.

The export trade has been an important factor in the expansion of the Cleveland industries practically all of which are associated with iron and steel. In addition to the export of pig iron which goes mainly to Belgium, Germany, Holland, and the United States, there is normally a large movement of manufactured iron and steel products to the British Colonies, South America, India, and the Far East. In 1924, these exports amounted to 647,000 tons, one-sixth of the total British iron and steel exports. Compared with 1913 the exports had decreased by 27% owing to the capture of many overseas markets by foreign competitors.

The prosperity of the Cleveland District is bound up with the iron and steel industry. At the present time foreign competitors are producing these materials more cheaply and underselling Cleveland products even in the home markets. To meet this every effort is being made to reduce costs. Plants have been modernized and more attention is being given to the production of high grade finished products than formerly. Problye the most significant fact so far as this district is concerned is the decreasing significance of Cleveland ironstone and the increasing dependance upon imported ores.

THE APPLE INDUSTRY OF CALHOUN COUNTY, ILLINOIS.*

Bessie Ashton, University of Illinois

Calhoun County, by its position between the Illinois and Mississippi rivers, by its leadership in the State in the production of apples, and by its transportation problems, presents an interesting geographic study. In 1890 it was surpassed by twenty-five Illinois counties in the quantity of apples sold. Today it produces about one-half the commercial apple crop of the State. It is said that more apples are produced here than in any other equal area in the world. The importance of this industry in this small area beccomes more evident when compared with the peach crop. In 1924, a good peach year, the commercial apple crop of Calhoun County was one and one-half times the commercial peach crop of the State, or more than a half million bushels, and when the young orchards now planted reach bearing age, the production for the county will probably reach one million bushels in a good crop year. This was the only county in Illinois in which the value of fruits and nuts exceeded the value of cereals in 1919.

In importance of cultivated crops the rank of Calhoun County in the State is reversed. In 1924 it occupied a position fifth from the bottom in the list of 102 counties in total value of the leading eleven crops, and received from them less than one-tenth as much as the same crops contributed to LaSalle County, first in the State in this respect. In value per acre only three small counties in the extreme southern part of the State had a lower return from the same source.

The reason for this one-sided development of Calhoun County is chiefly that of rough topography. The major part of the county is a much dissected ridge, sloping steeply to the Illinois River on the east in the northern and central part and to the Mississippi on the west in the central and southern part. A small triangular area of bottom land bordering the Mississippi in the northern part of the county offers land suitable for the production of corn and other cultivated crops. This lowland narrows southward and disappears north of Hamburg, where the

*Edited by the section chairman, Dr. W. O. Blanchard, as the author is deceased.

bluff road borders the Mississippi River. The only areas available for cultivation in this section are small strips near the river, or very small patches in the bottoms of the smaller stream valleys. Another small area in the southern part of the county near the Illinois River is suitable for general farming. The remainder of the land is so rough and the slopes so steep that cultivation is not practicable. This condition explains the fact that Calhoun County stands last among Illinois counties in per cent of farm land improved, having only 55 per cent somewhat more than half in 1920, as compared with 64.5 in Alexander, the next county, and 85.4, (more than four-fifths), the average for the State.

However, the rough topography, which reduces the importance of general agriculture and hampers the live stock industry through the lack of grain for feed, is especially favorable to the apple industry, as it permits free air and soil drainage. The orchards occupy the ridge tops, for the most part, though some of the younger orchards have been planted on lower ground. Ridge orchards are less subject to frost, and the color of the fruit on higher land, where the foliage is less dense, is better. The higher humidity in the lowland orchards causes the fruit to suffer from sooty blotch, the prevention of which requires an extra spraying. The steep intermediate slopes are left unused. The nature of the exposure is also important. Southward facing slopes, if gentle, are used with profit, but if steep the soil dries out too rapidly and the trees die.

The climate is generally favorable. Rainfall is adequate, (about 37 inches), and frosts relatively infrequent. A cold rainy spell in blooming time, which interferes with pollination, occurs about once in eight to ten years, and frosts injure the fruit about three out of ten years. Orchards near the river within reach of water influence are less affected, and sometimes bear when trees elsewhere do not.

The soil is weathered limestone, and loess, which covers much of the county, in places to a thickness of 80 feet. It is a sandy clay, which retains moisture better than other soils and does not bake.

With fairly favorable conditions of climate and soil, apples pay better on this rough land than any other crop. This is the best section in the country for the Willow Twig, one of the most profitable varieties of apple grown in Illinois, and one which has been known to net $900 per acre.

Marketing is handicapped by poor transportation facilities. The small population has been unable to make expensive road improvements, and State aid has been tardy. The county owns but one short stretch of about ten miles of concrete road from Kampsville to Hardin, opened to traffic in October, 1927. In the limestone region the roads are rough and stony, and the "red clay hills" of the loess areas become slippery and dangerous after rains. Few of the numerous small streams are bridged, though they respond quickly in volume to sudden showers. Traveling in Calhoun County, therefore, is at times a precarious adventure.

No bridge crosses either the Illinois or Mississippi rivers from Calhoun County, therefore all the apples shipped must be moved by water, except those from the orchards in the extreme northern part, some of which are hauled from eight to twelve miles to Pleasant Hill or other points on the railroad in Pike County. The nearest railroad is the extension made by the Chicago and Alton in 1925 to the Illinois River opposite Hardin. Apples shipped from this point are ferried across the river in trucks or taken across in barges to the railroad, which reaches the waterside. Improvement of roads in the vicinity has led to increase in use of motor trucks, and apples have been carried from the southern orchards to the St. Louis market in this way. The remainder of the crop is hauled by wagon or truck to one of the river landings, and moved by barge or boat to St. Louis or Peoria, or to one of the railroad points on the river from which the apples can be taken by rail to St. Louis or Chicago.[1] Rail connection with Chicago is especially desirable, as prices are higher in that market than in St. Louis, where competition with apples from the Ozarks must be met. Rail transportation has the advantage of refrigerator cars needed by the early crop, which constitutes about one-fourth of the total, it eliminates bruising of the apples incidental to rough handling on cobble stone landings, and costs no more than boat and wharfage charges.[2] Rail transportation also multiplies the number of markets available.

The future of the apple industry in Calhoun County seems assured. Profits from this source are greater on one acre of this rough land than from ten acres of other crops. There has been a steady increase both in amount of production and in number of

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[1] In 1926 more than 100,000 barrels were shipped from the landing at Hamburg.

[2] Hardin to St. Louis rates, 36 cents per barrel by ferry and rail, 45 cents by all water route. Hardin to Chicago by ferry and rail, 39 cents.

trees, while the older apple raising counties in the State have suffered a decline. In number of trees Calhoun County had in 1924 more than three times as many as Pike County, its closest rival in production. The greatest handicap has been poor means of transportation, but a change is taking place in this respect. The county has its first stretch of hard road completed, and hard road connections are being made in neighboring counties. The advantage of the recent railroad extension to East Hardin is being felt, and negotiations are under way for the building of a railroad from Grafton to Quincy, traversing the county lengthwise. Recently a charter was granted to a company for the construction of a toll bridge over the Illinois River near Deer Plain, and prospects seem bright for an appropriation of $400,000 at the next General Assembly for the construction of a bridge over the Illinois at Hardin. With the increase in prosperity which these changes are bound to bring, there will be more money in the county for minor local improvements.

Another need is a system of more careful grading, which growth of the industry demands. Heretofore each individual apple grower has set the standard for his product with the result that there is no uniformity in quality and the county has the reputation of shipping poorly graded fruit. Recently, however, attempts have been made to set a national stanadard. With these changes, which are already inaugurated or in sight, the "Kingdom of Calhoun" will come into its own with apples as its major asset.

PAPERS IN MEDICINE AND PUBLIC HEALTH

BASAL METABOLIC TESTS AS A VALUABLE AID TO THE GENERAL PRACTITIONER.

By Paz G. King, A. B., B. Sc. M. D.

Old practitioners of Medicine rebel against the usual up-to-date diagnostic methods and deny the value of well established and universally accepted laboratory procedures. They think that the clinical picture with its symptoms is sufficient to supply all the information needed to the entire conclusion of a given case based on clinical experience and observation. They doubt the integrity of modern laboratory procedures and disregard them. They find it very difficult to adapt themselves to the new, elaborate and time-consuming tests. It is not intended to belittle the great value of clinical observation in the diagnosis, treatment and prognosis of disease.

Metabolism is the sum of all physical and chemical processes by which a living organized substance is produced and maintained and also the transformation by which energy is made available for the uses of the organism. It is the building up and breaking down processes which are constantly going on within the human body. Basal Metabolism is usually defined as the oxygen consumed per minute by an individual, measured from 14 to 18 hours after eating, when the individual is at rest but not asleep.

Normal Oxygen consumption depends on the height and weight, age, and sex of an individual. An older person living a relaxed life requires less oxygen than a younger individual who is growing and who lives an active life. In order to obtain normal standards of O_2 consumption normal individuals have been subject to tests. All these individuals have normal physical and mental characteristics, that is, normal height and weight for their age, sex and group, such as tall, short, stout, thin or medium.

Elaborate methods have been used by such authorities as Benedict and DuBois. These consist of the determination of oxygen consumption and carbon dioxide out-put of normal individuals. Such factors as heat production and body temperature were considered carefully. They computed with great accuracy body surface and oxygen consumption per unit, and also took into consideration the height and weight and age and sex of each individual. In this way an analytically developed formula has been derived, which gives the normal oxygen consumption of individuals different in physical characteristics.

There were two sets of normal values referred to by technicians Benedict's and DuBois' normal. These normal values are estimated values based on the results obtained by a great number of tests run on normal individuals. There are marked differences in the two sets of values:

10% minus to 20% plus in extreme cases,
0% to 5% plus in ordinary cases.

However most laboratorians and clinicians disregard these differences and consider 10% minus to 15% plus as *normal* values.

The test is run early in the morning with the patient absolutely fasting under basal conditions. By the aid of any of the standard Metabolimeters the amount of O_2 consumed in a given time is recorded on a graph. This total amount of O_2 is divided by the number of minutes or duration of the test to obtain the O_2 consumption per minute. The Barometric Pressure and temperature of the O_2 is recorded as part of the data. Corrections are then made in order to reduce the O_2 consumption to standard barometric pressure and temperature. The corrected amount of O_2 consumed per minute is compared with the normal standard as given by either DuBois' or Benedict's tables of normals. The patient's O_2 consumption is either above or below normal. This number is a plus or a minus and is divided by the number which in the tables is given as a normal for an individual of the same height and weight, age and sex. Hence the percentage either a plus or a minus is obtained. There are other methods of arriving at the same conclusions but the above described is the one method of computing most commonly used by technicians.

A Basal Metabolic Rate, when accurately determined by a dependable technician with reliable apparatus, is of great value in the diagnosis, treatment and prognosis of diseases of the thyroid gland. In most cases a careful history, the clinical finding and symptoms make the diagnosis of thyroid disease an easy matter. But, there are occasionally cases which present difficult diagnostic problems not only to the average practitioner of medicine but even to the experienced diagnostician. In such cases a normal basal metabolic rate gives the internist the absolute assurance to rule out diseases of the thyroid gland.

A Metabolic Rate should be run in all cases in which patients show an enlarged *thyroid,* unexplained tachycardia, bilateral or even unilateral exophthalmos, rapid loss of weight, nervous irritability, vasomotor symptoms (vomiting, diarrhea and sweating). It should also be taken in all cases in which patients have a retarded mentality, sluggish vitality with gain in weigh.

In other words the Basal Metabolic Rate is useful; in differentiating toxic goiter from tuberculosis, from early cardiac or myocardial involvement.

In *surgery,* it is useful to determine the effect of rest and diet to warrant a thyroidectomy and to verify and arrest the toxic condition of the patient.

In *therapy* it is of great value in cases of hypothyroidism, to warrant the administration of thyroid extract and to regulate its doses. The obesity of eunuchoidism, of big eaters and laziness show no changes in the basal metabolic rate. But in cretinism, myxoedema, and in the obesity of hypopituitarism we find a decrease in the Basal Metabolic Rate.

RESTORATION OF FUNCTION IN THE MOUTH AND TEETH AS A HEALTH MEASURE.

V. A. Latham, M. D., D. D. S., F. R. M. S., Chicago.

The ignorance today in which the work of the dentist is so generally misunderstood is appalling, in spite of so much effort being made to show its far-reaching functions. The public ought not to fail to notice and appreciate the policy of the medical and dental professions in giving so much time, work and cash, at present almost unique in its kind. They are promoting in every way possible, two great movements that in a narrow view might seem to be most damaging to them; first, that of education which is designed at great expense, to bring into the competitive field against them the ablest and best equipped rivals; second, research of which the deliberate aim is to prevent dental surgeons and physicians, so far as is possible, from having any work to do at all. Where is there a more notable case of public spirited altruism? Both of these great movements, supported by the professions, tend to improve the knowledge and treatment or better prevention of disease. Great Britain since 1921, requires not only a registration fee, but an annual fee for retention on that registration made by the Dental Board. Even with the small number of dentists there the fund is over 40,000 pounds a year, and this is spent under the management of the Board to promote education and research, also aiding able students needing it, and offering advanced postgraduate courses, etc. If medical men did the same, something more than a quarter of a million annually could be secured. Generous it may be, but like all good things, it has its dangers. The greatest fostering indifference and paternalism, and too much is already given by us to charity which is unfortunately obtained by most of those who do not need it. How to eliminate the unworthy is a task, as well to not pauperize the doctors who must live. Again, where is there another profession which requires the time, energy and cash value to secure a degree of science! The public cares nothing for this so long as relief is given. Hence the faddists come along promising quick results and we all know only too well it cannot be done in the majority of cases. Hence, today we preach the Rules of Hygiene and right living. "It is better to prepare and prevent than to repair and repent." The harvest time is still to come. Especially so in the field of dental research for decay is on the increase—why?

In the important technic of reparative dentistry we must cooperate with the study of scientific and industrial research and for these we undertake special problems in mechanics, physics, chemistry, metallurgy and refractory materials. Even these are not enough, but physiology, anatomy, both human and comparative, must be known; then histopathology, then a most careful watching to note the symmetry of the face and structures. Who can doubt the value and pressing need of this research from the point of view of the citizen? The subject of dental disease is national—yes, international, and brings directly a colossal and terrific volume of discomfort, ill-health, inefficiency, pain and ugliness. We all know now the systemic effects by disorders of the dental appendages. Even a war has its good points when in an effort to make an army, navy and personnel efficient, the shocking conditions, physically and dentally were exposed. The strain, wounds and disease brought forth strenuous efforts by the medical-dental professions and researches, to recover and save from these deformities all possible. New methods, drugs, appliances, treatments were brought about and these cannot be bought first hand—but must be evolved by the brains and efforts of those in charge. The right man in the right place and of his unfettered labor.

Bishop Hall of Norwich, England, said truly three hundred years ago: "There was never good thing easily come by. * * * God sells Knowledge for sweat." Again, a warning—endowment of research not uncommonly leads to a good deal of research after endowment. There are always those, whether trained or not, who will investigate in any direction without definite clue or objective. Hence, cooperation by those of various departments of science is needful. General discussion of the topic, a systematic scheme planned out, and a number of scientific students undertake the subject from various angles. Later, come together and report results, discuss, condemn, suggest, and prove, clear the subject by agreement, then continue by progress or re-study of mooted points. It may be said here, that credit would not be individual. What of it—if the various ones give their views? Then final proof—it is individual as well as collateral and for use to aid mankind. Few medical people ever think or receive their just reward in life; but it may come fifty to one hundred years after death. His family usually suffers with him for ethics stand in the way of selling his discoveries. Medals, pictures and statues are cold and poor bread givers to his wife, children or himself. Often his own cash has been used for the benefit of others to their detriment. We have too many life-givers who die unknown or unnamed. The true limit to a research program is fixed not by the money at disposal, but by the number of men or women both fit and available for the enterprise and they must spend long hours, without any relief to follow the progress of the subject. Such workers will always be scarce, but *pay them to live* and work and *do not* put all the money in mammoth buildings and starve those longing and anxious to do their best for mankind. Alien subjects often have a knack of opening a door totally undreamed of and most discoveries come from errors. Teeth may be normal in shape, color or position, and yet with microscopic study, reveal faulty chemistry; hence structural defects are present and do not aid in your remakes.

Why the dental curriculum should be separated from the medical I have never been quite able to understand. Full basic science courses are equally needed and biochemistry is vital to both. Diet during growth, for physiologic processes must be up to par. Anatomic progression we need and progressive care, prenatal as well as postnatal. Experiments have proven that the normal structure of teeth and jaws, like the bones and other organs, depends upon the right supply of metabolic functions to balance and conserve body energy. Pyorrhea, so much dreaded, I regret to say, we still know very little of its etiology any more than we do of cancer; seems to show signs of faulty metabolism which results in the loss of the teeth by pathologic processes. Josef Weinmann and Liebesny report their studies saying, "eighty per cent of them seem to be due to definite diminution in the activity of the pituitary gland. Diathermy and internal glandular doses helped in four to eight weeks. Hence it is to be hoped that clinical work may be started along these lines and reported to Dr. Weinmann of Vienna or others in this country. This brings us to the subject of the paper.

The loss of any organ of the body implies loss of balance, function and value to the patient. It may do harm by bringing about pathological processes. Hence, self-preservation is the law of man and his advisors. Prophylaxis—prevention is the key to the situation. Hence, less routine and more individual study of the patient. Education from the beginning of life and this means embryology, chemistry, biology in its broadest sense for all parties concerned. To others, I leave this topic and speak only of those who, like cancer and tubercular cases, come too late for perfect results. We may cure but there is always *permanent* damage present. Nature does her best, given the needed stimulus and help to recover—but do we as a rule, grant her this? No, only partway—self indulgence or want of knowledge on the part of both patient and doctor. Oral sepsis is a factor in producing chronic bronchitis and those in middle life should be carefully watched by a dentist. Emphysema and cardiac lesions are usually found. Children are prone to tuberculosis infective diseases, chest troubles, ears, throat conditions and caries. Careful examinations, X-Rays revealed apical abscesses with granuloma or resorption and when removed the chest conditions at once cleared up. Nasal obstruction, antral infections are a forerunner of bronchitis, and bronchial catarrh has some analogy with cases of mucous colitis. Cultures from all sinuses, postnasal spaces as well as the sputum should be made. These patients excrete large amounts of uric acid and we would like to know what is the physiologists' opinion as to it being a factor in health or disease in man? We must not forget the influence of ductless and other glands on the structure of the teeth, also on the nervous system of people at middle life.

In a report by the Director General, of the New Zealand Department of Health, Dr. T. H. A. Valentine the infant mortality rate was 41.9 per 100°, and dental caries given by Dr. R. J. R. Mecredy, over 90% of the children affected. The relation of the candy stores to caries is seen by the greater number in the teeth and treated cases per head in the schools near a store. The actual ratio is as 100 in the school near the confectionary store to 73.5 in those remote. Caries is therefore 25% less and the stores selling sweets etc., are responsible for a quarter of the dental caries found in schools. It is to be noted there are more slight attacks of vomiting, malaise, headaches, foul smelling mouths due to gastro-intestinal disturbances, possibly due now to the *excessive* and *nauseating sweetness so* prevalent in candy today. Many complaints are made and it is a pity the manufacturers do not return to a less sickly compound, whether it is from the honey, saccharose, lactose, glucose or whatnot, that soon converts to acid-ferments etc. *Do away with the sickly confections* and children will be benefitted greatly. The blame lies with all of us from the colleges, teachers, the subject and the operator. There is hope; let the physician take heed of the partial or edentulous mouth and help the patient, the dentist and himself. Times without number, I see cases of so-called dyspepsia, gastric ulcer, intestinal toxemia, septic throats, tonsils diseased, antral infection and ears, chronic appendicitis with their friendly gall bladders joining forces, dysenteric ulcers, pernicious anemia, etc., etc.—even carcinoma of the tongue, throat, stomach, etc., yet *the physician does not pay any attention to the functional work of the oral cavity.* It is many years ago since it was observed that gastro-intestinal surgery profits, with splendid results, by first cleaning up the mouth and teeth. The blood picture improves—resistance is gained and bacterial foci hindered. Septic emboli are less common. Mental cases improve. Nervous manifestations with nerve trauma due to fibroid conditions, may cause pressure or toxic irritations with so-called neuralgia of the head and face, and affects the eyes and ears to their detriment. Faulty occlusions can aid pyorrhea by rocking the teeth. Periosteal and periodental inflamations follow with its attendant sequelæ resulting in osteitis, etc. Pulps begin to show circulatory changes just as the arteries of the body sclerose. Calcific deposits similar to atheroma result, ending in many cases with obliterative masses of secondary dentine and hypercementosis of the apex.

Cases are reported where teeth and bones unite. Various growths can occur by continued trauma—cysts, odontoma, even carcinoma. The cheeks and other soft structures follow and the entire face changed not for the better. Balance, alignment and occlusion are lost; contour of the lips, nose and chin follows, resulting in a picture of a prematurely aged patient. The friends and family all protest, but the patient may have been wrongly advised to delay replacing organs by artificial substitutes. Remember, *the longer a patient goes without replacement, the more difficult it is to know the correct contour and occlusion or bite.* More damage goes on to the features by sagging of the muscles. Functions foreign to a certain muscle creep in and new characteristics are acquired and we have to overcome them, just as an orthopedic surgeon does by a lad letting his brace get loose and faulty habits acquired when further damage follows. The bones of the face acquire a curious deviation from the central path—enough to cause distress, headaches and vision disturbances and even later, paralysis in some form or contractures.

These criticisms belong to the cases in youth as well as those who are injured by extractions. Never in the history of dentistry have we noted so many youngsters needing orthodontic aid. Whether it follows the law of eugenics, we need not wonder. Like father, like son still carries on and irregularities can be traced through generations increasing in degree as time goes on. Bad habits aid in cause and effect, diet prenatally, possibly; position in uterus is possible in a mild way. Obstetric procedures I rather doubt, on account of the short time required to deliver, unless instrumental trauma occurs so severely as to be permanent. That growing children need most careful watching to see the beginning of mal-occlusion, whether thumb or tongue sucking, breast nursing, too large and long continued nipple use; pulling faces and faulty resting of the jaws *must* be stopped. Forcible gum chewing is, I believe, a danger when indulged in to any great degree. Though muscle action may be helped, their strength may do damage, just as the frenum of the lip or osteoporosis of the maxillæ forcibly separate the central incisors. Consultation of works like Talbot, Kingsley, Jackson, Angle, Dewey, Clapp, etc., offer much in this subject. The orthodontist is here to stay. Cooperation with the rhinologist, laryngologist is needed but the family dentist and physician are the first to become cognizant. Years ago, at a meeting of the American Medical Association, Stomatology Section, I urged *early* regulation of the jaws so the teeth might erupt better and in normality if possible. Three questions arose: (1) How little ones could safely be handled and what appliances to use, as the teeth were small and the bones, tissues and sinuses soft, also to avoid irritation? (2) Would the developing roots and pulps be damaged? (3) Would the child show nervous disturbances, lose weight through pain and discomfort? Dr. E. A. Bogue very kindly said, "If *you will* guarantee these from your scientific work, I am willing to regulate the cases and report results later at this Section." I agreed that the child must be physically trained, examined and the weight and amount of sleep noticed, little stress used, early irritation watched, and procedures stopped or controlled, absolute cleanliness maintained and force limited; those appliances used with a degree of support of the bone and soft tissue as well as the teeth; so movement was general. X-rays then could not be considered. Their valued help, if taken as they should be of the angles of position with the film and teeth noted to avoid distortion. The resorption of apices was merely guessed in those days. Dietry and outdoor care with all hygienic principles watched; I am glad to say the results justified the efforts and the question of learning the amount of necessary expansion found. Dr. Hawley, Washington, D. C., introduced his method, others followed. What has resulted? In youth the avoidance of bad physical conditions, tonsils, adenoids, a deviated septum with stenosis of the Eustachian canal; pressure on the nerves, compression of anterior lobes of brain through contractions of the antra with optic nerve pressure; bad lungs due to lack of oxidation and faulty chest development, inefficient breathing, asthma, anemia predisposing to tubercular conditions aided or prevented. Nervous and mental cases improved or cured which, from an economic viewpoint is worth considering.

Epilepsy with bad physique and gastric faults have been aided greatly. Malformations always cause distress to those afflicted and operations should be done early to avoid later difficulties in speech, manner and results. *Urge older patients to replace lost teeth as soon as possible,* but beware of faulty mechanical appliances that may do more harm than good. A badly fitted crown or filling may ''jump the bite'' or cause great damage. Weak abuttments, needless failure and expense. Bridges may be a blessing or a curse and the odor always with us from decomposition, if the patient is careless as well as the dentist in his selection of cases.

All patients should be separately studied. All materials vary, as well as the mouth they are selected to help. Experience is needed and should be carefully selected. A beautiful, expensive appliance is of little value, if mechanically misplaced or badly made. Cooperation between patient and dentist is most necessary to allow usage, fitting and encouragement. Patience on both sides is a big asset. Displacement and fault finding because the patient will *not* tax a dentist's time to be fitted, makes enemies and breeds mischief for a well meaning practitioner and may injure both, also the cause of dentistry.

It goes without saying, the oral cavity must be made as healthy as possible by the removal of loose, carious broken down abscessed teeth and gingivitis, fistulous openings cleared up. On all these points *no persuasion or assumed* direction on the part of the patient *must be allowed* to influence your own conviction and opinion. Firmness is on all accounts desirable under such circumstances. Submission to your patient's wishes only involves much vexation as a direct result, whilst it defers that which they regard as a great trial until a future time, when the results of operation render the entire readjustment necessary of any appliance. Perhaps the most vexing question is, ''How soon after extraction, artificial teeth may be inserted? Experience by the dentist and a careful consideration of the patient's condition; with power to stand some discomfort and to help in overcoming obstacles. Many advise a long time to elapse. My own experience from the moment the patient is willing to try and allow impressions to be taken, is to place the mechanical substitute in place. Less absorption has gone on and the main object is that the patient knows how his jaws should come together, and we get a better occlusal fitting, good contour of the face; less aching and discomfort by holding the mouth open to its normal width, than having the jaws brought too close. In early times, measurements by compasses were taken of the size of the jaws; a piece of bone was cut into an approximate adaptation to the space to be filled; the natural gums and teeth were then colored. Walrus tusks were also used to carve into block teeth. Fauchard wrote about his method in 1728 and it was many years later before impressions were taken in softened bees' wax; then came the invention of trays to hold the wax. Later, a composition or plaster of Paris was universally employed. The palatal organs perform an important part in the production of articulate speech; any defects, therefore, in structure, or any departure even from the ordinary type of formation, is accomplished by an irregularity in the chamber of produced sounds more or less marked according to the locality and extent of defects. In cases of congenital fissure mastication and deglutition are interefered with in varying degrees. Children grow up and can adapt themselves in time, but it is a disgrace to allow such to go through life if they should live. By avoiding septic infections of the sinuses and adjacent parts, let alone the dangers to the lungs, etc. Cleft palates were known to Hollerius in 1552, who proposed to stop the apertures with wax or sponge. They were first operated surgically by W. D. Lemmonnier in 1760, and the patients are grateful and the sooner they are operated upon with good surgical skill, the better.

Ambrose Páre of Paris made, I think one of the earliest recorded appliances in 1585, of a metal plate over the opening and screwing on a piece of sponge known later as an obturator. Fauchard in 1728, improved this and so it has been carried on to the time of Eustache of Beziers, 1799-1800, von Graefe who revived operative measures in 1816, Warren of Boston 1820, Langenbeck and others. In England, to Sir Wm. Ferguson 1844, belongs the improved technique, Salter, Snell 1828, Oakley Coles 1868, Heath carried on. America pioneered with Warren, Fillebrown, Richardson, Norman Kingsley 1904, Mears, Talbot, Brophy, Cryer and Brown of Milwaukee. To give a slight comparison the use of a truss for hernia when with the clean, careful surgery of today, who would wear these odorous, ungainly appliances and constant expenses? The marvels done in facial surgery, ears, clefts, necrosis and injuries, cannot be appreciated as they should, unless the victims are seen and our gratitude is to those who have made such results possible. An artistic, carefully fitted appliance, helps the symmetry, cosmetic appearance of the patient, gives comfort and pleasure to subject and family; saves the photographic image and a good profile is a sure test of adaptation in correct artistic measuring of the lips, nose, eyes and chin. Remember, a great fault of patients is to expect a perfect plate after twenty to fifty years of use. Urge these cases to return and have a remake, because it is your duty as physicians to help the dentist to restore function. Improve the occlusion, lengthen the face to correct the lines of contour, for cosmetic reasons and above all, better mastication, cleanliness, for rubber and metal plates can become foul. Pressure must be relieved on the fifth nerve branches; hardening tissues prevented through long, daily wearing, arrest premature aging and avoid gastro-intestinal and neoplastic lesions. Ill fitting, unclean dentures often cause the intestinal floral changes and colon infections can be far reaching; to the liver, kidneys and heart by bacterial invasions, through the circulatory system, with septic infarcts, emboli, etc. Do not expect many perfectly fitted lower indentures when all the alveolar ridge is gone and the plate lies on the salivary glands and tongue muscles.

Watch for swellings, stenosis and ranula by shutting off the salivary fluid. Even weighted plates have a poor chance for muscle attachments may throw up the plate, due to bad exodontia work, or resorption in an excessive degree and the patient's attitude. The message I bring is to improve the patient's condition by a practical restoration of function as near to her normal one as possible by well fitted appliances. Bring back mastication to a full degree, use cleanliness, chew the food well, eat right foods with enjoyment in moderation, improved elimination results and comfort. Through improvement in facial restoration the patient is helped and pleased and the physician and dentist acquires good friends whether young or old and health is a happy result. And remember that the heart that is truly happy never grows old.

PREVALENCE, CAUSES AND INFLUENCES OF IRREGULAR ALIGNMENT OF TEETH.

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As civilization advances, and we get farther away from the simple lives of our ancestors, we find man developing many ailments which are the outcome of his modern habits of life.

Probably no part of the body has suffered so much as the teeth; and we see in modern children an array of irregular teeth, ranging from slight over-lapping to gross displacements of the jaws, which affect the whole organism.

It is estimated that about seventy-five per cent of all children are afflicted to some degree and many authorities place the number even higher. I had occasion to examine between fifty and seventy-five children recently and I did not see six with perfect arrangement of the teeth.

There are many theories advanced as to the reasons for the foregoing; but not a great deal is definitely known. It is my purpose here, merely, to sketch briefly a few of the out-standing principles.

The position of the individual teeth is only an indication of the retarded growth of the jaws which have not enlarged sufficiently to contain the full complement of teeth.

This condition is rarely found among primitive people. Most of the skulls of the early races show well developed jaws with teeth in perfect alignment.

These people ate hard, coarse foods requiring vigorous mastication which stimulated the jaws to growth. The modern child eats only soft foods during the time that the teeth are forming and coming into place in the mouth, therefore, the jaws do not receive the stimulation necessary to their complete development.

Diet is an important factor. Dr. Howe of Boston, who has made notable experiments in this field, emphasizes a faulty diet as primary causation. Infants and young children should have their diet carefully planned. As soon as they are able to chew, give them plenty of vegetables, particularly leafy vegetables, and raw fruits. The mother should also have a diet which contains a liberal supply of milk and leafy vegetables.

I have no statistics at hand in regard to rickets in relationship to the jaws; but it is only logical to assume that if rickets can cause such deformities as the bow-legs, knock-knees, and pigeon breasts with which we are all familiar—why can it not cause some of the misshaped jaws which are occuring with such frequency in the present generation.

In patients where there has been enlarged adenoid vegetation or nasal obstruction of any nature, producing a continued period of mouth breathing, there is generally produced the common and unsightly condition of the upper teeth protruding from between the lips.

Habits are responsible for much of the trouble. Youngsters should be closely watched for all kinds of habits such as biting the lips, cheeks, tongue and finger nails; sucking the thumbs, tongue, fingers and pacifiers; or pillowing the face upon the hands or arms while sleeping. All these habits produce a constant pressure on the teeth and their supporting tissues, and if indulged in for any length of time, will cause a displacement.

Often through neglect, the baby teeth become so decayed that it is necessary to etxract them long before the time when they would be lost naturally. The space left will then close, so that when the second tooth follows, it is crowded outside the dental arch.

Frequently, the baby teeth do not fall out at the proper time. Especially is this true when abscesses are present. The following tooth must then push its way to one side or the other.

Just how much influence crowded arrangements of the teeth have upon the general health, would be difficult to say. However, we do know that it predisposes to decay and diseases of the gums. In extreme cases the children are utterly unable to masticate their food; with the result that they suffer from indigestion, anaemia, malnutrition and accompanying underweight.

The constricted upper arches do not allow adequate breathing space even when obstructing nasal growths have been removed. Usually, these children have short upper lips and find it impossible to close their mouths. This makes them more susceptible to colds, asthma, sore throats and pulmonary diseases.

The cosmetic side of the question is important as related to mental health. Quite young children are often extremely sensitive where the abnormality is conspicuous. There are many cases on record of young adults bordering on melancholia because of the unsightly deformities of their jaws.

The great mass of children are not receiving any treatment for these conditions. Many parents do not know that correction is possible; others think it unimportant.

There is great need for education of parents and teachers and all those in charge of children. Children must be taken to the dentist's office as soon as their teeth are in position, so that small cavities may be filled. Where extractions are necessary appliances should be made to hold the space until the new teeth come in.

The economic problem is a large one. The clinics are taking care of only a limited number. It remains a question as to how the countless hundreds of children are to receive the care which is so essential during the years when their bones are plastic and a most nearly perfect result can be obtained.

We can only hope that sometime in the near future society will realize its indebtedness to children and see to it that every child in every walk of life comes to fullest development, mentally and physically, of which it is capable.

RELATION OF PARASITES TO MAN IN RURAL COMMUNITIES.

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Scourges and devastating epidemics have forced cities with their concentrated populations to devote the necessary time and effort in developing pure water supplies, safeguarding food and milk, and establishing more or less efficient methods of waste disposal, although in some unfortunate instances the latter has consisted of conducting the offensive material away from the city into the rural districts.

To a great extent our rural population has been unaware of the grave dangers of certain practices, especially those leading to soil and water pollution. Customs still prevail which became established at the time the country was new and supported a very sparse rural population. The increasing density of our rural population, combined in at least some instances with an increasing degree of infestation with certain parasites, has increased the dangers of many common practices. Our present economic custom of employing transient farm laborers who while employed live in more or less intimate contact with their employer's family, combined with an increasing tendency for travel among the rural population have greatly increased the danger of parasites being introduced into rural communities.

In the past our rural communities have been protected from the importation of foreign parasites by the small amount of foreign travel and the long time travelers were in transit, which greatly reduced the chances of a parasite gaining a foothold in an area. Our splendid isolation from heavily parasitized populations is fast being swept away and our systems of protective sanitation should be planned to protect not only against parasites known to be present, but against those that can easily be introduced. According to Chandler (1922) 65 per cent of the homes in southern United States were estimated to be without privies of any kind. In this region at present such a condition is difficult to find. However many privies are poorly constructed, allowing free access to flies, and in extremely wet weather over-flowing often polluting the community water supply. Children, laborers, and sometimes others, are often guilty of not using the privy upon many occasions, increasing the ease with which parasites may be spread.

We may expect the introduction of parasitic diseases which are not at present endemic in this country. Many of these, due to the natural or acquired tolerance of races who have lived with them for centuries, cause little disturbance in their natural habitat, but when introduced into a favorable environment in less resistant populations may prove serious.

Until about forty years ago sleeping sickness was confined to a limited part of tropical Africa, but with the coming of the Europeans with their definite lines and more rapid means of travel the disease was carried to new regions where the people had not acquired a partial immunity to it. Accordingly the population of one district in Central Africa was reduced from 300,000 to 100,000 in the course of seven years (1901 to 1908).

The Greeks did not begin to decline until they conquered Asia Minor, bringing back the malaria parasite with them. Their description of the symptoms of the disease leave little doubt as to its identity. The Romans easily conquered these parasitized Greeks, only to introduce the disease into Italy where it still remains. It is probably that it was as a means of treating the symptoms of this disease that the famous Roman baths were constructed, and the disease no doubt contributed to the ease with which the northern tribes were able to defeat the Romans of this later period.

Fortunately the introduction of a new parasite does not always infest new areas. Probably many introductions are necessary before conditions are found favorable to its multiplication. In the case of a parasite requiring one or more intermediate hosts, the chances of the parasite and the necessary intermediate hosts being introduced under favorable conditions are remote, yet with repeated introductions infestation may occur.

The African eye worm, *Filaria loa,* has been introduced into this country many times without gaining a footing. The Guinea worm, *Dracunculus medinensis,* was brought to the New World with the slave trade, and while it failed to gain a foothold in this country it has become endemic in West Indies and in certain parts of South America.

A classical example of a recently introduced parasite is *Diphyllobothrium latum,* the broad fish tapeworm of man. This parasite is common among the people of Northern Europe, and in spite of the fact that two intermediate hosts, a copepod and later a fish, are required for its propagation, it has gained firm foothold in our northern states. Lack of suitable care in the disposal of feces allowing pollution of streams and lakes, combined with the practice of eating smoked or pickled fish not properly cooked were two customs which formerly had been relatively harmless, but after the introduction of this parasite these customs were fraught with danger.

All trematodes have an extremely complicated life history. We have in this country liver flukes of cattle and sheep and lung flukes of swine, but do not have those flukes which in certain countries prove a serious detriment to the well-being of the population. In Egypt over half of the population is said to be infested with the Egyptian blood fluke, *Schistosoma haematobium*. In the case of this parasite the eggs are deposited into the bladder, and are spread by water contaminated by the urine of infested individuals. Since infestation may occur not only by drinking water containing the cercarial, but by bathing in contaminated water, the prevalent custom of urinating in streams would prove deleterious should this trematode be introduced into this country and adapt itself to utilizing our fresh water snails as an intermediate host.

When the hookworm was introduced by infested slaves from Africa, the custom in regard to waste disposal of the English blooded pioneers in the mountainous regions of the south were such as to furnish an ideal environment for these parasites. The custom of defecating in a wooded thicket, which previously had little or no bearing upon their well being, now proved to be the means of disseminating this parasite accompanied by intellectual and economic decline.

Trichiniasis is a real menace. Urban communities are at least partly protected by our systems of meat inspection, but in our rural communities the slaughter houses are not efficiently inspected. In one which I frequently visited, the viscera, diaphragm and also abnormal appearing pieces of meat are fed raw to swine. In this particular slaughter house rats are abundant. Introduction of *Trichinella spiralis* into such a slaughter house would probably result in a local epidemic of trichiniasis. Only the fortunate circumstance of the parasite not having been introduced under suitable conditions and the generally prevalent custom of thoroughly cooking pork have prevented serious outbreaks. "Hamburger stands", especially in rural villages, frequently serve sausage from such slaughter houses. Often this meat is served without being thoroughly cooked.

Many parasites normally present in domestic animals may prove injurious to human health, especially in those instances where the animals live in fairly close contact with people. *Ascaris lumbricoides* of human and porcine origin, while apparently morphologically identical, are physiologically distinct. This, however, does not prevent the infestive ova from the porcine strain hatching in the human digestive system, boring through the intestinal mucosa, reaching the liver, going next to the lungs and after sufficient development causing the typical verminous cough.

While I know of no experimental work done on the subject, the case of the whipworm, *Trichuris trichiura,* of man and swine, may be parallel to that of Ascaris lumbricoides. Swartze reports that the whipworms of man and swine are morphologically identical.

In the case of *Balantidium coli,* one of the pathogenic intestinal protozoa of man, the pig is supposed to be the reservoir of infestation. In a series of instances of human infestation with *B. coli,* Kofoid was able to trace the information to pigs. In many instances we find pig pens in close proximity to unscreened dwellings in our rural regions. House flies are abundant. It has been found that the house fly will hastily feed upon material, then retire to a more quiet spot and regurgitate the contents of the cecum. In the laboratory flies will readily ingest material containing Ascaris eggs, carry it considerable distances and regurgitate it. They will eat only a part of the regurgitated material and leave the eggs as part of the fly speck. In this manner the eggs of various parasites may be spread by house flies.

The time is rapidly passing when we can safely rely upon distance as an effective barrier against the introduction of parasites. Our splendid isolation from heavily parasitized populations is rapidly passing. It is imperative that our population be educated against these increasing dangers. In the grammar schools and high schools suitable training in sanitation and the rudiments of parasitology should be taught by suitably trained teachers. The support of the local veterinarians and physicians should be enlisted, and by the education of our rural population as to the dangers of certain customs, it should be largely possible to prevent many of these parasites from gaining a foothold even tho accidentally introduced.

PAPERS IN PSYCHOLOGY AND EDUCATION

AN ANALYSIS OF THE HIGH SCHOOL CURRICULA OF SEVEN HUNDRED FORTY-THREE STUDENTS WHO ENTERED THE COLLEGE OF LIBERAL ARTS OF NORTHWESTERN UNIVERSITY IN 1927.

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The primary purpose of this report is to present the findings of a study concerning the extent and nature of the high school preparation of students who entered the College of Liberal Arts of Northwestern University in 1927. More specifically stated the purposes are:

1. To indicate the number and percentage of students who took each subject.

2. To indicate the average, mode, distribution, and range of the units presented for each subject.

3. To indicate the number of students who had taken specific amounts of each of the following groups of subjects:

a) English
b) Mathematics
c) Foreign Languages
d) Social Sciences
e) Natural Sciences
f) Vocational Subjects
   1) Commercial
   2) Industrial
   3) Home Arts
   4) Fine Arts

4. To indicate the extent to which the students had emphasized the principle of concentration in their course or the principle of distribution among several fields of organized knowledge.

The characteristics of this study considered most significant are: first; the approach to the problem is from the point of view of the subjects which the students had actually taken in high school, rather than from the point of view of the courses of study offered by the high schools from which the students came, and second; use is made of the curricula of a large number of students as a basis for the study. The curricula of 743 students, or practically the entire number of freshmen who entered the School of Liberal Arts of Northwestern University in 1927, were used. It should be stated, however, as a limitation of the study, that the specific findings obtained can apply only to the curricula of the particular group studied, and not to the curricula of high school students in general. This limitation must be recognized because of the probable selected character of the group of students who go to college.

The descriptive method is used. The plan of procedure is to present the findings in terms of specific subjects first, and then in terms of the categories—English, mathematics, foreign languages, social sciences, natural sciences, and vocational subjects. Finally an attempt will be made to indicate the extent to which the students had emphasized the principle of concentration in their high school courses.

To insure uniformity in understanding it may be well to define certain terms that will be used frequently. The term, *unit,* will be used in accordance with the following definition as stated in the United States Bureau of Education Bulletin No. 7, 1913, p. 7. ''A unit represents a year's study in any subject in a secondary school constituting approximately a quarter of a full year's work. This statement is designed to afford a standard of measurement for the work done in secondary schools. It takes the four year high school course as a basis and assumes that the length of the school year is from 36 to 40 weeks, that a period is from 40 to 60 minutes in length, and that the study is pursued for four or five periods per week.'' The term, *groups of subjects,* will be used synonomously with the terms, *categories* and *fields of study.* These terms will refer to such departments of study as English, mathematics, natural sciences, social sciences, foreign languages, and vocational subjects.

Specific Subjects.

Table I. shows a distribution of the number of students who had taken each of the subjects that were offered for admission. Table II. shows a distribution of the number of students with respect to the specific amount of each subject that was taken. In both tables the subjects are arranged in order of frequency. We read Table I. thus: Seven hundred forty-three, or one hundred per cent of the students considered, had taken English in high school. The average number of units taken was 3.79, the mode was 4 units, and the range from 3 to 5 units. Table II. is read: One hundred seventeen students, or 15.8% of the total number considered, had taken three units of English in high school. All percentages are based on the total number of students considered, which was 743.

Tables I. and II. show that English was the only subject taken by all of the 743 students. The average number of units of English taken was larger than for any other subject. In the field of mathematics, algebra and plane geometry were each taken by more than 98% of the students. Of the foreign languages, Latin was taken by 86% and ranked second in respect to the average number of units taken. French was taken by approximately 50% of the students while only 13 had taken Greek. The number of students who had taken Spanish was approximately three times greater than the number who had taken German. Among the social studies United States History ranked first in frequency. Ancient History and Medieval and Modern History were each taken by more than 60%. Civics was taken by approximately 70%. In the field of natural science, no subject was taken by more than 50% of the students, with the exception of Introductory Science which was taken by 60%. In the vocational field, 24 subjects were presented, none of which was taken by more than 40% of the students. The total number of subjects presented for admission by the 743 students collectively was 77.

TABLE I.

Subjects Taken in High School by Seven Hundred and Forty-three Freshmen Entrants at Northwestern University, 1927.

Subjects	No. of Cases	Per-cent of Total	Av. No. Units	Mode	Range
1. English	743	100	3.79	4	3 - 5
2. Algebra 1	739	99.5	1	1	.5 - 1
3. Plain Geom	732	98.5	.99	1	.5 - 1
4. Latin	640	86.1	2.69	2	1 - 4
5. U. S. Hist	623	83.8	.87	1	.5 - 1
6. Civics	531	71.5	.71	.5	.5 - 1.5
7. Ancient Hist	473	63.6	.95	1	.5 - 1.5
8. Mod. & Med. Hist	459	61.9	.95	1	.5 - 1.5
9. Algebra 2	454	61	.60	.5	.5 - 1
10. Introd. Sci	447	60.2	.93	1	.5 - 1
11. French	366	49.2	2.41	2	.5 - 4.5
12. Chemistry	356	48	.99	1	.5 - 1
13. Physics	349	47	.99	1	.5 - 1
14. Freehand Draw	290	39	1.52	2	.5 - 3
15. Chem. Lab	289	38.9	.52	.5	.5 - 1
16. Physics Lab	281	37.8	.52	.5	.5 - 1
17. Music Theory	259	34.8	.87	1	.5 - 1.5
18. Solid Geom	199	26.8	.52	.5	.5 - 1
19. Botany	185	24.9	.82	1	.5 - 1
20. Dramatics	177	23.8	1.07	1	1 - 2
21. Physical Trn	174	23.5	1.111	1	.5 - 2
22. Spanish	169	22.7	1.99	2	.5 - 4
23. Economics	160	21.5	.55	.5	.5 - 1
24. Typing	135	18.1	.96	1	.5 - 4
25. Zoology	129	17.4	.77	1	.5 - 1
26. Mechanical D	110	14.8	1.59	1	.5 - 4
27. Physiology	96	12.9	.55	.5	.5 - 1
28. Botany Lab	89	12	.5	.5	.5
29. Physiography	88	11.8	.63	.5	.5 - 1
30. Trigonometry	86	11.6	.52	.5	.5 - 1
31. Biology	85	11.5	.91	1	.5 - 1
32. Com'mer. Law	79	10.6	.50	.5	.5 - 1
33. English Hist	71	9.6	.81	1	.5 - 1
34. Dom. Science	69	9.3	.98	1	.5 - 2
35. Manual Trn	67	9	1.12	1	.5 - 2
36. Zoology Lab	62	8.3	.5	.5	.5
37. German	59	7.9	1.94	2	.5 - 4
38. Com'm Arith	57	7.6	.69	.5	.5 - 1
39. Music Applied	52	7	.99	1	.5 - 1.5
40. Shorthand	51	6.9	1.09	1	.5 - 2
41. Dom. Art	50	6.8	.91	1	.5 - 2
42. Bus Geog	48	6.4	.61	.5	.5 - 1
43. Sociology	45	6	.52	.5	.5 - 1
44. Bookkeeping	42	5.6	1.08	1	.5 - 2
45. Pub. Speaking	39	5.3	.5	.5	.5
46. Drama	36	4.8	.79	1	.5 - 1
47. Journalism	34	4.6	.65	.5	.5 - 1
48. Geography	34	4.6	.68	.5	.5 - 1
49. General Hist	32	4.3	.97	1	.5 - 2
50. Bible	30	4	1.93	1	.5 - 4
51. Industrial Trn	24	3.2	.90	.5	.5 - 2.5
52. Art	19	2.5	.87	1	.5 - 1.5
53. College Alg	18	2.4	.53	.5	.5 - 1
54. Auto Shop	17	2.3	2.09		.5 - 4
55. Agriculture	17	2.3	.91	1	.5 - 2
56. Elements Bus	15	2.1	.60	.5	.5 - 1
57. Greek	13	1.07	1.84	1	1 - 3
58. Adv. Arith	11	1.5	.63	.5	.5 - 1
59. Salesmanship	11	1.5	.59	.5	.5 - 1
60. Psychology	10	1.4	.65	.5	.5 - 1
61. Printing	9	1.1	.89		.5 - 2
62. Office Pract	9	1.1	1	1	1
63. Normal Trn	8	1	.94	.5	.5 - 2
64. Penmanship	7	.9	.86	1	.5 - 1
65. Political Sci	6	.8	.5	.5	.5
66. Astronomy	5	.7	.60	.5	.5 - 1
67. Story Telling	4	.5	.87	1	.5 - 1
68. Spelling	3	.4	.83	1	.5 - 1
69. Library Prac	3	.3	1.5		1 - 2
70. First Aid	2	.2	.75		.5 - 1
71. Bus. English	2	.2	.50	.5	.5
72. Polish	2	.2	2	2	2
73. Lat. Amer. Hist	2	.2	.5	.5	.5
74. Analytical Geom	1	.1	.5	.5	.5
75. Danish	1	.1	1	1	1
76. Modern Probs	1	.1	1	1	1
77. Gen. Mechanics	1	.1	.5	.5	.5

TABLE II.

NUMBER OF UNITS OF VARIOUS SUBJECTS TAKEN IN HIGH SCHOOL BY SEVEN HUNDRED AND FORTY-THREE FRESHMEN ENTRANTS AT NORTHWESTERN UNIVERSITY 1927.

SUBJECTS	NUMBER OF UNITS .5	1	1.5	2	2.5	3	3.5	4	4.5	5
1. English	—	—	—	—	—	117 15.8	125 16.9	454 61.1	36 4.8	11 1.4
2. Algebra 1	2 .3	737 99.2	—	—	—	—	—	—	—	—
3. Plane Geometry	9 1.2	723 99.2	—	—	—	—	—	—	—	—
4. Latin		63 8.4	5 .7	240 32.3	7 .9	135 18.2	15 2.1	175 23.5	—	—
5. U. S. History	157 21.1	466 62.7	—	—	—	—	—	—	—	—
6. Civics	342 46	150 20.2	39 5.3	—	—	—	—	—	—	—
7. Ancient History	49 6.5	421 56.6	3 .4	—	—	—	—	—	—	—
8. Mod. and Med. History	52 7	397 53.5	10 1.4	—	—	—	—	—	—	—
9. Algebra II	359 48.3	95 12.8	—	—	—	—	—	—	—	—
10. Introductory Science	56 7.6	391 52.6	—	—	—	—	—	—	—	—
11. French	3 .5	56 7.6	6 .8	159 21.2	4 5	100 13.5	7 .9	29 3.9	2 .3	—
12. Chemistry	15 2.1	341 45.9	—	—	—	—	—	—	—	—
13. Physics	10 1.4	339 45.6	—	—	—	—	—	—	—	—
14. Freehand Drawing	33 4.5	99 13.4	7 .9	139 18.7	1 .1	11 1.4	—	—	—	—
15. Chemistry Lab.	277 36.3	12 1.6	—	—	—	—	—	—	—	—
16. Physics Lab.	273 36.7	8 1.1	—	—	—	—	—	—	—	—
17. Music Theory	89 12	147 19.8	23 3	—	—	—	—	—	—	—

TABLE II.—*Continued.*

SUBJECTS	NUMBER OF UNITS									
	.5	1	1.5	2	2.5	3	3.5	4	4.5	5
18. Solid Geometry	193 26	6 .8	—	—	—	—	—	—	—	—
19. Botany	67 9	118 15.9	—	—	—	—	—	—	—	—
20. Dramatics	—	167 22.4	—	10 1.4	—	—	—	—	—	—
21. Physical Training	59 7.9	66 8.9	49 6.7	—	—	—	—	—	—	—
22. Spanish	2 .3	48 6.4	6 .8	67 9	2 .3	35 4.8	1 .1	8 1	—	—
23. Economics	143 19.2	17 2.3	—	—	—	—	—	—	—	—
24. Typing	43 5.7	77 10.5	5 .7	8 1	—	1 .1	—	1 .1	—	—
25. Zoology	60 8.1	69 9.3	—	—	—	—	—	—	—	—
26. Mechanical Drawing	18 2.4	47 6.3	4 .5	20 2.7	1 .1	10 1.4	—	10 1.4	—	—
27. Physiology	86 11.5	10 1.4	—	—	—	—	—	—	—	—
28. Botany Lab	89 12	—	—	—	—	—	—	—	—	—
29. Physiography	66 8.9	22 2.9	—	—	—	—	—	—	—	—
30. Trigonometry	83 11.2	3 .4	—	—	—	—	—	—	—	—
31. Biology	15 2.1	70 9.4	—	—	—	—	—	—	—	—
32. Commercial Law	75 10.1	4 .5	—	—	—	—	—	—	—	—
33. English History	27 3.7	44 5.9	—	—	—	—	—	—	—	—
34. Domestic Science	10 1.4	53 7.1	4 .5	2 .3	—	—	—	—	—	—
35. Manual Training	17 2.3	32 4.3	3 .4	15 2	—	—	—	—	—	—

TABLE II.—*Continued.*

SUBJECTS	NUMBER OF UNITS .5	1	1.5	2	2.5	3	3.5	4	4.5	5
36. Zoology Lab	62 8.3	—	—	—	—	—	—	—	—	—
37. German	2 .3	14 1.9	1 .1	31 4.1	1	7 .5	—	3	—	—
38. Commercial Arithmetic	35 4.7	22 2.9	—	—	—	—	—	—	—	—
39. Music Applied	17 2.3	19 2.5	16 2.2	—	—	—	—	—	—	—
40. Shorthand	10. 1.4	30 4	3 .5	8 1	—	—	—	—	—	—
41. Domestic Art	16 2.2	29 3.9	3 .4	2 .3	—	—	—	—	—	—
42. Business Geography	41 5.5	7 .9	—	—	—	—	—	—	—	—
43. Sociology	43 5.7	2 .3	—	—	—	—	—	—	—	—
44. Bookkeeping	7 .9	27 3.6	2 .3	6 .8	—	—	—	—	—	—
45. Public Speaking	39 5.3	—	—	—	—	—	—	—	—	—
46. Drama	17 2.3	19 2.5	—	—	—	—	—	—	—	—
47. Journalism	24 3.2	10 1.4	—	—	—	—	—	—	—	—
48. Geography	22 2.9	12 1.6	—	—	—	—	—	—	—	—
49. General History	5 .7	25 3.4	1 .1	1 .1	—	—	—	—	—	—
50. Bible	5 .6	10 1.4	1 .1	5 .6	—	2 .3	—	7 .9	—	—
51. Industrial Training	11 1.5	10 1.4	1 .1	1 .1	1 .1	—	—	—	—	—
52. Art	9 1.2	7 .9	2 .3	1 .1	—	—	—	—	—	—
53. College Algebra	17 2.3	1 .1	—	—	—	—	—	—	—	—

TABLE II.—*Continued.*

SUBJECTS	NUMBER OF UNITS									
	.5	1	1.5	2	2.5	3	3.5	4	4.5	5
54. Auto Shop	3 .4	5 .7	—	1 .1	—	5 .7	—	3 .4	—	—
55. Agriculture	7 .8	10 1.4	—	1 .1	—	—	—	—	—	—
56. Elements of Bus	12 1.6	3 .5	—	—	—	—	—	—	—	—
57. Greek	—	6 .8	—	3 .4	—	4 .5	—	—	—	—
58. Advanced Arithmetic	8 1	3 .5	—	—	—	—	—	—	—	—
59. Salesmanship	9 1.2	2 .3	—	—	—	—	—	—	—	—
60. Psychology	7 .9	3 .5	—	—	—	—	—	—	—	—
61. Printing	4 .5	4 .5	—	1 .1	—	—	—	—	—	—
62. Office Practice	—	9 1.2	—	—	—	—	—	—	—	—
63. Normal Training	4 .5	2 .3	1 .1	1 .1	—	—	—	—	—	—
64. Penmanship	2 .3	5 .7	—	—	—	—	—	—	—	—
65. Political Science	6 .8	—	—	—	—	—	—	—	—	—
66. Astronomy	4 .6	1 .1	—	—	—	—	—	—	—	—
67. Story Telling	1 .1	3 .4	—	—	—	—	—	—	—	—
68. Spelling	1 .1	2 .3	—	—	—	—	—	—	—	—
69. Library Practice	—	1 .1	1 .1	1 .1	—	—	—	—	—	—
70. First Aid	1 .1	1 .1	—	—	—	—	—	—	—	—
71. Business English	2 .3	—	—	—	—	—	—	—	—	—

TABLE II.—*Concluded.*

SUBJECTS	NUMBER OF UNITS .5	1	1.5	2	2.5	3	3.5	4	4.5	5
72. Polish	—	—	—	2 .3	—	—	—	—	—	—
73. Latin Amer. History	2 .3	—	—	—	—	—	—	—	—	—
74. Analytical Geometry	1 .1	—	—	—	—	—	—	—	—	—
75. Danish	—	1 .1	—	—	—	—	—	—	—	—
76. Modern Problems	—	1 .1	—	—	—	—	—	—	—	—
77. General Mechanics	1	—	—	—	—	—	—	—	—	—

Our analysis so far has been in terms of specific subjects. We will next consider the amount of work the students had in the several fields of study.

1. *English*

Tables I. and II. show that all of the students had English, and that the average number of units taken was 3.79. The mode was 4 units, and the range was from 3 to 5 units.

2. *Mathematics*

All of the 743 students had pursued at least one course in the field of mathematics. Table III. shows considerable variation in the amount that they had had. Eighty-eight per cent of the students had 2 or 3 units. The range was from 1 to 5 units. The combination of subjects most frequently taken was either a year of algebra and a year of plane geometry making a total of two units which was the case of 35% of the students, or a year and a half of algebra and plane and solid geometry, making 3 units, which was the combination taken by 26% of the students.

TABLE III.

DISTRIBUTION OF THE NUMBER OF STUDENTS WHO HAD TAKEN SPECIFIC AMOUNTS OF MATHEMATICS.

Units	Cases	Per Cent of Total
5	2	.3
4.5	2	.3
4	28	3.7
3.5	42	5.7
4	211	28.4
2.5	177	23.8
2	271	36.5
1.5	6	.8
1	4	.5
Total	743	100.
Mode	2 units	
Average	2.56 units	

3. *Foreign Languages*

The foreign languages that were presented for admission were ancient—Latin and Greek, and modern—French, German, Spanish, Danish and Polish.

Tables IV. and V. give distributions of the number of students who had pursued courses in the ancient and modern languages respectively, and Table VI. indicates the total number of students who had taken work in the field of foreign language.

All of the 743 students had had some work in the foreign languages. It appears that there was a decided tendency for the students to take at least two years of some particular foreign language. In the case of the ancient languages approximately 75% of students had from 2 to 4 units inclusive. In the case of the modern languages, approximately 50% of the students had two or three units. The average number of units of all foreign languages taken was 4.07.

TABLE IV.

Distribution of the Number of Students Who Had Taken Specific Amounts of Ancient Languages.

Units	Cases	Per Cent of Total
7	2	.3
6	3	.4
5	3	.4
4	170	22.9
3.5	15	2.0
3	135	18.2
2.5	6	.8
2	246	33.1
1.5	5	.6
1	56	7.5
Total	641	86.2
Mode	2 units	
Average	2.73 units	

TABLE V.

Distribution of the Number of Students Who Had Taken Specific Amounts of Modern Languages.

Units	Cases	Per Cent of Total
7	1	.1
6	4	.5
5.5	1	.1
5	7	.9
4.5	6	.8
4	48	6.5
3.5	10	1.4
3	133	18.0
2.5	5	.6
2	231	31.1
1.5	14	1.9
1	80	10.8
.5	4	.5
Total	544	73.2
Mode	2 units	
Average	2.39 units	

TABLE VI.

DISTRIBUTION OF THE NUMBER OF STUDENTS WHO HAD TAKEN SPECIFIC AMOUNTS OF FOREIGN LANGUAGES.

Units	Cases	Per Cent of Total
10	1	.1
9	4	.5
8	8	1.0
7.5	3	.4
7	47	6.4
6.5	2	.3
6	72	9.7
5.5	15	2.1
5	85	11.4
4.5	16	2.2
4	219	29.5
3.5	16	2.2
3	97	13.0
2.5	4	.5
2	152	20.4
1	2	.3
Total	743	100
Mode	4 units	
Average	4.07 units	

Table VII shows the specific foreign languages the students had taken in high school. We read Table VII thus: One hundred ninety-four students or 26% of the 743, had one ancient language only in high school. It is seen that the most frequently occurring case was one ancient and one modern language which was the combination taken by over 50% of the students. Thirty-seven per cent of the students had work in only one foreign language and of these 70% had their work in an ancient language.

TABLE VII.

NUMBER OF STUDENTS WHO HAD ONE OR MORE ANCIENT AND MODERN LANGUAGES IN HIGH SCHOOL.

Languages	No. of Students	Per Cent
1 anc. language	194	26
2 anc. languages	5	.7
1 mod. language	85	11.4
2 mod. languages	27	3.6
1 anc. and 1 mod. language	400	54
1 anc. and 2 mod. languages	25	3.4
1 mod. and 2 anc. languages	7	.9
Total	743	100

4. *Social Science*

The subjects included in the group of social sciences are history, sociology, political science, economics, and civics. As shown by Table VIII, each of the students had pursued work in this field. Ninety-five per cent of the students had from 2 to 4 units. The average number of units was 2.7.

TABLE VIII.

DISTRIBUTION OF THE NUMBER OF STUDENTS WHO HAD TAKEN SPECIFIC AMOUNTS OF SOCIAL SCIENCE.

Units	Cases	Per Cent of Total
5	4	.5
4.5	15	2.0
4	76	10.2
3.5	114	15.3
3	159	21.4
2.5	124	16.7
2	156	20.9
1.5	48	6.5
1	48	6.5
Total	743	100
Mode	3 units	
Average	2.7 units	

5. *Natural Science*

The following subjects were presented in the field of natural science: physics, chemistry, botany, zoology, physiography, introductory science, physiology, biology, and astronomy. Table IX. shows that 97.8% of the students had work in natural science; the largest number, 392 or 39.3%, had two units. Fifty-four per cent of the students had taken either physics or chemistry. Twenty-one per cent had taken both physics and chemistry, and 25% had neither.

TABLE IX.

DISTRIBUTION OF THE NUMBER OF STUDENTS WHO HAD TAKEN SPECIFIC AMOUNTS OF NATURAL SCIENCE.

Units	Cases	Per Cent of Total
5.5	1	.1
5	7	.9
4.5	5	.6
4	44	5.9
3.5	14	1.9
3	102	13.8
2.5	48	6.5
2	292	39.3
1.5	58	7.8
1	153	20.6
.5	3	.4
Total	727	97.8
Mode	2 units	
Average	2.09 units	

6. *Vocational Subjects*

The subjects that were presented in the vocational field are given under the following sub-heads:

a) Commercial:

Bookkeeping	Office Practice
Arithemetic	English
Law	Geography
Typing	Salesmanship
Shorthand	Elements of Business

b) Manual Arts:

Manual Training	Industrial Training
General Mechanics	Auto Shop
Mechanical Drawing	

c) Fine Arts:

Music (Theory and Applied)
Art
Freehand Drawing

d) Home Arts:

Domestic Science
Domestic Art

e) Unclassified:

Journalism	Printing
Agriculture	Normal Training

Tables X., XI., XII., and XIII. indicate the distribution of the students who took work in each of the sub-fields of the vocational group.

TABLE X.

DISTRIBUTION OF THE NUMBER OF STUDENTS WHO HAD TAKEN SPECIFIC AMOUNTS OF COMMERCIAL SUBJECTS.

Units	Cases	Per Cent of Total
4	5	.6
3.5	8	1.0
3	8	1.0
2.5	14	1.9
2	24	3.2
1.5	20	2.8
1	101	13.7
.5	95	12.8
Total	275	37.0
Mode	1 unit	
Average	1.21 units	

TABLE XI.

DISTRIBUTION OF THE NUMBER OF STUDENTS WHO HAD TAKEN SPECIFIC AMOUNTS OF MANUAL ARTS SUBJECTS.

Units	Cases	Per Cent of Total
5	1	.1
4.5	3	.4
4	6	.8
3.5	8	1.0
3	14	1.9
2.5	19	2.6
2	30	4.1
1.5	22	3.0
1	40	5.4
.5	24	3.2
Total	167	22.5
Mode	1 unit	
Average	1.87 units	

TABLE XII.

DISTRIBUTION OF THE NUMBER OF STUDENTS WHO HAD TAKEN SPECIFIC AMOUNTS OF FINE ARTS SUBJECTS.

Units	Cases	Per Cent of Total
3.5	9	1.2
3	28	3.7
2.5	46	6.2
2	181	24.4
1.5	60	8.1
1	38	5.1
.5	16	2.2
Total	378	50.9
Mode	2 units	
Average	1.93 units	

TABLE XIII.

DISTRIBUTION OF THE NUMBER OF STUDENTS WHO HAD TAKEN SPECIFIC AMOUNTS OF HOME ARTS SUBJECTS.

Units	Cases	Per Cent of Total
3.5	1	.1
3	2	.3
2	10	1.4
1	62	8.3
.5	43	5.8
Total	118	15.9
Mode	1 unit	
Average	.96 units	

Table XIV. shows a combined distribution for all of the vocational subjects.

TABLE XIV.

Distribution of the Number of Students Who Had Taken Specific Amounts of Vocational Subjects.

Units	Cases	Per Cent of Total
6	2	.3
5.5	6	.8
5	10	1.4
4.5	24	3.2
4	26	3.6
3.5	55	7.5
3	80	10.8
2.5	114	15.3
2	119	15.7
1.5	103	13.9
1	46	6.2
.5	22	3.0
Total	607	81.7
Mode	2 units	
Average	2.3 units	

Tables X., XI., XII., XIII., and XIV. show that 33% of the students had taken commercial work, that 22% had taken manual arts subjects, 50% had taken fine arts, and 16% had taken home arts. Eighty-one percent of the students had taken some work in the vocational field. The average number of units taken was 2.3. The range was from ½ to 6 units.

Extent of Concentration.

Our final consideration is to determine the extent to which the 743 students had emphasized either the principle of concentration in their high school course or the principle of distribution among several fields. The data that have already been presented show that all of the students had some work in English, mathematics, foreign languages, and social science. Ninety-seven per cent of the students had some work in natural science, and 81% had some work in vocational subjects. This would indicate that practically all of the students had at least some work in five fields of organized knowledge, and over 80% in six fields. However, since a student was considered to have had some work in a particular field if he had merely ½ unit in that field, it would still be possible for the student to concentrate his work very largely in a few fields by taking, for example, ½ unit in each of 4 fields and the remaining units in 2 fields.

Data on the question of the extent to which the students had emphasized the principle of concentration in their high school courses will be presented from three different points of view: first, from the point of view of the aggregate number of units presented in six general fields of organized knowledge; second, from the point of view of the number of students who had taken more than five units of work in one field; and third, from the point of view of the number of courses the students had taken in high school.

1. Figure I. shows the aggregate number of units that were offered in each of six fields of study. We read Figure I. thus:

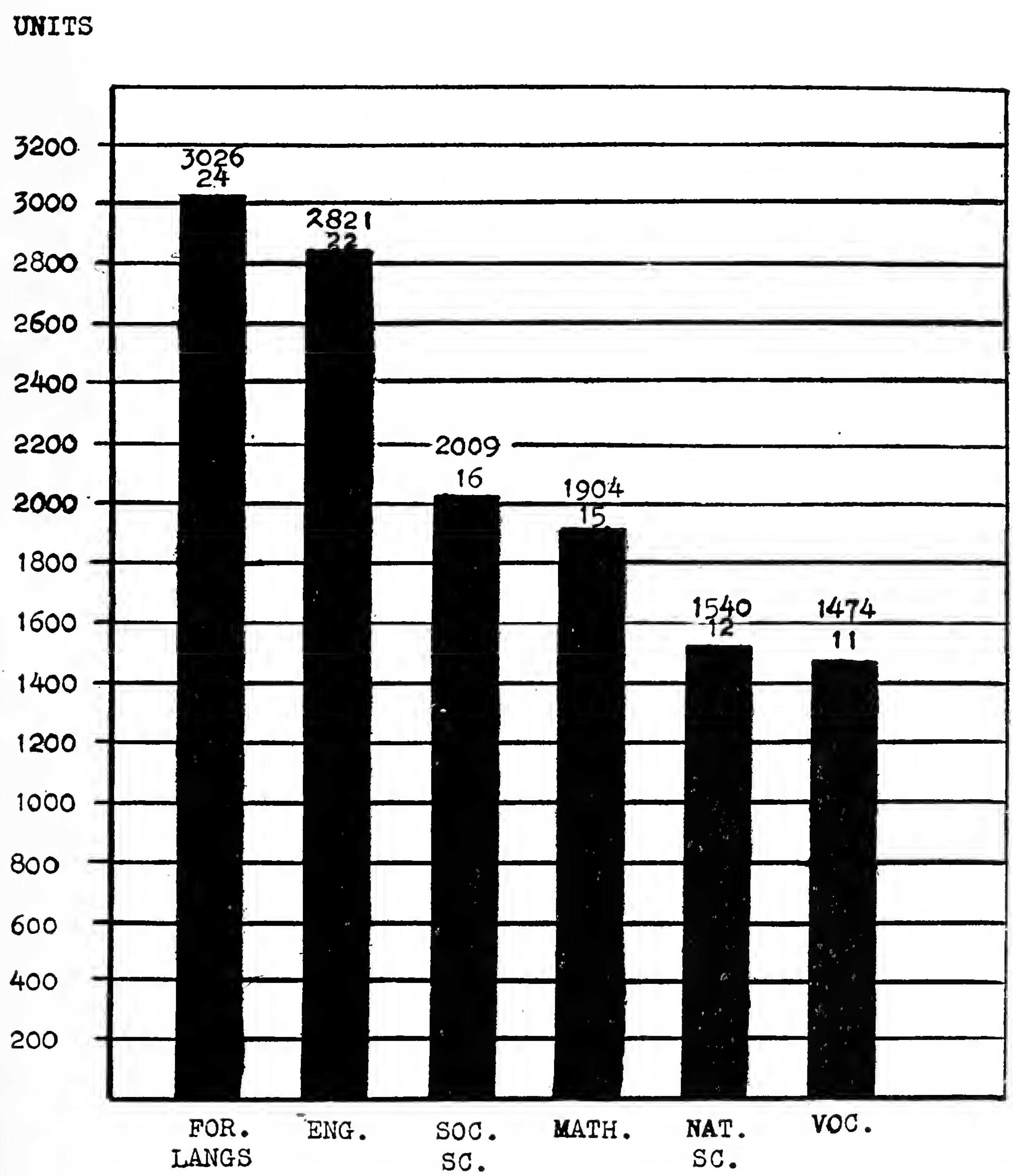

FIG. 1.—Aggregate number of units presented for admission.

We read Fig. 1 thus: Three-thousand-twenty-six units or twenty-four per cent of the aggregate number were presented in Foreign Languages.

three-thousand-twenty-six, or 24% of the total number of units presented for admission were in the field of foreign languages. Forty-six per cent of the total number of units were of linguistic subjects. If we consider English and foreign languages as one field, we see that nearly 50% of the total number of units were concentrated in one of five fields. The total number of units including all fields was 12,744, an average of 17.1 units per student.

2. Table XV. shows that 264 or 35% of the students had taken five or more units in one group of subjects. In practically every case the group in which students had five or more units was that of foreign languages. It was further found that 35% of the students had more than 50% of their work in linguistic subjects and 95% had more than one-third of their work in this general field. Upon the assumption that a student who had taken five or more units in one field had concentrated his course, it would appear justifiable to conclude that there was a tendency on the part of approximately one-third of the students to concentrate their high school course in one field, and in most cases that field was foreign languages.

TABLE XV.

NUMBER OF STUDENTS WHO HAD TAKEN FIVE OR MORE UNITS IN ONE FIELD.

Units	Cases	Per Cent of Total
10	1	.1
9	4	.5
8	7	.9
7.5	3	.4
7	47	6.4
6.5	2	.3
6	73	9.8
5.5	22	3.0
5	105	14.1
Total	264	35.5

3. Analysis was made of the number of courses each student had taken. Data on this analysis are given in Table XVI. The range of the number of subjects taken was from 9 to 20. Approximately 70% of the students had taken 12 to 16 subjects inclusive. Six students had taken as many as 20 subjects, while 17 had taken only 9. Table XVI. shows that there was a marked tendency on the part of certain students to emphasize the principle of concentration in their courses, while others emphasized

the principle of distribution of their courses so as to include a comparatively large number of subjects.

TABLE XVI.

DISTRIBUTION OF THE NUMBER OF SUBJECTS THE STUDENTS HAD TAKEN.

No. of Subjects	Cases	Per Cent of Total
20	6	.8
19	13	1.7
18	32	4.3
17	50	6.7
16	69	9.3
15	117	15.7
14	128	17.2
13	115	15.5
12	85	11.5
11	78	10.5
10	33	4.5
9	17	2.3
Total	743	100
Mode	14 subjects	
Average	13.86 subjects	

Conclusions.

1. Seventy-seven different subjects were included in the high school curricula of the students studied. The average number of subjects each student had taken was 14, the range being from 9 to 20. Approximately 70% of the students had taken from 12 to 16 subjects inclusive. The average number of units per student was 17.1.

2. Each of the 743 students had pursued courses in English, mathematics, foreign languages, and social science. Ninety-seven per cent had work in natural science, and 81% in the vocational field. A curriculum built upon the average number of units the students collectively had taken in each of the six different fields would be as follows: English 3½ units, mathematics 2½ units, social science 3 units, natural science 2 units, foreign languages 4 units, and vocational subjects 2½ units.

3. English was the only specific subject taken by all of the 743 students, and ranked first in the average number of units taken. Algebra and plane geometry were each taken by more than 98%. Latin was taken by 86%, while approximately 50% had French. Only 13 students had taken Greek. Eighty-three per cent of the students had taken United States History, which ranked first in the field of social science. In the field of natural

science less than 50% had taken any particular subject excepting introductory science, which was taken by 60%. In the vocational group, 24 subjects were presented, each of which was taken by less than 40% of the students.

4. Since 35% of the students had taken five or more units of work in one of six fields of study, and since approximately 50% of the aggregate number of units presented in all fields were in linguistic subjects, we may conclude that a significant percentage of the students had emphasized the principle of concentration in their high school course. On the other hand, the fact that more than 50% of the students had taken from 14 to 20 subjects shows that a considerable number of students emphasized the principle of distribution among several fields of organized knowledge.

OVERCOMING PRIMARY READING DIFFICULTIES.

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What are the mental processes of a child in learning to read? This is the question which the writer of this paper, who has been a high school teacher, undertook to answer two years ago when the first of his own two children at the end of her first school year encountered some reading difficulties. As a parent, where could he find the information that would throw light upon an unexpected problem in his own home with his own child?

While some anxiety existed in the mind of the parent, nevertheless he felt his child's difficulties were corrective and with this hope in mind he set himself to two tasks: first, to read what psychology has taught regarding the difficulties of a child in learning to read; and second, to try his art of teaching with his own child. As a vacation job, at neither loss of time to himself or child, what could be more interesting, and perhaps more profitable, than such a course of study?

As a parent, he could not be expected to set up the apparatus or take the time necessary to carry on an experiment such as the analysis of the steps given by Starch[1], for instance, entails. He could at best but make make observation of his child while reading under his own careful attention and supervision, and then, if necessary, turn his child over to a clinic.

The parent was made somewhat happy when he learned from his readings that the wigglings of the body—movements of the hands, the feet, and the trunk were neither hindrances or assists but were the efforts of the child to adjust herself to this more or less artificial form of behavior involved in reading.

It was some satisfaction again, to learn, that reading is a *complex* process, involving at least three major difficulties, according to Buswell[2]: (1) acquiring ability to pronounce words, (2) recognition of meaning of words, and (3) interpreting sentences or paragraphs. It was probably one or all of these pitfalls that had been causing the trouble.

In observing the child it was found that she did not seem to

[1] Starch, Daniel, **Educational Psychology** the Macmillan Co., 1922, p. 261.
[2] Buswell, Guy Thomas, **Fundamental Reading Habits: A Study of their Development.** Supplementary Educational Monographs, The University of Chicago, 1922, No. 21 p. 4

relate the printed word with the spoken word. With her eyes on one page she was pronouncing by rote what was printed on the opposite page or in other parts of the book. Her associations in the home had developed in her ability to pronounce and use some words quite beyond her years. Illness of the mother, occupation of the attention of the father in the supervision of pupils on the high school level, together, had worked at a disadvantage to the advancement of one in their own family. They had not put themselves on the level of the child in their leisure and play life. For that matter, that particular year, they had had very little leisure or play.

Securing from the first grade teacher, five books—three primary readers and two first readers, the child was set to a task against which she at first rebelled. The easiest of the three primary readers was given to her first and she was required to read fifteen pages a day, with the reward of one dollar if she completed the book by the end of the first week. Her storm of protest, at what she felt was a ponderous task, was overcome by a threat of punishment. Having her attention drawn to the picture and glancing at the work below she caught an association that began to work wonders. She began to feel that she could read. Within five minutes she had read the fifteen pages. Before a week she had read the book, and received her dollar. She needed no punishment. She was given another primary reader, with the same reward offered her. Within a week she had completed the second book. She was then given a first reader, but required to read but five pages a day. In order to restore confidence, after completing the first reader, she was again given a primary reader. A second of the first readers was given her as the last of the group. She was then ready for her vacation. She had her five dollars and the joy that she could read as other little girls.

The author of this paper does not offer this method as a solution to all cases. He is conscious that he violated more than one psychological principle in teaching. He only knows that his method worked. At the end of her third school year, which happens to coincide with the time of writing this paper, the parent is glad to report that his daughter is reading on the average of more than one book a week and is among the very best in the third year class. She has made the reading adaptation, reading story books, children's magazine's, funnies with great enjoyment. She is healthy and in every way normal.

Lack of attention in the home, and perhaps, somewhat the temperament of the child, may be given as the causes of the reading difficulties. The child had built up a defense attitude, although but seven years old which might have developed into a real problem case. As a teacher of more advanced pupils, the author wonders if many problem cases do not have their origin in conditions not unlike that in his own home.

THE EFFECTS OF PRACTICE ON INDIVIDUAL DIFFERENCES.

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The general problem. There is, perhaps, no question of greater significance both to psychological theory and to educational theory than the question, How does training affect individual differences among people? That individuals differ widely in the various traits with which education is concerned is a well-known fact; and it is probably no exaggeration to say that it is the most important and the most difficult problem in education at present to determine how proper provisions for these differences may be made. In our attempts to deal with this problem, our thinking is necessarily influenced greatly by our views concerning the essential cause of these differences and the manner in which, and the extent to which, they are affected by training.

Opposed views concerning the effects of practice on individual differences. Educational literature presents two diametrically opposed views concerning the primary cause of individual differences and the manner in which equal amounts of training affect these differences. The prevalent view, supported by many of the most eminent educational phychologists, is that differences among individuals are due in a larger degree to nature than to nurture and that equal amounts of training therefore increase these differences. The following quotation from Thorndike[1] will serve to set forth this view:

"In so far as the differences are due to differences in the quantity and quality of training which they have had in the function in question, the provision of equal amounts of the same sort of training for all individuals in the group should act to *reduce* the differences * * *. If the addition of equal amounts of practice does *not* reduce the differences found amongst men, those differences can not well be explained to any large extent by supposing them to have been due to corresponding differences in amount of previous practice. If, that is, inequalities in achievement are not reduced by equalizing practice, they cannot well have been caused by inequalities in previous practice. If differences in opportunity cause the differences men display, making

[1] Thorndike, E. L. Educational Psychology, Vol. III. New York: Teachers College, Columbia University, 1914, pp. 304-305.

opportunity more nearly equal for all by adding equal amounts to it in each case should make the differences less.

"The facts found are rather startling. Equalizing practice *seems to increase differences.* The superior man seems to have got his present superiority by his own nature rather than by superior advantages of the past, since, during a period of equal advantages for all, he increases his lead."

Among others who have expressed similar views may be mentioned Terman, Starch, Dearborn, Henmon, and Gates. Not all students of the problem, however, agree with the view set forth above. Some maintain that differences in achievement among people—at least in many types of performance—are primarily due to differences in training and that consequently equalizing opportunities for improvement tends to reduce these differences. Bagley, for example, says[2]:

"The present paper will * * * include a reference to the related studies which have now thoroughly discredited the determinists' contention that individual differences are inevitably widened by training—the investigations which prove that education, under certain conditions at least, actually operates as a 'leveling-up' agency."

Difficulties encountered in an experimental investigation of the effects of practice on initial differences. The fact that numerous experimental studies of the question have failed to result in a generally accepted answer suggests that an experimental attack upon the problem is attended with serious difficulties that render a conclusive answer almost, if not quite, unobtainable. One who examines the available evidence afforded by the various studies of the problem can hardly avoid the suspicion that many of the investigators were not clearly conscious of the difficulties involved. It is the main purpose of this paper to suggest some of the most troublesome questions which the experimental investigator of problem must face. These may be grouped under four headings as follows: (1) Determining equal amounts of practice; (2) Securing satisfactory measures of ability at various levels of practice; (3) Measuring individual gains; and (4) Comparing individual gains. These will be discused in order, though in the brief time allowed it will be possible only to suggest the major difficulties without any extensive elaboration or any discussion of the most promising means of obviating them.

[2] Bagley, W. C. Determinism in Education. Baltimore: Warwick and York, Inc., 1925, p. 133.

I. Determining Equal Amounts of Practice.

The difficulty involved in measuring practice. Practice in a given function consists in the exercise of neural connection that are useful in that function and also in the inhibition and elimination of useless and harmful connections. We are not able to apply a defined unit of neural activity to a given performance and thus measure directly the amount of practice received by the learner. We are therefore forced to resort to indirect measurement with the aid of any unit which can be employed, thus obtaining a measure which is valid only to the degree that the relationship between the neural activity and the unit employed is constant or varies in a known manner.

Measurement of practice in time units. Thorndike advocates the measurement of practice in time units. This recommendation has the obvious merits that the units are clearly defined, familiar, and readily applicable to practice in all functions. Thus one knows, at least in one sense, exactly what is meant by ten minutes of practice in multiplying one three-place number by another or in substituting digits for symbols. If one wished to compare rates of improvement in different functions, doubtless it would be advisable to measure the practice in time units.

It cannot be maintained, however, that practice in a given function for a given length of time is exactly equal practice for all persons. Thus the person who can multiply one three-place number by another correctly in thirty seconds will receive, in terms of exercise of useful connections, more practice in this function in ten minutes than will the person who requires two minutes for each example.

Measurement in work units. Practice may also be measured in terms of the number of units of work performed, regardless of the different lengths of time required by different subjects in completing the work. It is probable, however, that such amounts of practice are not truly equal for all learners, since the less proficient subject likely receives more practice in the sense of inhibiting or eliminating undesirable neural connections than does the more capable subject.

Conclusion. We do not know what constitutes exactly equal practice for all learners. Instead of inquiring how *equal amounts* of practice affect individual differences, we can only inquire how practice for *equal lengths of time,* or practice involving the performance of *equal amounts of work*, affect these differences.

II. Securing Satisfactory Measures of Ability.

Fluctuations in measures of ability. Ability may be defined as a state or degree of readiness-to-act on the part of the individual, primarily of the individual's nervous system. It, therefore, can not be measured directly, but is to be described only in terms of performance. Since ability can be known only through performance, the latter is measured and the assumption made that, as ability varies, so will performance. Monroe says[3]: "It is assumed that the performance sustains a constant functional relation to the ability which is being measured * * *. This assumption means that any change in ability from pupil to pupil produces a proportional change in the performances, and that all variations in performances are produced by corresponding changes in ability."

The writer just quoted points out[4] that the assumed constant functional relation between ability and performance is never realized, consequently errors are introduced if the scores obtained are taken as measures of ability. He is therefore led to distinguish between the ability which is assumed and the ability which is measured[5]:

"In this connection it is, perhaps, helpful to distinguish between the ability a pupil possesses but may not exercise completely because he makes little effort, and the ability which functions in the production of the performance. The former we may call his *potential ability*. The ability which is active is his *kinetic ability*. This is what we measure."

The term "ability" appears to be used usually in the sense of "potential ability", i. e., the total resources of the individual upon which he can, and will, draw in a given performance provided all the factors influencing the performance operate as favorably as possible in the direction of the utilization of all available resources. Such a state of affairs, however, rarely or never exists, and if it did it probably could not be recognized as such. Hence we can not, in general, measure "potential ability".

"Kinetic ability", however, is much more easily measured with a fair degree of accuracy, at least in many types of per-

[3] Monroe, Walter S. An Introduction to the Theory of Educational Measurements. Boston: Houghton Mifflin Company, 1923, p. 22.
[4] Ibid. p. 24.
[5] Ibid. p. 193.

formances. Hence it appears to be a somewhat more useful concept in studying the effects of practice than does the concept "potential ability." Since we have defined ability under a given set of conditions as a readiness-to-act resulting from the combined influence of all the factors involved, we may then assume a constant functional relation between this readiness-to-act and the resulting performance.

This definition of ability relieves us, in a large measure, from the necessity of considering the troublesome factor of unreliability of the obtained scores as measures of ability. On the other hand, it forces us to think of ability in a given function, even apart from changes due to practice, as a very unstable trait, since it fluctuates with every change in the combination of factors producing it.

Defects in measuring instruments. A more serious difficulty is found in the defects of the measuring instruments employed to determine the status of the learner before and after practice. In general, the zero points of these instruments are not clearly defined, nor are the different units of any scale known to be equal. It follows that a score, say, of four does not usually mean twice as much ability as that represented by a score of two, nor does a gain from a score of five to a score of ten necessarily represent the same amount of improvement as does a gain from the latter to a score of fifteen. In other words, the lack of defined zero points invalidates the ratio method of comparing gains and the inequality of units introduces errors into taking differences between initial and final scores.

III. Measuring Individual Gains.

Numerous possible procedures. If one lists all the different methods that have been employed in measuring the gain made by an individual during practice, one will find a total number that will probably be surprisingly large. The writer has found forty-one different ways of expressing individual gains, all of which may be useful, at least in certain cases, and no one of which is faultless. He has also found at least twelve different methods by which these gains have been treated in order to determine the effects of practice on initial differences. With a few exceptions, each of the forty-one measures of individual gains may be treated by any of the twelve methods of measuring the effects of the training. At least, there are more than three hundred fifty possible ways of treating the raw scores in order to ascertain the effects of practice, no two of which will, except by chance, yield identical results. It is not surprising, therefore, that investigators of the question do not agree in their conclusions.

Among the questions at issue in deciding upon the proper method of expressing the gains made by individuals during practice, the following may be mentioned: (1) Shall gain be taken from the initial score to the final score, or from the initial score to the best score, or from the average of several early scores to the average of several late scores? (2) Shall efficiency—and hence gain—be measured in units of work-per-unit-time or in units of time-per-unit-work? (3) Shall gain be expressed as gross gain or as percentile gain?

We can not here undertake to answer any of these questions, further than to say that, since no one procedure is demonstrably superior in all cases, it appears that several of the better procedures should be employed and the results of all taken into consideration in arriving at final conclusions.

IV. Comparison of Individual Gains.

Various possible procedures. Having determined, by several different methods, the gain made by each learner during practice, the investigator then faces the question, How should these various sets of measures of gain be treated in order that the effects of the practice on individual differences may be ascertained? It has already been stated that at least twelve different procedures are possible, no one of which is wholly satisfactory and no two of which are certain to point toward the same final conclusion. If time permitted, it could be shown that some of these methods often lead to erroneous conclusions, while others—particularly when they point to the same general conclusion—are fairly reliable. Without attempting here any defense of his choice, the writer believes that all of the following procedures should be employed and the results of all considered in interpreting the data:

(1) Computing the average gross gains of the highest and lowest quartiles or tertiles;

(2) Computing the average percentile gains of these groups;

(3) Correlating initial scores and gross gains;

(4) Correlating initial scores and percentile gains;

(5) Computing coefficients of variability at the beginning and end of practice;

(6) Observing the trends during practice of a number of ratios of the series, best/worst, second best/second worst, and so on.

One further difficulty. We may sum up the difficulties thus far mentioned by saying, with no high degree of exaggeration: (1) We do not know what constitutes equal practice; (2) we could not measure its effects if we did know; and (3) we should not know what to do with the measures if we had them. To these three discouraging statements, we may add another, if we accept the view, which is generally held, that a given gain in score denotes a greater amount of improvement if made along the upper portion of the practice curve than if it occurs along the lower portion—namely, we should not know what the results meant, even if we had accurate measures of ability at the beginning and end of training and knew what statistical treatment to apply to them. It appears, therefore, that the ambitious researcher who sets out to investigate the effects of practice on individual differences need not fear that he will find himself engaged in a task that does not call into action all of his talents and powers.

Present status of the problem. Had it been possible to do so adequately in the brief time allotted to this paper, the writer would have preferred to consider the experimental evidence available on the question. He can not refrain, however, from remarking that, in his judgment, this body of evidence has frequently been misinterpreted. A careful consideration of the procedures followed in many of these investigations reveals that —not to mention other defects—the statistical treatment applied to the data has not been wisely chosen. As a consequence, the investigator has often arrived at unjustifiable conclusions.

The writer has examined thirty-one studies, in twenty-seven of which the investigators were either primarily concerned with the problem of the effects of practice on individual differences, or at least sufficiently interested in the question to interpret their data with reference to it. In four of the thirty-one studies, no mention of the problem occurred, but the raw scores have been analyzed by the writer for any light they might throw on the problem. Furthermore, in the twenty-seven studies in which the problem was considered, the present writer subjected the raw scores, when reported, to a more careful analysis than the original investigators, and often arrived at conclusions that differed from theirs.

It is true that the original investigators concluded more often than otherwise that practice increases differences. The present writer, however, reached the opposite conclusion. If we consider all the different functions that were practiced, counting each as many times as training was given in it, by different investigators or by the same investigator with different groups, the original investigators concluded as follows: In the case of forty-four functions, training increased the differences; with twenty-two functions the opposite was true; and in eight cases the effects of the training were uncertain.

If to these seventy-four functions are added nine others, the effects of the training in which are not stated by the original investigators, the present writer's interpretation is: In eight cases practice increased the initial differences; in thirty-nine cases the result was the contrary; and in thirty-six cases the effects of the training on initial differences were slight or uncertain.

In closing, it may be said that the writer has, during the past two years, conducted three rather careful and elaborate investigations of the problem, and reached about the same conclusions from his data as he did from those of previous studies; that is, in the case of a majority, though not all, of the functions practiced, the training seemed to reduce initial differences among the learners.

In the light of the conclusions reached by a careful evaluation of the evidence afforded by earlier studies of the problem, as well as that obtained in his own investigations, the writer believes that the prevalent view in educational psychology to the effect that training increases individual differences is not in harmony with the experimental evidence.

THE RELATION OF FAILURE IN COLLEGE SCHOLARSHIP TO INTELLIGENCE AND TO THE NUMBER OF HOURS OF WORK CARRIED.

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In this study an attempt was made to determine the relationship between unsatisfactory academic work in college and the intelligence of the student as measured by intelligence tests, and also between unsatisfactory academic work and the number of hours of work carried. The specific questions with which the study dealt were as follows:

1. To what extent does the probability of academic failure differ for students of different levels of intelligence?

2. To what extent does this probability of failure differ for students who are carrying different amounts of work? Do students of a given degree of intelligence tend to fail in more hours or in a larger proportion of hours as they increase the number of hours of work carried, and, if so, is such a statement true for certain levels of intelligence, but not for others?

The cases included in the study consisted of students registered at Ohio State University during a period of two years. The number of students upon whom the study was based averaged more than 5,300 for each of four semesters. The Ohio State University Psychological Test was the intelligence test used, and on the basis of the scores made on this test, each student was given a percentile intelligence rating. In addition, each student was designated as belonging to one of the five intelligence classes which were defined as follows:

Class I	included percentile ratings	96-100
Class II	included percentile ratings	76-95
Class III	included percentile ratings	26-75
Class IV	included percentile ratings	6-25
Class V	included percentile ratings	1- 5

As stated above the study was based upon an average of over 5,300 students for each of four semesters, or a total of 21,202 cases. A given student may have been registered either one, two, three, or four of the semesters included in the study. If, for example, he was registered in each of the four semesters, he alone accounted for four of the 21,202 cases. The distribution of these students according to college class, intelligence class, and number of hours of work carried per semester is given in Table I.

The first step was to determine for each semester who of these students had become delinquent. The term 'delinquent' is used throughout the study to mean students who were failed, or were conditioned in one or more courses. In Table II is shown the percent of students delinquent when distributed according to college class, intelligence class, and number of hours of work carried. From this table it may be noted that for the whole group of students almost exactly one-third (33.5 percent) were

TABLE I.

Distribution of the Students According to College Class, Intelligence Class and Number of Hours of Work Carried.

College Class	Number of Hours of Work Carried	Number of Students in Intelligence Class					
		I	II	III	IV	V	Total
Freshmen	1-14	15	76	299	149	47	586
	15-18	164	773	2428	928	210	4503
	19 plus	136	465	1026	286	57	1970
	Total	315	1314	3753	1363	314	7059
Sophomore	1-14	25	134	445	155	51	810
	15-18	159	803	2214	793	180	4149
	19 plus	85	277	607	184	30	1183
	Total	269	1214	3266	1132	261	6142
Junior	1-14	26	91	239	83	34	473
	15-18	164	714	1665	566	115	3224
	19 plus	46	205	420	95	15	781
	Total	236	1010	2324	744	164	4478
Senior	1-14	25	121	219	63	15	443
	15-18	127	474	881	299	43	1824
	19 plus	56	167	283	72	18	596
	Total	208	762	1383	434	76	2863
Special	1-14	15	59	120	63	35	292
	15-18	20	28	165	72	33	318
	19 plus	1	8	32	4	5	50
	Total	36	95	317	139	73	660
Total	1-14	106	481	1322	513	182	2604
	15-18	634	2792	7353	2658	581	14018
	19 plus	324	1122	2368	641	125	4580
	Total	1064	4395	11043	3812	888	21202

delinquent each semester. As another illustration of the type of information given by this table it is seen that of all freshmen included in the study, 42.3 percent on the average were delinquent each semester; of those freshmen of Class V intelligence (the lowest class), 64 percent on the average were delinquent each

TABLE II.

Percentage of Students Delinquent When Distributed According to College Class, Intelligence Class and Number of Hours of Work Carried.

College Class	Number of Hours of Work Carried	Per Cent Delinquent in Intelligence Class					
		I	II	III	IV	V	Total
Freshmen	1-14	13.3	31.6	46.5	54.5	59.6	46.8
	15-18	17.7	29.8	40.6	55.0	62.9	41.9
	19 plus	21.3	27.7	44.3	59.1	71.9	41.8
	Total	19.0	29.1	42.1	55.8	64.0	42.3
Sophomore	1-14	32.0	30.6	49.0	45.2	47.1	44.6
	15-18	24.5	29.8	38.9	48.8	56.1	39.2
	19 plus	21.2	26.7	32.8	41.3	30.0	31.8
	Total	24.2	29.2	39.2	47.1	51.3	38.5
Junior	1-14	19.2	27.5	25.9	38.6	38.2	29.0
	15-18	15.9	24.4	25.8	37.5	42.6	27.6
	19 plus	13.0	19.0	25.5	35.8	26.7	24.3
	Total	15.7	23.6	25.7	37.4	40.2	27.2
Senior	1-14	0.0	7.4	7.8	14.3	0.0	7.9
	15-18	4.7	6.5	11.0	13.4	32.6	10.3
	19 plus	10.7	9.6	9.5	18.1	11.1	10.6
	Total	5.8	7.3	10.2	14.3	21.1	10.0
Special	1-14	13.3	13.6	29.2	42.9	54.3	30.8
	15-18	10.0	17.9	47.3	54.2	66.7	45.9
	19 plus	0.0	0.0	43.8	50.0	60.0	38.0
	Total	11.1	13.7	40.1	48.9	60.3	38.6
Total	1-14	16.0	22.2	35.6	42.7	45.6	34.4
	15-18	16.1	24.3	33.3	44.7	54.7	33.8
	19 plus	18.2	23.0	33.9	45.9	47.2	32.1
	Total	16.6	23.8	33.7	44.6	51.8	33.5

semester; of those freshmen of Class V intelligence carrying nineteen or more hours of work, 71.9 percent on the average were delinquent each semester. This table shows that of all students of Class I intelligence 16.6 percent on the average were delinquent each semester; of students of Class II intelligence, 23.8 percent; of those of Class III intelligence, 33.7 percent; of those of Class IV intelligence, 44.6 percent; and of those of

Class V intelligence, 51.8 percent. That is, the probability of a student of Class V intelligence becoming delinquent in scholarship was over three times the probability that a student of Class I intelligence would become delinquent.

In making this study, a great deal of interest had been centered in the question as to how accurately the intelligence test rating distinguished those students who were delinquent in scholarship from those who were not conditioned or failed in any of their work. One writer in discussing this question has declared that "the time is not far distant, if not already at hand, when we can predict with almost mathematical precision by means of properly administered intelligence tests those who are doomed in advance to failure." In view of such a hopeful prediction, it may be somewhat disappointing to state that the results of the present study clearly indicate that the time referred to has not yet arrived. It is quite evident that academic delinquency is not confined to any one level of intelligence. This is what might be expected in view of the fact that academic success or failure is the resultant of many factors of which intelligence is but one, although an important one.

In the use of the term 'delinquency' an important consideration has thus far been disregarded. It will be recalled that a delinquent student has been defined as one who was either conditioned or failed in some of his work, no account being taken of the amount of work in which he was conditioned or failed. An examination of the data with respect to the number of hours in which delinquent students of the five intelligence classes were conditioned and failed on the average each semester revealed a rather unexpected fact. Delinquent students of high intelligence were delinquent in practically the same amount of work as delinquent students of low intelligence, delinquent students of Class I intelligence being conditioned or failed on the average in 4.85 hours, and such students of Class V intelligence in 5.61 hours each semester.

A comparison of the probability of the students of the various college classes, as freshman, sophomore, junior, and senior, becoming delinquent also revealed significant results. The usual statement is that the freshman year is the difficult year of adjustment and that, if this year is survived successfully, things look fairly promising for the college student. The results of the study indicated also rather conclusively that in the sophmore year the probability that a student will become delinquent is practically as great as it is during the freshman year, 42.3 percent of all freshmen being delinquent each semester, and 38.5 percent of all sophomores. In the junior year this probability drops considerably, there being 27.2 percent of juniors delinquent each semester. Of the seniors, there were delinquent but 10 percent, which is less than one-fourth the proportion of freshmen. These data show that the distinction between lower classmen and upper classmen is not without some foundation in fact. The freshmen and sophomores are very similar in their probability of academic failure, and they form a group which is quite different in this respect from the juniors and seniors.

An important fact emerged from the division of the students into those carrying light, average, and heavy schedules of work. The probability that a student carrying fourteen hours or less of work would become delinquent was as great as it was in the case of a student carrying nineteen or more hours of work. Table II shows that of those students who carried a light schedule (14 hours or less), 34.4 percent became delinquent; of those carrying an average schedule (15 to 18 hours), 33.8 percent; and of those with a heavy schedule (19 hours or more), 32.1 percent. Not only was this true with respect to the group as a whole, it was equally true when the students of each intelligence class were considered separately. Just as they stand, these data suggest that within the limits of twelve to twenty-one hours a student may carry either a light or a heavy schedule without changing his chances of becoming delinquent in any of his work. Before accepting such a conclusion, however, the following factor must be examined. Whenever a student by his actual record in the university proved himself to be such a poor scholar that he was placed on probation, the amount of work which he might schedule was reduced. Students whose records were poor, but still not bad enough to cause them to be placed on probation, were likewise advised to take light schedules. In other words, due to certain restrictions, students who were known to be weak in scholarship were as a rule carrying light schedules. In order to eliminate the influence of this factor, the following method was used. A tabulation of all data was made in the case of the freshman students only for the first semesters of the two years included in the study. There were available for this purpose 3,673 cases. Obviously, the restrictions mentioned did not apply to these freshman students during their first semester's work. The results obtained are presented in Table III.

TABLE III.

PERCENT OF FRESHMAN STUDENTS WHO WERE DELINQUENT IN SCHOLARSHIP DURING THEIR FIRST SEMESTER'S WORK.

Number of Hours of Work Carried	Per Cent Delinquent in Intelligence Class					
	I	II	III	IV	V	Total
14 and less....	20.0	26.8	44.3	56.9	52.2	44.9
15 to 18........	14.8	33.1	43.9	63.4	67.0	46.4
19 and over....	21.9	30.9	47.2	67.7	78.3	46.5
Total	18.2	31.8	45.0	64.0	68.0	46.3

When the results for this group of freshmen as a whole are examined, it is found that they do not throw much light on the question under consideration. It still appears as though students who carried a light schedule were as likely to become delinquent as those with a heavy schedule. If, however, the results for each intelligence class are noted separately, an interesting and significant fact becomes apparent. While it still remains true that in the case of students of intelligence Clases I, II, and III, those carrying a heavy schedule had as many chances of carrying it without incurring any conditions and failures as did those with a light schedule, in the case of students of Classes IV and V intelligence the situation changed. Among those students there was a decided tendency for those attempting a heavy schedule to become delinquent in a greater proportion of cases than for those students carrying a light schedule. These facts require a modification of the first conclusion suggested, and it may now be stated as follows: Within the limits of twelve to twenty-one hours, the probability that a student carrying a light schedule will become delinquent in some of this work was practically as great as the probability that a student carrying a heavy schedule would become delinquent, except in the case of students in the lowest quartile of intelligence. Among such students an increase in the number of hours of work carried resulted in an increase in the probability that they would become delinquent.

The satisfactory explanation of this conclusion presents an interesting question. It seems plausible to assume that an increase in the amount of work carried will result in an increase in the probability that in some of the work the student will be conditioned or failed. It is quite likely that if the schedule of hours were increased indefinitely beyond the limit of twenty-one or twenty-two hours, the probability of delinquency would increase for all levels of intelligence. Within the limits set, however, and for students of average and superior intelligence the probability of delinquency appears to be conditioned more by other factors than by the amount of work carried. What several of these other factors are may be suggested, and some objective evidence offered in support of one of them. In the first place, many students have certain ideas and ideals with respect to scholarship which do not react favorably upon scholarship. While serving as secretary of the College of Education of Ohio State University the writer frequently came into contact with students of average and superior intelligence who frankly stated that they were interested in scholarship only to the extent of meeting minimum requirements, of "getting by." The standard of scholarship remains constant for such individuals regardless of the amount of work they are carrying. They strive for no higher quality of scholarship in their work when carrying twelve hours than when scheduled for twenty hours, and as a result they do not achieve a higher quality. On the other hand, their degree of intelligence is high enough to permit them within these limits of hours to attain equally well their standard, the minimum requirements, even though the amount of work is increased. In the second place, students of high intelligence frequently study fewer hours than students of low intelligence. Consequently, when a student of average or superior intelligence increases the number of hours of work carried, he still has a reserve of spare time from which to draw for the meagre preparation of the extra work. The student of low intelligence, on the other hand, is already using his available time nearer to its absolute limit and the addition of more hours of work finds him with a smaller reserve of extra time upon which to draw. This assumption of less study on the part of students of superior intelligence has some objective evidence to support it. In one study[1], in which an attempt was made to secure an objective measure of time spent in study, a correlation of —.29 was reported between time spent in study and intelligence, indicating that there is a tendency for those who are most intelligent to study least. Although little objective evidence has been presented on this point, it seems reasonable to suggest that the ideals of many students with respect to scholarship and the consequent lack of attention to study are two of the factors which to a greater or less degree are responsible for the situation revealed in the present study.

[1] Wilson, W. R. "Mental Tests and College Teaching" School and Society, 15:629-635. June 10, 1922.

THE MEASURING MOVEMENT AND THE COLLEGE STUDENT IN A SMALL COLLEGE.

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Quite recently the scientific and measuring movements in education have begun to reach the college field. Many signs of this could be cited. The widespread comment on "Research Adventures in University Teaching," a pioneer book by the Presseys, revealed how little in the way of scientific studies of the college existed except upon finance and administration. The courses just beginning to be offered in universities, such as Columbia, Chicago and Minnesota on college problems, the summer conferences on university problems, and the recent commission of the National Society of College Teachers of Education indicate this growing interest. This paper will try to indicate some of the activities of a group at Rockford College working intermittently and more or less individually. Only a small fraction of the statistical results are indicated here. We have thought of these activities as primarily exploratory. Most of them were made to throw light on some immediate practical difficulty. Next year the small group in a senior course in "Problems of Education" will work on college problems and some of the data now being accumulated will be worked up more fully.

1. *Studies of Intelligence.*

A brief group test of intelligence has been given to all Freshmen during Freshman Week for practical uses. To a limited extent tests have been given to such groups as the students in upper class courses in education, or mathematics club. In a limited way some retesting of students for variation has been attempted. The general distribution of intelligence, relationship with success and failure in academic, special (music, art and so forth), and athletic courses and their deviations, intelligence of the probation, problem, and "drop out" group have been studied. We are working on the different distributions of intelligence in the various sections, departments, and in the various groupings of honor students.

The college has a required orientation course for all Freshmen. Originally these students were grouped into sections alphabetically. Astonishing differences between the sections thus formed by chance were found. A careful study of the variation as to intelligence and marks between sections resulted this year in a grouping by which the high sixth of the students in intelligence test scores, along with equal numbers of average students, formed two sections and the low sixth, with equal numbers of average students, formed two other sections. This answered the difficulties from faculty preference for "high ability" rather than "low ability" sections, and the results are being studied. Next year a straight ability grouping is to be tried.

Space will forbid giving the statistical results, but a few may be given as samples. The median intelligence scores for the freshmen, (two years, Otis, S. A., twenty minutes) were 42,47, for the six sections in Orientation, chosen at random (alphabetically) 57.2, 46.8, 46, 47, 50.4, 43. For three groups of upperclassmen 47, 46, 49.5. By Otis' tables 47 is equivalent to an I. Q. of 1.18, and to a percentile rank of 94. The division points separating the five quintiles were 40, 45, 49, 54, representing I. Q. 109, 116, 120, 124 and percentile ranks 77, 90, 95, 97.8. Yet our previous marking systems had assumed sections were equal. The relationship between Otis scores and final mark in Orientation for the six sections gave coefficient of correlation .37±.05, correlation ratios of .3795±.046 and .425±.044, but for the two groups of three sections taught by the same instructors in rotation r=.124±.075 and .486±.058, while the correlation ratios were .2176±.073 and .397±.064 against .4895±.058 and .5857±.05. A comparison of orientation marks with all other marks that semester gave a coefficient of correlation of .53±.04 and correlation ratios of .85 and .78, and of Otis scores with general average gave a correlation ratio of .4858±.042.

A great deal of time has been spent interpreting this material, using the correlations with marks by graph, scatter diagram, translations into approximate intelligence quotient and percentile rank equivalents. The cases of material deviation have been worked over with the Personnel Committee, the Adviser of Students, administrative officers and instructors interested. Analyses of this material in terms of probation students, girls dropping out for such reasons as poor academic work, disciplinary action, health, finances, transfer to other colleges, etc. have been made.

One method of intrepretation has been to arrange a class into deciles in each of two sets of data and indicate those deviating markedly in their decile rank. This has been used most frequently.

2. *Marks.*

These studies merge impreceptibly with the others. Beside the routine analysis of marks given, such comparisons as between marks given and the normal curve, between departments between instructors, deviations between academic and special (music, art, etc.) marks, deviations between the average scholarship grade and average intelligence of the groups receiving the higher and lower marks in the various departments have been made. A system of having the faculty recommend a list of girls in terms of "general ability and scholarly interest" for yearly membership in our honorary society has been used to check against the regular method of selection by tabulating averages.

3. *Case Study.*

In four successive years four methods of personnel control, advising, and case study have been used. At the present time, a full-time adviser of students supplements the usual activities of the president (who acts as "dean of the college"), the dean of women, and the registrar. She is assisted by a large Personnel Committee, representing the various points of view and departments in the college. It includes as well members technically trained in applied psychology, social work, hygiene and statistics. By interlocking memberships, the committee cooperates very closely with the committees handling recommendation for teaching and other positions, graduate scholarships, etc. An elaborate rating blank has been worked out and is being brought into use. To explore the possibilities a small number of the girls was used as "cases" in a research by the life history method. Interviews of about an hour, each guided by a schedule of life history questions, immediately afterwards put down in shorthand and transcribed in full, were used as the method of getting the life history material. Other more or less experimental sources of material have been the use of English themes, and conference periods, autobiographical papers and term papers in advanced educational psychology courses, the gathering together of information from fellow students, (particularly dormitory corridor heads and student government officers) in a way possible only where practically the whole student community lives under one roof. As a control group for the study of the problems, interests and attitudes of business girls 75 upper class students filled out the elaborate questionnaire and provided comparable data on intelligence scores, etc. This material is now being worked up.

By a fortunate accident the city of Rockford was the location of the sanitarium of a well-known psychiatrist who was on the board of directors of the Illinois Society for Mental Hygiene. For next year an organization of the "psychiatric clinic" or "behavior study clinic" has been worked out under him, using members of the staff of the college for psychometric testing and a senior case worker of the local Associated Charities (now doing specialized graduate work in this field in New York) as psychiatrical social worker. It is expected that this organization can be used to support the work of the Personnel Committee of the college and the "deans" in the local secondary schools.

4. *Physical Efficiency Testing.*

The Brace Tests for Physical Efficiency have been used in the physical education department along with objective tests of various physical activities (apparatus work, tennis, archery, etc.) and the results correlated together and with measures of intelligence, college marks, high school and so forth. The correlations are relatively low.

The Brace motor ability scores given 332 students at beginning of winter term by Miss Fleming yielded a mean of 41, a range of 14.71. A scale score on Brace's test of basketball skill compared with motor ability score gave an accomplishment index, which correlated with the marks (of basketball, as winter sport, subjective marking) r. $= .52 \pm .087$. These course marks for winter sports were compared with general scholarship by finding the average mark in sports for the highest, middle, and lowest thirds in general scholarship, yielding $+.86$, $+.64$, $+.73$ respectively on a scale in which C is 0.00 and B is 1.00.

5. *Subject matter Abilities and Disabilities.*

In his book, Dr. Pressey indicates a close relationship between college failure and deficiencies in such fundamental elementary school activities as reading, composition, spelling, arithmetic and so forth. He suggests that very little relationship exists between college success and the subject matter and abilities dealt with in high school. At Rockford we have tried to check this by two efforts. The Stanford Achievement Test was given to an upper class group (prospective teachers in the education department) and a very much higher standard found than Dr. Pressey indicated. Possibly the difference between a college enrollment rigidly limited to 400, drawing a large majority of its students from the upper third of the high school graduating classes as compared with a state university admitting any high school graduate explains the discrepancy. At the present time we are furnishing three groups of students as subjects for the standardization at the college level of the new Breslich-Reavis Arithmetic Tests. The norms are not available with which to compare the college groups, but a very wide variation in such a fundamental elementary school sphere as arithmetic computations is observed. The bearing of this upon college failures in such subjects as physics and accounting is obvious. Apparently almost no data exist on college performance in the elementary school skills. An elaborate study on arithmetic of students in some of the Illinois Teachers' Colleges is reported but has not been published.

As part of the Freshman week program, some of the Iowa placement tests have been tried (tests of capacity for, and of training in such fields as foreign language and mathematics). The Iowa tests in English, and Inglis vocabulary tests are being used alongside a very elaborate subjective test of English composition. Students of lower rank go into "training sections" of sub-college level English. Students of highest rank are exempted from the routine Freshmen courses and go immediately into the more advanced work. An elaborate speech test is given; students of lower ability are required to take remedial courses in speech. The work of setting up a system whereby proof of ability to make practical use of foreign language is substituted for the old requirement of "taking so many courses" in it in high school and college is under way. In connection with the work of the Speech Department the Seashore tests of musical talent are used.

6. *Content Testing, College Courses.*

Less has been done with objective testing because of the small size of the classes, there being one instructor for each nine or ten students. The Waples-Reavis test of teaching technique has been used with education students. Some true-false testing and some measurement of attitudes are now going on with students of education and economics. An honors examination system using a chief examiner from an outside university plus the preparation of an extensive paper on a field not covered by courses gives an additional criterion of the accuracy of subjective marking.

7. *Curriculum.*

For a number of years the curriculum committee and the committees in charge of the orientation courses in science and in social science have been working intensively. In many cases weekly meetings throughout the semester have been used. Part of the work listed above is a result of questions raised in their discussion, but a report on their activities is hardly within the topic of this paper.

STUDYING PERSONALITY BY LIFE HISTORIES—BUSINESS GIRLS AND COLLEGE GIRLS.

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Strictly speaking, life histories are fairly complete accounts of the person's life in all its phases and covering a sufficient period of time to indicate the genesis of important habits, interests, and attitudes. Such personal data are gathered by a variety of means. Some of the most common are by tests and questionnaires, interviews, written autobiographical documents, diaries, and letters. For particular problems, complete life histories are often not necessary and emphasis can be placed on a selected list of items.

The material presented here centers around the interests and problems of young business girls. It is part of a study now being made by the Religious Education Association of Chicago at the request and with the aid of the Y. W. C. A. The immediate purpose is to give more objective data than are now at hand to serve as the background for planning club and class programs. For comparative purposes, information on certain phases of the general problem has also been obtained for college girls.

The question may arise why business girls and college girls tion has come of the problem of so-called normal girls, that is, of girls who are able to handle their problems sufficiently well to should be studied. Perhaps the best answer is that they have not been thoroughly studied as yet. It is only recently that recognifit in with present conventional ways of living. The study of both college and business girls is justified by the fact that for most of the girls, college or business, whichever happens to be the lot of the individual girl, represents the first thorough and major readjustment the girl has been called upon to make. For the majority of children, the home they have known and been familiar with from infancy shelters them through their public school days. They are in an invironment where their chief defects are often overlooked, where their faults are condoned, where they have love and affection, companionship in plenty, advice and counsel. They are usually dependent on the family group, not only economically, but also emotionally and for a large part of their satisfactions in the way of material needs of life (place to sleep, food, selection of clothing, etc.) and also of psychological satisfactions (appreciation, response, praise, etc.)

In college or business the girl is at least semi-independent economically and only partially under family supervision for the spending of money. There is for each the necessity to adjust to new surroundings, to new living conditions, to new rules and conventions, to new people on every side; there is the necessity to make new friends as contacts with old ones drop away through disuse; to exert new skills, to become an individual rather than a member of a family, and to affiliate herself with new groups of which she eventually becomes a part as a new adjustment is worked out, as complete and comfortable as was the old family one.

During such a period of readjustment there is extra strain on every weakness in the girl's makeup. Deficiencies become more evident, and many which were passed over at home threaten the girl's ability to adjust to her new surroundings. There are several possibilities as to outcome. Her difficulties may have such a marked reflection in her personality that she becomes a "problem" and in time requires the attention of psychiatric care. Or she may worry along, not quite happy, but without acute personality or emotional difficulties. She is not mentally disorganized but she is socially unorganized. Or she may in time work out ways to obtain satisfactions for her major interests and feel herself competent to handle new problems as they arise. In doing this she may fit herself into a compact and routinized way of living as rigid as was the family and as difficult to break away from when some other change comes into her life. Or she may develop sufficient flexibility and resourcefulness within herself to make future changes and adjustments fairly simple.

In all this process of adjustment there is need for assistance to the girl and for study of the process, for at least three good reasons: to prevent major difficulties from arising; to assist a more rapid and adequate adjustment; to discover what training the girl might have had in previous years which would have assisted her.

The following methods and sources of information were used. A questionnaire containing 57 questions, all of which required not a "yes" or "no" but a detailed and original answer, was given to approximately 150 girls at summer Y. W. C. A. conferences. The same questionnaire was also filled out by 75 students in a woman's college. The Otis intelligence test, higher form A, was given to approximately 200 business girls in five cities, together with a blank calling for 19 items of general information. Fifty girls were then given an hour's interview or induced to write life histories in which information was secured on educational and employment record and ambitions, the way they spent leisure time, their family, recreational, friendly, church, and other relationships. In addition to this original material, several sets of records at the Chicago Y. W. C. A. were examined and abstracted, library material was examined, and Y. W. C. A. secretaries all over the country were queried for such information as the problems and interests they had observed in business girls and the educational and recreational programs of their Y. W. C. A.'s.

The present study centers around three questions. What are the interests of business and of college girls—the aims, ideals and goals for which they actually plan or which they see in their day dreams? What are the problems of business and of college girls—the things which puzzle and worry them? How does the girl attempt to meet her problems—what psychological and educational resources has she for meeting them—what "counts" in making a good adjustment?

And finally, there is the question, of what interest is all this to educational psychology?

1. The interests will be considered first—since these give the pattern according to which the girl is forming or hopes to form her life.

Business girls assembled at the Y. W. C. A. business girls' conference at Camp Gray, Mich., last summer were asked to fill out the questionnaire already mentioned. 69 of the papers were from unmarried girls, under thirty years of age, and from American homes. These girls were between the ages of 18 and 30, with 68.3% between the ages of 18 and 24; ⅔ of them were stenographers, secretaries, or bookkeepers; ⅔ had graduated from high school. They lived in communities ranging in size from 6000 to 3,000,000 people. Most of them lived at home, most of them belonged to some church. From various checks, it seems safe to conclude that these girls represent one large sector of the business girls' group, the conservative, steady, convention-abiding sector.

Seventy-five college girls also answered the questionnaire. They were juniors and seniors in a woman's college of the middle west. Two-thirds of then lived in the college dormitories, one-third lived at home. They came from towns ranging in size from 6,000 to 3,000,000 people, with the median sized town 65,000. They ranged in age from 16 to 23 years with the median at 20 years. They were as a group somewhat younger than the business girls studied. Two-thirds were church members. They formed a group comparable in background and major relationships with the business girls.

Interests may be divided into immediate, remote, and visionary. The girl's immediate interests may be discovered by learning what she does, particularly with her free time, and what she enjoys doing with her friends. Sports, clubs, and such recreations as dancing, music, shows, are the chief interests which hold the business girl to her girl chum. Work, education, church work, reading, are mentioned by only a very few girls. Clubs, the family circle, dancing and shows are the chief evening occupations. Night school, lectures and reading are mentioned by a very few girls. On Sundays, the church and home predominate as places of interest. During vacations, camps and conferences were most popular, with home or visits to relatives, summer resorts (often with the family) and travel and "new things" following closely. Her hobbies are sports, with dancing, reading and music at a lower level. In other words, the girl's favorite way of spending her free time is with people, and she favors amusements with action, thrill, and romance.

In immediate interests, judging from the question on hobbies and one on activities with her girl chum, the college girl shows the same major interest in sports and athletics which the business girl has. She claims a greater interest in music, art, dramatics, reading and writing than the business girl, perhaps because her daily round of studies has accentuated her interest in them, and often aspires to some future eminence in some line of art.

For their more remote goals, both business and college girls have marriage. Eighty-one per cent of the business girls and eighty percent of the college girls say they hope to be married by the time they are 35. More college than business girls hope to combine some type of work with marriage or regard work as a satisfactory substitute for marriage. In their day dreams, both business and college girls testify that they dream of marriage and of future business or professional success. For the college girl there are also day dreams of travel.

The business girl is not without her interest in travel. The question, what would you do if you inherited $1000, brought the reply, travel, from thirty-five percent of the business girls and forty-eight percent of the college girls. Helping at home ranked as second choice with the business girls, while save part or all and obtain education tied for third place. With the college girls education ranked second with save some or all a poor third. Very few college girls would contribute any to their families. This ranking of ways of spending $1000 indicates, not less concern of the college girls for their homes, but a greater economic need on the part of parents of business girls and the willingness of the girls to shoulder some of the responsibility. The business girls' desire to save indicates also one fundamental type of past and future experience which differs between the two groups.

Both groups are seriously interested in men and while there is a minority in each group which does not have dates with men most of them do. For the college girls, dating is more or less confined to the summer vacation. For business girls the norm is one man friend with one to three dates per week. For college girls the norm is one to three men with one to three dates per week.

To sum up, we would say both groups are interested in sports and physical activities, both wish deeply to travel, and hope eventually to marry. Both have a steady interest in church and home. For a certain number of each group, money, clothes, personal status, are of prime concern. The business girl has an interest in education in general, the college girl in certain cultural and art phases. Both are concerned with their immediate occupations (jobs or school) and wonder rather vaguely how to obtain future success.

2. Next, the problems: What are the actual problems that disturb business and college girls? These problems also indicate interests—the interests which have given trouble.

A certain number both of business and college girls fail so utterly to adjust to problems, that they come to some type of official notice or develop phychopathic qualities. We will pass over this group and consider only the problems of the normal group.

One question asked was, "what do you lack to make you really happy?" Sixteen percent of the business girls and thirty-eight percent of the college girls said they lacked nothing. In other words, business has brought to girls more problems and the feeling of greater lacks than college brings. Education, certain personal qualities, and marriage or men friends, are the three chief things lacked by business girls. Personality traits, money and clothes rank first with college girls and enormously higher than with business girls, while marriage and men friends lag somewhat behind. It is probably true that for both groups the desire for charming social and personal qualities and for money and clothes, if translated, means men friends and marriage.

As to important problems solved since the girls entered business or college, twenty-four percent of the business girls and ten percent of the college girls had none to solve. Here again it is evident that the business girl meets more difficulties than the college girl. Problems concerning money, saving, economy rank highest with the business girl, with problems concerning her job coming second. For the college girl, problems concerning school rank first, what to do after graduation second, with money matters and personal problems of conduct tying for third.

Twenty-seven percent of the business girls and twenty-one percent of the college girls feel handicapped by health or some physical defect.

3. What equipment has the business girl to help her attain her interests and meet her problems?

One approach to this problem has been made through the use of the Otis mental test, higher form A. The following information is based on the results from the first 107 tests given to unmarried business girls under thirty years of age. On the thirty minute basis, the scores range all the way from 9 to 75. Nine is exceedingly low and raises the suspicion whether the girl cooperated. Seventy-five is the highest possible score obtainable on the test. The median score was 50, which is a high normal score and above the score of 42, which Otis regards as the average adult score. There were only 7.5% of the girls who fell below the normal ranking, 49.5% who ranked as normal, and 43% who ranked higher than normal. Otis expects in a normal distribution to have 20% below normal, 60% normal, and 20% better than normal.

These business girl scores may be compared with scores for college students. One hundred fifty-one freshmen in the woman's college referred to earlier in this paper were tested. The range was from 27 to 73 with a median score of 54. Upper classmen in the same college rank somewhat higher.

Otis reports scores for college students. For 524 students in nine universities and colleges, the lowest score was 20, the highest 75, the median 60. The medians of the individual colleges ranged all the way from 37 to 68. Intellectually, then, the business girl is well equipped to meet her problems.

It is hoped a little later to be able to give about one hundred girls various personality tests to discover other traits than intelligence which may figure in their success. There are at hand now several other types of information.

Educationally, the 107 business girls have had all the way from 7th grade education through 4 years of college. The median and the mode are both four years of high school. Nevertheless, as many as 41% have had less than 4 years of high school work.

Vocationally, how well prepared are these girls to meet their problems? Sixty-four girls or almost 60% are stenographers, secretaries or bookkeepers with one teacher and one telegraph operator included. The others hold such unspecialized positions as clerical or general office worker, typist, comptometer operator, cashier, salesgirl, etc. The educational range of the girls in the unspecialized group is as wide as that of the specialized group. Both groups have girls with eighth grade education and both have college graduates. It is significant that of the fifteen girls with some college training, seven are doing clerical work. Apparently it is not length of time spent in school which counts, but the type of training secured.

The salary scale of the unspecialized group runs about four dollars less per week for the beginners and the difference becomes vastly greater among experienced workers of each group. Thus the highest paid secretary received $37 per week and the highest paid bookkeeper $46 but the highest paid clerical worker received only $27 per week.

In intelligence level, the clerical group ranks as high as the specialized workers.

It can only be concluded from this array of data that what counts in adjustment vocationally is type of training, rather than length of time spent in education or degree of intelligence (assuming of course a certain minimal level of intelligence).

Many of the other maladjustments are closely linked with the type of work the girl does. If she is in a large office or lives in a girl's rooming house or club or has sisters in business there is the question of status. Is she an unspecialized, low-paid clerical worker while the girl across the hall or her sister is a highly paid secretary? Does her low salary make it impossible for her to have the kind of room she wishes, to wear clothes as fine as those of her friends, to take vacation trips? Does her low salary make it impossible for her to assist her family and meet their needs without impoverishing herself? Can she spare the money for further training? Certainly in the low paid jobs she cannot hope to save enough to enable her to attend school full time and the problem revolves around night work, the energy involved, the giving up of good times and of friendships, which for the business girl are pursued chiefly in the evening.

The business girl has, of course, other qualities which aid her in solving her problems. There are qualities which are not statistically statable without tests, but which have become evident during interviews. She is fairly flexible; she does not break easily under a strain. She comes for the most part from homes without high economic standing and even in her mediocre job she often has more than she had before she began to work. Her desire for education tends to die out in time and she admits that she would not make the sacrifices necessary to obtain one. This is an adjustment and removes her craving. Unfortunately it is a rather unprogressive adjustment.

4. From the point of view of education, what should busisess girls have had to fit them better for life—and what might they still have?

(a) They should have a complete four-year course in high school. Many girls stop before they graduate, either because their parents demand it or because their own ambitions are vague. Later, many of these girls find that they need the full high school course, either because of the background it gives or to fit them to go on into some specialized or professional field.

(b) The girl who must work after she leaves school ought to have some special vocational training. This usually means shorthand, typing, or bookkeeping. Girls without such training can fill only the most general and the lower paid positions, such as filing, general clerical work, or switchboard work. For many girls, this vocational training must come during high school, or it is never attained.

(c) Whether schools can do much for the physical, mental, and emotional difficulties is a question. Certain schools, especially city schools, give attention to physical well-being. Mental testing permits some classifications of pupils, and vocational guidance helps. Here and there a school has placed in its program mental hygiene work.

(d) There is need to have some way to carry over from school days, the interests and friends the girl has there acquired. Girls quickly lose their cultural interests and their old friends unless some opportunity is provided for expression. Is it too much to expect the school to provide for a time at least, some activities for its recent graduates to carry them through this difficult transition period until they have found new contacts with their business associates?

(e) After a year or so of work the girl needs guidance as acutely as she needed it while in training. Positions which were names to her in high school have become real for her. She knows what business requires and she knows where she is lacking. The glamour of her first entrance into business has worn off. Unless she has a young man in the immediate offing, she frequently wishes to get into some other type of work. Often she knows what type she wants. But she does not know, and without outside help probably never will know, whether she is fitted for the work, what the educational requirements are, etc.

(f) There are of course agencies which provide for some of these things, and in city schools night classes fulfil certain of the needs. The agencies, such as night schools of universities, Y. W. C. A.'s, girls' clubs of various sorts, are too frequently confined to the larger cities, and because of financial or other reasons they often reach only a fraction of the girls in need of assistance.

There are certain interests and problems for which the school can probably not give assistance, such as the desire to travel, the need for more adequate ways of meeting men, the further improvement in personal qualities. But many such interests are blocked in their fulfillment because of inadequate or improper schooling in earlier years.

THE PLACE OF SUPERVISION IN THE PUBLIC SCHOOLS.

J. H. Winstrom, Superintendent of Schools, Springfield.

The other day I took my car to a garage to have some repairs made. I found upon inquiry that one department was responsible for all work necessary on the repairs of the engine and another department responsible for the corrections of all electrical equipment such as battery charging, wiring, and lighting. What was true of this particular automobile plant is true of many other well managed concerns in all parts where the automobile industry is carried on in a profitable way.

A friend of mine is employed as a Farm Loan inspector for one of our large insurance companies. He was not chosen by chance—he had training and experience which fitted him to correctly evaluate real estate. Bankers and others interested in land values for one reason or other accept his judgment—few questions are asked because he knows his job. This is not an arrangement which is at all unique. Similar ones are found the world over in a well managed business.

These two illustrations let us think of, as expert direction or supervision of business. Those of us who have commercial dealings, I feel, will agree that it is necessary to have such direction. What place, then, should this sort of an arrangement have in a school program?

Most of the larger school systems and many of the smaller ones have on their instructional staffs people designated as supervisors. This is a comparitively recent arrangement. The reason for it no doubt being so many subjects must now be included in a school program that the average teacher is not trained to handle all of them. Where in the year 1775 *Reading, Spelling, Writing, Arithmetic*, and *Bible* constituted the curriculum; now, even the Elementary School program has in it twenty or more topics that demand attention. In this paper I cannot take up the case of justifying the need of special supervisors. What I hope to accomplish is to emphasize the need for expert direction by *someone* without necessarily increasing the cost of instruction.

Some time ago an inquiry was made into the attitude on the direction of new and inexperienced teachers. The inquiry embraced representative schools of 36 different states, those having over 200 teachers, 50 to 200 teachers and less than 50 teachers. Replies indicated that an attempt was made to give expert direction in 90% of the larger schools, 71% the medium sized schools, and 40% of the smaller schools. 70 schools reported no provision in expert direction but of that number 68 expressed the need for it.

The study further indicated the reaction as to where Superintendents felt supervision was most necessary. In the elementary grades (1 to 8) inclusive, 50% of the replies specified that help was most needed in grades 1, 2, 7 and 8, and in the freshmen and senior year of the High School. With reference to subject matter, the replies showed that supervision was needed most in Geography, History, Language and English in both grades and high school. There was almost unanimous opinion in that arithmetic in the grades and mathematics in High School can be taught most easily without expert direction. This may mean that in teaching an exact science where results can be quite readily measured and checked, less direction is necessary. The suggestion seems to be carried out in the arrangement of the newer texts in arithmetic.

In the school system which I represent an attempt has been made this year to rather carefully check the results of pupil progress. In our lower grades, kindergarten, grades 1, 2 and 3, the work is under the direction of a special supervisor. If our measuring of results is an indication, and I have reason to think it is, then expert direction is needed in all grades. We feel that we have as good teachers in our upper grades as we have in our lower grades but there seemed to be a much larger variation in what was accomplished in the different subjects in grades 7 and 8 than in grades 1, 2 and 3.

Where then is supervision necessary? There is but one reply and that is *everywhere*. This does not mean more school costs, in fact it may lessen the cost of education. It does mean more care in choosing our teachers. It means that we demand teachers trained for a specific job, not merely that they have 30, 60 or 100 college hours on their transcript. Most necessary of all it means that we must choose more wisely our principals and supervisors, especially the principals.

If expert direction in education is a necessity, and I believe the average tax-payer and patron will agree that it is, then we must look in the main for that direction to come from the head of each individual school. This does not mean that co-ordination of the various schools in a system shall be ignored. It simply stresses the need of initiative and skill on the part of those immediately responsible for the instruction of pupils in the various school districts.

There are two ways open to correct whatever defects are found in our system of supervision. The first way is to more carefully choose the persons who are to occupy the principals' position. We must, if choosing an elemetnary school principal, insist on his knowledge of elementary school instruction. There are too many applicants for executive positions who, on the strength of having completed four years of college work, feel they are full-fledged administrators. They may be able to tactfully handle patrons, maintain a type of discipline, look after the clerical duties required by way of reports and records yet be totally ignorant of the real need of the school, namely that of supervision of instruction. Teachers, pupils and patrons will welcome selection of the principals who are experts in directing class-room activities. Naturally, with this it is assumed that personal qualities and character have their proper place.

The second way to secure better direction is to demand that the people who are in charge of our schools shall improve along the lines where improvement counts most. This means especially training that can be put into practise at once. Too many teachers, and administrators too, are simply seeking more credits—more college hours. A course in French next summer may have its value for a principal but if he needs direction in how to supervise and evaluate intermediate grade reading then he better choose the latter since that is his immediate problem and will serve his community best at the present time. There seems to be need of constantly holding before us the fact that what we do and what we plan in education is not for ourselves, but that it is for the improvement of the education of the children in the schools we serve.

Conditions will right themselves just as rapidly as the real need is felt. There is much excellent work being done by principals, supervisors and teachers. This plea is made in the hope that more serious attention be paid to the administrative units of our schools because that is where we must in the final analysis place responsibility.

PAPERS IN HIGH SCHOOL SCIENCE

THE ESSENTIALS OF A SUCCESSFUL CHEMISTRY CLUB.

GORDON R. CEDARLEAF, ROCKFORD HIGH SCHOOL.

A Chemistry Club is not an organization with a self-starter. There are, however, opportunities for development of interest there not found in any other club. It is a body with ability which must be released, if I may say, through a catalytic agent. Success does not depend alone upon the officers and the advisor. It is an undying interest in science that fuses the body together, and which ultimately succeeds. This may seem that a successful club cannot be built up in one semester. The Rockford High School Chemistry Club was a seemingly exhausted club, but towards the end of last semester it flared up, and is now a beacon of scientific development in Rockford High School and in the city. The officers must be competent and the advisor jolly, inventive and possessed of executive ability.

You may ask how the so-called and sought for successful club may be founded. There is no gram-per-liter formula, but it is one that is applicable. I shall bring forth some of the basic ingredients, they are: Social, Competitive, and Scientific.

Under social I shall list banquets, picnics and suppers, and club meetings. Each semester is begun with a club meeting, at which time the banquet is planned for. The banquet is usually held in the R. H. S. Cafeteria. The alumni members as well as the members to be initiated are present. As a matter of enjoyment, and practice, but mainly of economy, the new members are the waiters. The banquet is a jolly, informal, get-together in terms of chemistry. After the banquet, the group adjourns to the gymnasium where games are played and the new members are formally made a soluble part of the organization. I shall list initiation schemes later.

Picnics and laboratory suppers supply a social item not obtained at the banquet or club meeting. To gather around a smoking fire, if a chemist should build such, with a sooted wiener and a burnt finger; or trying to cook an egg in a 150 c. c. beaker gives a household friendship. Picnics and suppers take a lot of time and preparation, but they are essential. I would suggest that the laboratory be thoroughly cleaned before supper, if at no other time, to prevent contamination. It was not long ago that a supper such as this was given at the High School laboratory. The supper was preceded by the regular meeting and at six o'clock supper was prepared. The eggs were boiled in the beakers; cocoa was drunk through glass tubes; the buns were heated in an incubator oven; and, I might add, that candy was made for dessert. After supper we all felt that we had a better manipulation knowledge of the apparatus.

The club meetings are of more interest to those of a scientific mind. After the business has been transacted, spectacular and instructive experiments are given. During the club meetings, and, when the treasury is low, candy is sold to the entire school at retail.

The Rockford High School Chemistry Club also has an orchestra named McEvoy's Music Murders, of course, dedicated to our advisor, Miss McEvoy. This orchestra, directed by Arne Korsmo with the chalk-talker, Herbert Rosengrin, the reader, Mildred Zahn; and the experimenters, Anton Kissel, Bruce Kinnie, and myself, performs during assemblies at the two Junior High Schools, and the Rockford High School. These assemblies have been voted among the best of the semester.

Competition always stimulates interest. To feed this nature, each class has an elimination contest for the best presentation of scientific matter. This gives the pupil a better presentation knowledge of this material.

One of the outstanding contests of the club is the annual Industrial Prize Contest. At the end of each semester, each pupil must take a special phase of commercial chemistry. He must thoroughly master his subject and also make an attractive explanatory exhibit of it. This process takes from five to six weeks. The best projects are then taken from each class and sent to five judges who are picked from the scientific circles of the city and school. The projects are then judged from the standpoint of knowledge of subject, presentation, originality of the finished product, and the method of presentation. The first winner is awarded a prize of $5.00, and the second, a prize of $2.00. The contest is one that has gained interest in the whole city. As a matter of illustration, one day I went to one of the chemical manufacturing plants in the city. The Industrial Contest immediately served as an introduction. I was the first prize winner of the first Industrial Contest which was inaugurated last semester. This project took the maker six weeks to develop and as a result he can speak photography with any amateur finisher in the city. Personally, I am glad that my name is in the lower left-hand corner of each sheet and also on the thesis. The second prize was carried off by the club president, Adolph Stohl. Stohl's research work was on "wood alcohol."

The third phase of club interest is brought in through experiments. The following is a list of good club meeting presentations:

1. Reduction of Copper Oxide with Hydrogen.
2. Marsh's Arsenic Test.
3. The singing Hydrogen flame.
4. Condensation of SO_2 gas.
5. Crystallization.
6. Electrolysis of NaCl Solution.
7. Electrolysis of KI Solution.
8. Colloidal Metal.

Experiments suitable for program presentation:

1. Chemical Fountain.
2. Chemical Smoke.
3. Green Flame.
4. Colored fire.
5. Explosion of Carbon disulfide and oxygen.
6. Explosion of $KClO_3$, Sugar and H_2SO_4.

Probably the Chemistry Club has the best material for initiations. Use was made at the last initiation of strawberry dew, cedarwood oil, wintergreen oil, iodine, $(NH_4)_2S$. We also hung test tubes around their necks and had them wear their chemical aprons during the day. After all a successful club is not an illusion, but it is as shown by the Rockford High School Chemistry Club, a reality.

DIRECTIONS FOR CLUB EXPERIMENTS, ARRANGED BY GORDON R. CEDARLEAF AND BBUCE B. KINNIE.

The following experiments are suitable for club presentation:

1. Reduction of Copper oxide with Hydrogen.
   Found in Chemical Laboratory Manual.
2. Marsh's Arsenic Test.
   May be found in any Chemical Test Book.
3. Singing Hydrogen flame.
   After the air column in a tube has been heated by a H_2 jet, a low humming sound will be heard.

4. Condensation of SO_2.

The gas is run from a SO_2 generator through two flasks of H_2SO_4 from which it is passed to a flask surrounded by ice and ether. This gas is very obnoxious.

6 & 7. Electrolysis of NaCl and KI Solution.

Litmus solution is used as an indicator for the NaCl electrolysis. Starch is used in the KI Electrolysis.

8. Colloidal Metal is made by striking an arc under water.

Copper Electrodes are connected to the D. C. line and brought under water.

Experiments suitable for program presentation:

1. Chemical Fountain.

The pinch cock is closed and Ether is poured on the top of the upper flask. This contracts the air in the flask and as the pinch cock is opened the atmospheric pressure forces the red litmus solution into the flask B, where it is turned blue by the NH_4OH.

2. Chemical Smoke.

Two large beakers (one containing a small amount of NH_4OH and the other a small amount of HCl) are brought together. The NH_4Cl is given off in a white cloud.

3. Green Flame.

4. Colored Fire.

The following are formulas for the fires.

A. Blue Fire:

$KClO_3$ 8 parts.
Copper sulfide 2 parts.
Copper oxide 1 part.
Sulphur 4 parts.

B. Red Fire:

Strontium nitrate 4 parts.
Potassium chlorate 12 parts.
Powdered sulphur 3 parts.
Powdered shellac 1 part.
Powdered charcoal ½ part.

C. Green Fire:

Barium nitrate 12 parts.
Potassium chlorate 6 parts.
Sulphur 3 parts.
Powdered shellac 1 part.
Powdered charcoal ½ part.

D. Yellow Fire:

Sulphur 1 part.
Sodium carbonate 1½ part.
Potassium chlorate 4 parts.

These fires are compounded and may be used in powder form or packed in paper tubes.

5. Explosion of Carbon Disulfide and Oxygen.

Oxygen is generated and collected in a 1" pipe one foot long which is closed at one end by a cap. After the pipe is full it is stopped and 2 to 5 c.c. of carbon disulfide are poured in and the tube shaken. A magnesium ribbon is then put on the end of a 2 foot rod and ignited. This is used to ignite the O_2 and carbon disulfide.

(Note). This experiment is a very dangerous one if not performed correctly. Never use a glass tube.

6 $KClO_3$ and Sugar.

1. $KClO_3$ is ground to a powder. It is then mixed with an equal amount of powdered sugar. 10 grams of $KClO_3$ are used. The $KClO_3$ and the sugar must not be ground together as an explosion will result.

   About ten grams of the mixture is then placed in a large evaporation dish and the reaction started by 1 c.c. of concentrated H_2SO_4.

POSSIBILITIES IN HIGH SCHOOL PHYSIOLOGY.

Mary R. Earnest, Decatur High School, Decatur, Illinois.

Why is Physiology taught in high schools? The above is a question every teacher of the subject and, I presume, every principal ask themselves innumerable times. In fact so many times has the question arisen that we have many so-called answers. Among them are the following:

1. To comply with the state law requirement for a given amount of hygiene.

2. As a portion of a very general course in biology, given in the first or second year of high school or in the junior high school. We say here that our aim is to broaden the student's understanding of his surroundings and himself. Sad but true it is little of himself he understands under such conditions.

3. As an elective in an extensive science curriculum, to give unit credit for college entrance. This might be justified because the colleges will welcome high school graduates, if the high schools will train them in straight thinking, without dictating in what subjects they shall have entrance credits.

4. As an instruction course in the training of students in real worth while living. I do not mean by not giving more reasons that these are all. There are many more, yet I feel all others would dovetail into one or more of those given.

Which of the above has the greatest, most stimulative possibilities in the development of straight thinking, giving him the mental power and physical correlation to become a person of the highest citizenship, should be chosen as the foundation of teaching physiology in high school.

We in Decatur have chosen the latter and set our aims for such accomplishment before the student the first day he is in the course in the following statement in his manual—"To know one's body with a general understanding of why it functions and how it functions enables one to appreciate, care for, and develop the possibilities which nature has privileged him to possess. Thus one may pursue the study of physiology with an ultimate aim of health for efficiency and true happiness."

With such an aim our next step is to plan our course so as to have a logical development of facts to bring out our aims individually, yet so interlocked at all times as to show that complete, effective, efficient operation of all essentials is necessary at all times for the best possible results.

Believing that the following organization does this we proceed with an introductory study of the general plan of the organization of the human body by first studying the living cells removed from our mouths. Following an examination of these cells, we study the uses of them until we find them, by adaptation, forming tissues of standard types. Now we must see our mounted types of tissues and learn how our types structurally vary. Soon we learn that tissues in turn are grouped by usage into larger units, etc., until we have the general plan well in mind.

Since the first attention living cells receive is a supply of nutrition, the next logical step is a study of foods. Here we need to study our classes of foods, our dependence on plants for them, (at this point we emphasize the importance of a knowledge of botany), how our body cells use foods, and why each food is used differently by the body cells.

Our next problem is the digestion of foods in order that our body cells may secure this valuable nutrition. We observe now by means of charts, models and specimens, (a local packer prides himself in procuring for our use the finest of specimens) how nature has builded our bodies around a structurally specialized and modified tube for this purpose. Studying each organ of this great alimentary tube we work out first the physical, then the chemical digestion as carried on by it. Sometimes we have to do a great deal of thinking and reasoning to work out just why a test for the digestion of proteins in the small intestine does not give the desired result when the food in our test has not been acted upon by the preceding organs. Here we can show as vividly as ever needed how the work of one organ is essential to that of another. We never think of food as being in our bodies while in this digestive passageway because it is merely a preparatory process for cellular usage.

Upon consideration of diseases of the digestive system we find why many of them have been due to poor selection of foods, bad eating habits, or possibly a slovenly type of posture. What student will not welcome the securing of these facts as early in life as he can get them? The high school student's mind grasps these facts readily and he can put them into use more easily now, than he could in middle life when probably suffering from digestive troubles he might have avoided.

In a study of the physical law of osmosis, by use of sheep's intestine we actually "see" food pass through intestinal wall tissue. Even with the food going into the blood vessels we are confronted with the problem of supplying all cells of the body. Having a knowledge from previous years of science study, that blood is our means of transportation to cells, we turn to the study of our own blood with the aid of the microscope. For the first time, for many, blood ceases to be red nauseating body fluid, dripping or trickling from cuts and becomes a fluid to be kept at a body temperature of 98.6 degrees while driven through the body to serve each cell with materials to give life, stimulate growth, and to protect them from diseases by warding off poisons.

Perfection of circulation is an essential. The mechanism of a beef or hog heart (since the structure is almost identical to that of the human heart) is even more interesting than the accuracy of the mechanism of a technically fine radio or minutely delicate motor. Models and charts serve as a check on the examined heart of the beef or hog. The problem of circulation is demonstrated by glass and rubber tubing connections made to a large beef heart. At a funnel connection carminized water is introduced and made to circulate, by hand pressure on the heart, through the tubes and the circulation pump. Does not this show how blood circulates? Very few students will fail to understand how the heart functions after such observations. One student even remarked after the observation—"The heart forces blood just like a pump forces water in an unbroken stream."

Again we are confronted with the fact that failure of the proper functioning of the system is the cause of many diseases. Numerous common colds are found to be preventible with proper circulation.

How are we going to reach the cells with our valuable nutrition? It is time to investigate the structural, positional, and functional differences in the blood vessels and in the composition of the blood as it passes through them. Here we find our field of extended circulation essential. A check-up on the relationship of food absorption and lymphatics ties together with our circulation process and makes our food carry to the individual cells. Here we have the materials to "fire" our food and "act" with the power consumed when we have eaten our various appetizing meals.

One thing that is still bothering us is how we secure the oxygen. Lungs are due for a thorough inspection as to structure and value to our general welfare. Diseases impairing the expansions of lungs for gaseous exchanges are easily understood to be a serious handicap to one's health. And a desire to have healthy lungs becomes an individual interest.

Excretion becomes an essential since waste products result from oxidation of foods. Kidneys from the hog with reports from references assigned to students of more advanced ability show how these wastes are carried from the body. Skin is treated in a similar way, when the diseases resulting from improper waste product removal are explained.

What will all of our effort be worth if we cannot, upon liberation of such power, as made possible by our food and oxygen, control it so as to use it advantageously? Nature must have made provisions for activity, but how? Our problem of movement brings in our study of muscles, structure, kinds, placement on the body, arrangement with reference to one another. Charts and reference reading with reports by athletes (usually several are present in each class) comprise materials for our discussion for most effective activity. Our physical training directors here give demonstrations in the gymnasium with his classes, for our check-up on muscle action.

Why can we hold these muscles in place to have such activity as a result of their controlled power? A framework is certainly essential and if a wide range of action is to be had the framework must be internal. The types of bones are studied in the human skelton both as to form and method of attachment. The use of the human skelton makes this study especially interesting for many. The relationship of mending broken and diseased bones goes back to our types of foods and diets for the bone construction.

Some have now arrived at the place in their work where they are interested in seeing what makes different systems work in unity. Nerves, as hard as they are to see, are observed in mesentary of intestine, spinal cord, and muscle tissue. The general plan of nerve co-ordination is discussed. Who would not consider it a privilege to know how this body is controlled? In the relationship of nerve structure to straight thinking and disjointed thinking here brought out, a student sees the fallacy of taking an hour to do ten minutes work. If this is not an opportunity to teach the physical possibility of mental concentration where will a high school course offer an explanation of the structural possibility?

With suitable specimens from the hog, the subject of embryonic development is discussed, and questions, previously placed in a box by students, are answered. However, since the physiology classes are segregated the majority of the questions are asked during the round table discussion. Many students, both boys and girls, have told me repeatedly that this was their first opportunity to get real scientific truth on the subject. Mothers of students in the classes are especially invited for this work.

A student having thus completed this course of general structural, and functional study of the individual is confronted with this statement at the close of his manual—"In completing your brief opening into the field of physiology you should realize that your body is a permanent temple for your soul while on earth, and that the least you can do is to make it a temple desirable as an environment for your soul."

In conclusion I wish to ask you if we do not follow a logical development of the subject of physiology in such a way as to make possible a vitalized field of opportunities for real health for efficiency, truth and real happiness?

Expressions selected at random from students taken at least a year after having completed the course say the most valuable gains are:

1. I learned a system of effective study.

2. An understanding of the body which caused a respect for it as a gift from my creator.

3. Through a knowledge of bettering my diet I have much better health.

I leave you to answer for yourselves, is physiology in high school a possibility worth while?

THE CHEMISTRY CLUB AS A FACTOR IN VITALIZING CHEMISTRY.

H. W. GARNETT, BLOOMINGTON HIGH SCHOOL,
BLOOMINGTON, ILLINOIS.

I believe I am safe in saying that during the past year I have received no less than twenty questionnaires, reports of investigations and miscellaneous tracts, dealing with the formation, registration, and summary of activities of science clubs, more particularly Chemistry Clubs. Ideals were aired and suggestions solicited after more or less the same fashion. However, the striking thing about it all was that there is a greater tendency than ever toward the formation of chemistry clubs, and for what purpose? To make chemistry *live*. In the prefaces of the last six editions of recent texts I have received, have been such phrases as "to vitalize the teachings," "make chemistry live in the minds of the students," "apply to daily life" and many others similar. Perhaps this vitalizing process can be effectively carried out by means of classroom discussion and laboratory work alone, but it is seldom done. The average teacher finds so much of importance to include in his course that extensive projects, field trips, etc., have to be sandwiched in rather than being made a part of an organized program. The Chemistry Club permits of the latter. You will pardon me if I refer to the work of the science clubs here in Bloomington High School.

The club was formed in the spring of 1926 and began active work in the following September. At the first meeting a goal was set and definite plans made to attain it, and may I say in passing that unless an organization recognizes some service to perform and performs that service, it were better not to have organized at all. For our first year the aim was "to bring chemistry in its fullest and broadest meaning before the community." During the year exhibits were prepared or secured by various groups of students and displayed in show windows down town. I believe you will find as I have, that merchants are ever ready to aid by giving window space for any worthwhile exhibit, and manufacturers are more than pleased to send materials for these exhibits. For instance when the group wished to build an exhibit around the slogan, "The chemist has embalmed the voices of Galli-Curci and Caruso in carbolic acid," the Victor people graciously prepared and sent the exhibit displayed here, to be the property of the school so long as it should be on display or otherwise made use of. The Standard Oil Company has an extremely interesting and educational portrayal of "The Story of Petroleum" in a 5′ by 8′ glass case, which may be had for a period of from three to four weeks if necessary, for merely paying the expressage back to Chicago.

During Fire Prevention week, club members talked on fire prevention to various organizations, such as Rotary, Kiwanis, etc., demonstrating with $NaHCO_3$ solution and acids the operation of the modern fire extinguisher.

Give a boy or a girl something to do and he'll become interested, and these students provide no exceptions to that truth. They came with suggestions and ideas galore. The ones which were practical or feasible were used, the rest discarded.

Preparing a display interesting as it may be, was not the primary object however. To the student it was the glory of telling dad, mother, or a friend something he himself had worked out, and which they did not know. To the instructor it was the thrill of having boys and girls realize that, unlike some of the subjects they had studied, this chemistry was a real thing in which one could and did get tremendously interested.

Toward the middle of the second semester one of the boys who had been working on an outside reading report, "What the Chemist sees in Illinois Resources," suggested a field trip of a kind never before attempted in this locality—a trip to some city to view the industries there. As a result of the exhibit work of the club several of the fathers and other men of the community had become interested, and one of these arranged for permission to visit the Illinois Steel Company plant at Joliet. A group of fifteen, or three car loads, of members went on this trip which was the forerunner of many delightful and interesting excursions. Among the plants visited since March, 1927, have been

Illinois Steel (Bessemer) Company at Joliet,
American Wire Fence at Joliet,
Alpha Portland Cement plant at LaSalle,
National Plate Glass at Ottawa,
Mueller Brass Foundry at Decatur,
Staley Corn Products at Decatur,
Sewage Disposal Plant at Urbana,

American Bottling Works and Western Glass Co. at Streator,
Commercial Solvents Company at Peoria,
Keystone Wire (Open Hearth Steel) at Bartonville,
M. & H. Zinc Works at LaSalle, and others.

At none of these plants did the students receive anything but the most courteous treatment, and they were taken through every step of the process by head chemists or by some one interested in chemical processes. At the Alpha Cement works several of the boys made tensile strength tests, made up test batches, did titrations, etc., while at another plant they were allowed to make simple tests on borings brought in of materials made. Do you think their text book work meant anything more to them after visiting one of these plants? May I insert here while discussing these field trips, that one of the trips each year is through the Chemistry Department at the Univeristy of Illinois, where the students hear men of importance and chemists of note talk to them on the fields of chemistry which are opening and which are only slightly developed, and of the opportunities therein.

The boys make it a practice to go equipped with test tubes and boxes and collect samples as they pass through the various steps of a process, and then when back home again they mount them and arrange in exhibits such as you see here of plate glass.

For some little time I fondly cherished the belief that I was the only person making use of the poster idea, but the old saying, "there is nothing new under the sun" has again been borne out. Miss Fannie Bell of Ridgewood, New Jersey, has been doing such excellent work with posters and has such a delightful article in the Journal of Education, March, 1928, that I can only recommend it to you if you have not already read it.

For some of our posters we are indebted to Bradbury's First Book in Chemistry, Holmes and Mattern's recent text, Elements of Chemistry, Alexander Smith's new text "Smith's Elementtary Chemistry," and to Science Classroom, for ideas, while most of the posters are original with the students themselves.

About the only vitalizing done as a part of classroom work are these notebooks, but since they and some outside reading reports are part of the class work, it doesn't have much of a thrill in it for some. On the other hand the laboratory is a busy place most evenings with groups working on a project, a committee planning the next excursion, a student getting material for his report to the club next Monday, or someone reading about something of interest chemically for the pure desire of knowing.

Briefly then I shall summarize the factors which I have found most nearly bring about the results desired, viz; interest in chemistry, not for high marks, personal glory, or curious play in the laboratory, but because a need has been aroused in their everyday life, and they are striving to fulfill that need. I do not say that these are the only means of developing true interest nor that they are the only way, but I do feel that excursions, both local and to outside cities, displays developed or secured by students, and posters either original or copies, all tend to develop this true interest, and in my experience it has proven better by far to place this in the hands of the Modern Alchemists as a part of their organized programs, rather than to attempt it through the medium of classroom work.

THE REACTION OF THE CLASS OF 1928 OF DECATUR HIGH SCHOOL TO THE STUDY OF GENERAL SCIENCE IN JUNIOR HIGH SCHOOL.

Betty Mannering, Decatur High School, Decatur, Illinois.

It is a modern educational practice to analyze each subject in the curriculum to determine its actual value. Has it a value of its own? Does it increase the value of another subject? Could the time be spent to better advantage otherwise? Such an inquiry has been directed toward the subject of General Science. Perhaps it might be well to determine the reaction of the students, themselves, to the subject. We have attempted, with the aid of a questionnaire and personal contacts with our classmates, to arrive at some conclusions as to their valuation of the subject.

This questionnaire was submitted to 205 members of the class of 1928 at Decatur High School. Their High School work being practically completed, they are now better able to judge their Public School Sciences as a whole. Briefly, the questionnaire covered the following points. Have you studied General Science? Was it worth your time? Do you recommend it? What High School Sciences have you taken? What others would you be interested in?

Of the 205 replies, the courses of 47 have not included General Science. This was to be expected in a group of students coming from different schools, since the curricula vary considerably. In passing it might be well to give some attention to this group. These are scarcely qualified to continue the questionnaire; nevertheless 19 voted YES on this question: "On the whole, do you think General Science worthy of a place on the Junior High curriculum?" In comparison, one voted NO while the other 27 were non-committal. The 19 who have completed their High School training without General Science, to all appearances wish they might have included it. The entire group of 47 averaged slightly more than 3 (3.15) semesters of High School Sciences. The group which did study General Science averaged over a semester more than this. This, in addition to the two semesters of General Science acquired in Junior High School. From this it appears evident that more High School Science is assured by the previous study of the general subject.

The larger group of 158 to which we have just referred should be better qualified to pass judgment on the merits and demerits of the subject at hand. They deserve our main investigation.

Of these, just 15 voted "Thumbs down." Although they expressed absolute disapproval of the subject, 6 of these, in contradiction admitted interest in special phases of science as a result of their investment in General Science. Considering that the 15 averaged less than 3 semesters of High School Science, an even lower average than the group who never had the subject, General Science must have served as vocational guidance to them. If their early dislike for science influenced them so that they selected High School subjects more to their interest—so much the better.

Five other seniors did not consider their own time well spent on General Science, but would give it a place on the curriculum. These few also averaged less than 3 semesters of High School science as did the group 15 who voted "Thumbs down."

The last two groups mentioned (15 and 5) are those who have actually studied General Science and disapprove of it. These figure 13% of those who studied it and only 9% of the entire 205.

The final and much the largest group, 138, favored the subject individually and also recommended it for the course of study. These constitute 67% of the entire 205 and 87% of those whose judgment is based on actual classroom experience. "Actions speak louder than words," and this group was no exception. They elected to take from 2 to 9 semesters of High School Science, averaging 4.5 semesters.

In speaking of this group we should like to quote the remarks on several papers, to give a more human touch to this research. One of the girls says, "I have learned about all types of life and am interested in studying it further. It shows how other things are in comparison to our human bodies. I am going to teach science of some kind when I finish two years of college, if I can go."

Another writes, "It was the small way in which General Science touched on Chemistry that made me interested in it."

Still another offers this. "I have been interested in Chemistry since I was ten years old and still find my interests bearing that way. My study of science has merely tended to stimulate this desire and as a result I have chosen it as my major in college and hope to take it up as a life work."

One of the boys who is opposed to General Science writes as follows: "I am interested in the origin of the earth and of the plants and animals. In fact, I am consumed by a desire to know as much as possible about the origin of everything. Chemistry best satisfies this. I would like Astronomy very much." This student evidently knows his special preference and does not care to spend his time in generalization. While there is no doubt of the value of specialization, it is all-important that the foundation be well established and the choice well made. Here is where General Science can be of value.

Many students expressed desires for various additional sciences. Of those now offered, Physics and Chemistry lead. Of those not now in the course, Astronomy lead by a wide margin with 61 requests for it. Other suggestions ranged from Geology to Psychology. On the whole, there seems to be a fair amount of interest in the scientific field in Decatur High School, even though we have no science clubs to stimulate it.

The purpose of General Science is to establish the fundamentals and measure the degree of interest. The pupil's interest will be either strengthened or transferred to other courses. It must not be forgotten that there are those who will never secure a High School education, and who will thus miss the special sciences. They will not be losers by their fleeting glimpse of this branch of knowledge. Life will be fuller because they have the tools which they may better learn the use of.

Every child of school age has had experience with the facts of science, whether he has studied them or not. As he reaches Junior High School age, he is constantly beset by the "whys" of life. This is the time when General Science can help him to answer his questions. The answers to these questions make him observe more closely and this in turn brings up more questions. And more answers. And the knowledge that the questions can be answered.

This research indicates to the author, at least, that General Science is accomplishing in Decatur, the purposes for which it is intended. The student group which took the heaviest course of science was that group which liked General Science. The group which took the lightest course was that group which did not like General Science. This indicates a stimulus on the part of one and vocational guidance on the part of the other. The importance of science as compared with other courses is not here considered. But since we live in a highly technical age, when science is coming into its own more and more, it does not seem to be asking too much to give General Science its due place in the system of education. And its place in the Decatur system meets the approval of a large majority of the Class of 1928.

TABULATION OF QUESTIONAIRE.

Class	Number	Average Semesters H. S. Science
Did not take General Science...	47	3.15
Express favor	19	3.2
Do not favor	1	3.0
Non-committal	27	3.1
Did take General Science.......	158	4.3
Express favor	138	4.5
Do not favor	15	2.8
Do not favor personally, but favor for others....	5	2.8

UNDERLINE CORRECT WORD OR NUMBER.

1. Have you ever studied general science? Yes. No.
2. In what year of school? 7 8 9 10 11 12.
3. Do you consider that it was time well spent for you? Yes. No.
4. On the whole, do you think it worthy of a place on the Junior High curriculum? Yes. No.
5. What part or parts of general science interest you most?

   Astronomy — Chemistry
   Botany — Physical geography
   Zoology — Physiology
   Physics — Any other part

6. Did the study of general science govern your choice of laboratory sciences? Yes. No.
7. What science or sciences have you taken? (Check those studied.)

   Astronomy — Chemistry
   Botany — Physical geography
   Zoology — Physiology
   Physics — Any other

   (Underline those you like best.)

8. What other science or sciences, if any, would you have enjoyed taking?
9. Mention one thing, if any, that you have become interested in through general science?

CONSTITUTION AND BY-LAWS

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Illinois State Academy of Science.

CONSTITUTION.

Article I. Name.

This Society shall be known as The Illinois State Academy of Science.

Article II. Objects.

The objects of the Academy shall be the promotion of scientific research, the diffusion of scientific knowledge and scientific spirit, and the unification of the science interests of the State.

Article III. Members.

The membership of the Academy shall consist of two classes as follows: *National Members* and *Local Members.*

National Members shall be those who are members also of the American Association for the Advancement of Science.

Local Members shall be those who are members of the local Academy only. Each member, except life members of the Academy, shall pay an admission fee of one dollar and an annual assessment of one dollar.

Both national members and local members may be either *Life Members, Active Members,* or *Non-resident Members.*

Life Members shall be national or local members who have paid fees to the Academy to the amount of twenty dollars at one time or complete payments before the annual meeting of 1928. The dues from such a source are to be placed as a permanent fund and only the income is to be used.

Active Members shall be national or local members who reside in the State of Illinois.

Non-resident Members shall be active members or life members who have removed from the State of Illinois. Their duties and privileges shall be the same as active members except that they may not hold office.

Charter Members are those who attended the organization meeting in 1908, signed the constitution, and paid dues for that year.

For election to any class of membership, the candidate's name must be proposed by two members, be approved by a majority of the committee on membership, and receive the assent of three-fourths of the members voting.

Article IV. Officers.

The officers of the Academy shall consist of a President, a First Vice-President, a Librarian, a Secretary, and a Treasurer. The Chief of the Division of State Museum of the Department of Registration and Education of the State Government shall be the Librarian of the Academy. These officers, except the Librarian, shall be chosen by ballot on recommendation of a nominating committee, at an annual meeting, and shall hold office for one year or until their successors qualify.

A Second Vice-President, who may be a resident of the town in which the next annual meeting is to be held, may be appointed by the council each year when the next meeting place shall have been decided upon.

The above officers shall perform the duties usually pertaining to their respective offices.

It shall be one of the duties of the President to prepare an address which shall be delivered before the Academy at the annual meeting at which his term of office expires.

The Librarian shall have charge of all the books, collections, and material property belonging to the Academy.

Article V. Council.

The Council shall consist of the President, First Vice-President, Second Vice-President, Secretary, Treasurer, Librarian, the retiring president and his immediate predecessor. To the Council shall be entrusted the management of the affairs of the Academy during the intervals between regular meetings.

At the Annual Meetings the presiding officer of each of the affiliated scientific societies of the State shall meet with the Academy Council for the discussion of policies.

Article VI. Standing Committees.

The Standing Committees of the Academy shall be a Committee on Publication, a Committee on Membership and a Committee on Affiliation and such other committees as the Academy shall from time to time deem desirable.

The Committee on Publication shall consist of the President, the Secretary and a third member chosen annually by the Academy.

The committees on Membership and Affiliation shall each consist of five members chosen annually by the Academy.

Article VII. Meetings.

The regular meetings of the Academy shall be held at such time and place as the Council may designate. Special meetings may be called by the Council, and shall be called upon written request of twenty members.

Article VIII. Publications.

The regular publications of the Academy shall include the Transactions of the Academy and such papers as are deemed suitable by the Committee on Publications.

All members shall receive gratis the current publications of the Academy.

Article IX. Affiliation.

The Academy may enter into such relations of affiliation with other organizations of appropriate character as may be recommended by the Council, and may be ordered by a three-fourths vote of the members present at any regular meeting.

Article X. Amendments.

This constitution may be amended by a three-fourths vote of the membership present at an annual meeting, provided that notice of the desired change has been sent by the Secretary to all members at least twenty days before such meeting.

BY-LAWS.

I. The following shall be the regular order of business:

1. Call to order.
2. Reports of officers.
3. Reports of standing committees.
4. Election of members.
5. Reports of special committees.
6. Appointment of special committees.
7. Unfinished business.
8. New business.
9. Election of officers.
10. Program.

Adjournment.

II. No meeting of the Academy shall be held without thirty days previous notice by the Secretary to all members.

III. Fifteen members shall constitute a quorum of the Academy. A majority of the Council shall constitute a quorum of the Council.

IV. No bill against the Academy shall be paid without an order signed by the President and the Secretary.

V. Members who shall allow their dues to remain unpaid for three years, having been annually notified of their arrearage by the Treasurer, shall have their names stricken from the roll.

VI. The Librarian shall have charge of the distribution, sale, and exchange of the published Transactions of the Academy, under such restrictions as may be imposed by the Council.

VII. The presiding officer shall at each annual meeting appoint a committee of three who shall examine and report in writing upon the account of the Treasurer.

VIII. No paper shall be entitled to a place on the program unless the manuscript or an abstract of the same shall have been previously delivered to the Secretary. No paper shall be presented at any meeting, by any person other than the author, except on vote of the members present at such meeting. No paper shall be published unless the manuscript be handed to the Secretary within thirty days after the Annual meeting. All papers are limited to twenty pages, additional pages are to be paid for by the author. Except by invitation of the Council, no paper my be accepted for the program unless the author is a member of the Academy or an applicant for membership.

IX. The Secretary and the Treasurer shall have their expenses paid from the Treasury of the Academy while attending council meetings and annual meetings. Other members of the council may have their expenses paid while attending meetings of the council, other than those in connection with annual meetings.

X. These by-laws may be suspended by a three-fourths vote of the membership present at any regular meeting.

LIST OF MEMBERS

List of Members

Note—The names of charter members are starred; names in black-faced type indicate membership in the American Association for the Advancement of Science. Numerals in parenthesis after each member indicate the date of joining the Academy.

LIFE MEMBERS.

Allee, W. C., Ph. D., University of Chicago, Chicago, Ill. (Zoology.) (1913.)
*Andrews, C. W., LL. D., The John Crerar Library, Chicago, Ill. (Sci. Bibl.) (1908.)
***Atwell, Chas. B.,** Ph.. M., Northwestern University, Evanston, Ill. (Botany.) (1900.)
*Bain, Walter G., M. D., St. John's Hospital, Springfield, Ill. (Bacteriology.) (1909.)
Baker, Frank C., University of Illinois, Urbana, Ill. (Zoology.) (1908.)
Barnes, R. M., LL. B., Lacon, Ill. (Zoology.) (1908.)
***Barnes, William,** M. D., 320 Millikin Bldg., Decatur, Ill. (Lepidoptera) (1908.)
Barton, Edward, Ph. D., Univ. of Iowa, Iowa City, Iowa. (Biology.) 1908.)
Barwell, John Wm., Madison and Sand Sts., Waukegan, Ill. (Anthropology.) (1908.)
***Bayley, W. S.,** Ph. D., University of Illinois, Urbana, Ill. (Geology.) (1908.)
***Betten, Cornelius,** Ph. D., Cornell University, Ithaca, N. Y. (Biology.) (1909.)
Blair, Mary Constance, Ph. D., 1011 Grove St., Evanston, Ill. (Bot. and Zool.) (1926.)
Bliss, Gilbert Ames, B. S., M. S., Ph. D., 5625 Kenwood Ave., Chicago, Ill. (Math.) (1926.)
Bleininger, A. V., B. S., Homer Laughlin China Co., Newell, W. Va., (Ceramics.) (1908.)
***Carman, Albert P.,** Ph. D., University of Illinois, Urbana, Ill. (Physics.) (1908.)
***Carpenter, Chas. K.,** D. D., Baileyville, Ill. (Ornithology.) (1908.)
***Chamberlain, C. J.,** Ph. D., University of Chicago, Chicago, Ill. (Botany.) (1911.)
***Child, C. M.,** Ph. D., University of Chicago, Chicago, Ill. (Zoology.) (1910.)
***Clawson, A. B.,** B. A., Dept. of Agriculture, Washington, D. C. (Biology.) (1908.)
***Cowles, H. C.,** Ph. D., University of Chicago, Chicago, Ill. (Botany.) (1908.)
***Crew, Henry,** Ph. D., Northwestern University, Evanston, Ill. (Physics.) (1908.)
***Crook, A. R.,** Ph. D., Chief, State Museum, Springfield, Ill. (Geology.) (1908.)
***Davis, J. J.,** B. S., Purdue University, Lafayette, Ind. (Entomology.) (1908).
Deal, Don. W., M. D., Leland Office Bldg., Springfield, Ill. (Medicine.) (1908.)
Ekblaw, George Elbert. A. M., 308 Lincoln, Urbana, Ill. (Geology.) (1924.)
Ekblaw, W. E., Ph. D., Clark University, Worcester, Mass. (Geology.) (1908.)
Ewing, H. E., U. S. Nat. Museum, Washington. D. C. (Biology.) (1908.)
Farrington, O. C., Ph. D., Field Museum, Chicago, Ill. (Minerology.) (1908.)
***Fischer, C. E. M.,** M. D., 25 E. Washington St., Chicago, Ill. (Medicine.) (1908.)
*Fisher, Fannie, Ass't Curator, State Museum, Springfield, Ill. (General Interest.) (1908.)
***Forbes, S. A.,** LL.D., Chief, Natural History Survey, Urbana, Ill. (Zoology.) (1908.)
Fuller, Geo. D., Ph. D. University of Chicago, Chicago, Ill. (Botany.) (1912.)
*Gates, Frank C., Ph. D., State Agricultural Coll., Manhattan, Kan. (Botany.) (1908.)
Gerhard, Wm. J., Field Museum, Chicago, Illinois. (1908.)
***Grant, U. S.,** Ph. D., Northwestern University, Evanston, Ill. (Geology.) (1908.)
Gurley, Wm. F. E., 6151 University Ave., Chicago, Ill. (Paleontology.) (1908.)
Hagler, E. E., M. D., Capitol Ave. and Fourth St., Springfield, Ill. (Occulist.) (1910.)
***Hale, John A.,** M. D., 117½ W. Ninth St., Los Angeles, Calif. (Medicine.) (1908.)
Hankinson, Thos. L., B. S. State Normal College, Ypsilanti, Mich. (Zool.) (1908.)
Hawthorne, W. C., B. S., 1410 E. 58th St., Chicago, Ill. (1908.)
***Hessler, J. C.,** Ph. D., Knox College, Galesburg, Ill. (Chemistry.) (1908.)

Holgate, T. F., LL. D., 617 Library St., Evanston, Ill. (Math.) (1908.)
Hoskins, William, 111 W. Monroe St., Chicago, Ill. (Chemistry.) (1908.)
Hottes, C. F., Ph. D., University of Illinois, Urbana, Ill. (Botany.) (1908.)
Hudelson, C. W., M. S., 206 S. Main St., Normal, Ill. (Agriculture.) (1921.)
Hunt, Robt. I., Decatur, Ill. (Soils.) (1908.)
***Hutton, J. Gladden,** M. S., State College, Brookings, S. D. (Geology.) (1908.)
Jordan, Edwin O., Ph. D., University of Chicago, Chicago, Ill. (Bacteriology.) (1912.)
*Kneale, Elmer J., Illinois State Register, Springfield, Ill. (Astronomy.) (1908.)
*Knipp, Charles T., Ph. D., University of Illinois, Urbana, Ill. (Physics.) (1908.)
Kuntz, Jacob, Ph. D., University of Illinois, Urbana, Ill. (Physics.) (1919.)
Langford, George, B. S., McKenna Process Co., Joliet, Ill. (Paleontology.) (1908.)
Latham, Vida A., M. D., D. D. S., 1644 Morse Ave., Chicago, Ill. (Microscopy.) (1909.)
Lillie, F. R., Ph. D., University of Chicago, Chicago, Ill. (Zoology.) (1912.)
Marshall, Ruth, Ph. D., Rockford College, Rockford, Ill. (Zoology.) (1912.)
McDougall, W. B., Ph. D., University of Illinois, Urbana, Ill. (Botany.) (1916.)
Michelson, A. A., LL. D., University of Chicago, Chicago, Ill. (Physics.) (1908.)
Miller, G. A., Ph. D., University of Illinois, Urbana, Ill. (Math.) (1910.)
Moffatt, Mrs. Elizabeth M., 1315 Crown Hill Ave., Los Angeles, Calif. (Zool.) (1916.)
Moffatt, Will S., M. D., 1315 Crown Hill Ave., Los Angeles, Calif. (Botany.) (1912.)
Mohr, Louis, 349 W. Illinois St., Chicago, Ill. (1909.)
***Noyes, Wm. A.,** Ph. D., LL. D., University of Illinois, Urbana, Ill. (Chem.) (1908.)
*Oglevee, C. S., Sc. D., Lincoln College, Lincoln, Ill. (Biology.) (1908.)
O'Hara, Fred S., M. D., 509 E. N. Grand Ave., Springfield, Ill. (Med.) (1925.)
***Parr, S. W.,** M. S., University of Illinois, Urbana, Ill. (Chem.) (1908.)
Payne, Edward W., First State Trust & Savings Bank, Springfield, Ill. (Archeology.) (1909.)
***Pepoon, H. S.,** M. D., Lake View High School, Chicago, Ill. (Zool. and Bot.) (1908.)
Reagan, Albert A., A. B., A. M., Cornfields, Ariz. (Paleontology.) (1921.)
Rentchler, Edna, K., B. A., Peabody Normal College, Nashville, Tenn. (Biology.) (1912.)
Savage, T. E., Ph. D., University of Illinois, Urbana, Ill. (Strategraphic Geology.) (1908.)
Schaffer, David Nicholas, M. D., 104 S. Michigan Ave., Chicago, Ill. (Medicine.) (1925.)
Shelford, V. E., Ph. D., Vivarium Bldg., Wright & Healy Sts., Champaign, Ill., (Zoology, Ecology.) (1908.)
Slocum, A. W., University of Chicago, Chicago, Ill. (1908.)
Smallwood, Mabel E., 550 Surf St., Chicago, Ill. (Zoology.) (1908.)
Smith, Mrs. Eleanor C., B. S., 104 Winston Ave., Joliet, Ill. (Biology.) (1919.)
Smith, Frank, M. S., Sc. D., 79 Fayette St., Hillsdale, Mich. (Zoology.) (1909.)
***Smith, Isabel Seymour,** 145 Woodland Ave., Oberlin, Ohio. (Botany.) (1908.)
Smith, Jesse L., Supt. of Schools, Highland Park, Ill. (1908.)
***Smith, L. H.,** Ph. D., University of Illinois, Urbana, Ill. (Plant Breeding.) (1908.)
Spicer, C. E., 100 Sherman St., Joliet, Ill. (Chemistry.) (1908.)
Stevenson, A. L., B. S., Field School, 7019 N. Ashland Ave., Chicago, Ill. (1908.)
Stillhamer, A. G., 705 N. East St., Bloomington, Ill. (Physics). (1908.)
*Strode, W. S., M. D. Lynwood, Calif. (Ornithology.) (1908.)
Sykes, Mabel, B. S., South Chicago High School, Chicago, Ill. (Geology.) (1908.)
Trelease, William, LL. D., University of Illinois, Urbana, Ill. (Botany.) (1909.)
Turton, Chas. M., M. A., 2055 E. 72nd Place, Chicago, Ill. (Physics.). (1908.)
Van Cleave, H. J., Ph. D., University of Illinois, Urbana, Ill. (Zoology.) (1910.)
Ward, Henry B., Ph. D., Sc., D., University of Illinois, Urbana, Ill. (Zoology.) (1910.)
Washburn, E. W., Ph. D., National Research Council, Washington, D. C. (Chemistry.) (1910.)
Weller, Annie L., Eastern Ill. State Teachers' College, Charleston, Ill. (1908.)
*Winter, S. G., M. A., Lombard College, Galesburg, Ill. (Histology.) (1908.)
***Wood, F. E.,** A. B., 804 N. Evans St., Bloomington, Ill. (Biology.) (1908.)
Zeleny, Charles, Ph. D., University of Illinois, Urbana, Ill. (Experimental Zoology.) (1910.)
***Zetek, James,** A. M., Box 245, Ancon, Panama Canal Zone. (Entomology.) (1908.)

ANNUAL MEMBERS.

Adams, H. W., Normal University, Normal, Ill., (Chemistry.) (1928.)
Adams, L. A., Ph. D., University of Illinois, Urbana, Ill. (Zoology.) (1923.)
Adams, William A., B. S. A., 2235 N. 75th Ave., Elmwood Park, Ill. (Archeology.) (1927.)
Adams, Roger, Ph. D., 603 Michigan Ave., Urbana, Illinois. (Chemistry.) (1926.)
Adamstone, F. B., M. A., Ph. D., University of Illinois, Urbana, Illinois. (Zoology.) (1926.)
Adler, Herman M., M. D., 721 S. Wood St., Chicago, Ill. (Medicine.) (1920.)
Agersborg, H. P. K., Ph. D., 1428 W. Riverview Ave., Decatur, Ill. (Zoology.) (1925.)
Aldrich, Frank W., Ph. D., 1506 E. Washington St., Bloomington, Ill. (Anthropology.) (1925.)
Alexander, Alida, M. A., Ilinois Woman's College, Jacksonville, Ill. (Botany.) (1918.)
Alldrege, Samuel M., A. B., P. O. Box 682, Johnston City, Ill. (Chemistry.) (1922.)
Ames, E. S., Ph. D., University of Chicago, Chicago, Ill. (Psychology.) (1920.)
Anderson, Martha, M. D., Hillcrest Sanitarium, Quincy, Ill. (Pathology.) (1928.)
Appleton, John B., M. S., Ph. D., University of Illinois, Urbana, Ill. (Geography.) (1926.)
Armstrong, Christie, A. B., Princeville, Ill. (Geography.) (1921.)
Arn, William G., B. S., Illinois Central Station, I. C. R. R. Co., Chicago, Ill. (Math. Geology, Physics.) (1927.)
Ashman, George C., Ph. D., Bradley Institute, Peoria, Ill. (Chemistry.) (1913.)
Astell, Louis A., B. A., Box 37, West Chicago, Ill. (Physiology and Hygiene.) (1925.)
Augur, Allison W., M. A., 5423 Woodlawn, Chicago, Ill. (Physics.) (1921.)
Bacon, Chas. Sumner, Ph. D., M. D., 2333 Cleveland Ave., Chicago, Ill. (1920.)
Bailey, Mrs. Alice Allen, M. S., University of Chicago, Chicago, Ill. (Botany., Path.) (1927.)
Bailey, Wm. M., M. S., 701 S. Poplar, Carbondale, Ill. (Botany.) (1921.)
Baird, S. H., 708 Woodland Ave., Springfield, Ill. (Chemistry.) (1925.)
Baker, C. J., B. S., 460 E. Ohio St., Chicago, Ill. (Chemistry.) (1926.)
Balduf, W. V., Ph. D., 308 Old Law Bldg., University of Illinois, Urbana, Ill. (Entomology.) (1924.)
Banck, Hans J. E., M. E., 1422 Dial Court, Springfield, Ill. (Engineering.) (1925.)
Bangs, Edward H., 212 W. Washington St., Chicago, Ill. (Agriculture and Electricity.) (1920.)
Barnes, Cecil, LL. B., M. A., 1522 1st National Bank Bldg., Chicago, Ill. (Physical Geography.) (1920.)
Bassett, C. F., Hinckley, Ill. (1925.)
Bassett, Mrs. C. F., B. S., Hinckley, Ill. (Geology.) (1926.)
Bastin, E. S., Ph. D., University of Chicago, Chicago, Ill. (Geology.) (1925.)
Bates, Onward, LL. D., 332 S. Michigan Ave., Chicago, Ill. (Civil Engineering) (1926.)
Bauman, Harold Ed. B., Farina, Ill. (Zoology.) (1926.)
Beecher, Wm. L., M. D., Ph. D., 4607 Beacon St., Chicago, Ill. (Medicine.) (1927.)
Behre, Chas. H., Jr., University of Cincinnati, Cincinnati, Ohio. (1921.)
Bell, Alfred H., Ph. D., University of Illinois, Urbana, Ill. (Geology.) (1927.)
Bell, Marie, Box 114, Albany, Indiana. (Biology.) (1926.)
Bengel, George A., 808 S. 4th St., Springfield, Ill. (Engineering.) (1925.)
Bentley, Madison, Department of Psychology, Cornell Univ., Ithaca, N. Y. (1920.)
Benton, Curtis, B. A., Macomb, Ill. (Entomology.) (1925.)
Bergeim, Olaf Ph. D., 1917 W. Polk St., Chicago, Ill. (Chemistry.) (1928.)
Bergman, Ross M., 613 S. Hale St., Wheaton, Ill. (Biology.) (1926.)
Bergsmark, Daniel R., S. B., University of Cincinnati, Cincinnati, Ohio. (Geography.) (1928.)
Bevan, Arthur, Ph. D., 248 Nat. Hist., University of Illinois, Urbana, Ill. (Geology.) (1924.)
Bigger, J. H., B. S., 1114 S. Main St., Jacksonville, Ill. (Entomologist.) (1925.)
Black, Arthur D., M. D., D. D. S., Northwestern University, Evanston, Ill. (Dentistry.) (1921.)
Blackstock, Ira B., M. A., 213 E. Jefferson St., Springfield, Ill. (Agriculture.) (1925.)
Blake, Anna M., B. S., 409 W. Willow St., Normal, Ill. (Botany and Physiology.) (1917.)
Blake, Mrs. Tiffany, Lake Forest, Ill. (1921.)
Blanchard, W. O., Ph. D., 305 Washington Blvd., Urbana, Ill. (Geography.) (1925.)
Block, D. Julian, Ph. D., 612 N. Michigan Blvd., Chicago, Ill. (Chemistry.) (1920.)
Boewe, G. H., B. E., 313 Taylor St., Charleston, Ill. (1928.)

Bohannon, F. C., B. S., Galesburg High School, Galesburg, Ill. (Geography and Geology.) (1924.)
Bonnell, Clarence, Township High School, Harrisburg, Ill. (Biology.) (1926.)
Boomer, S. E., M. A., 207 Harwood St., Carbondale, Ill. (Physics.) (1921.)
Boos, Mrs. Margaret Fuller, Ph. D., 197 W. Lafayette, Fayetteville, Ark. (Geology.) (1920.)
Boot, G. W., M. D., 813 Sherman Ave., Evanston, Ill. (Medicine and Geology.) (1920.)
Bracken, Ellis F., B. S., 7003 Eggleston Ave., Chicago, Ill. (Physics.) (1927.)
Brandenburger, F., B.E., Milstadt, Ill. (Geology.) (1928.)
Brannon, James Marshall, Ph. D., University of Illinois, Urbana, Ill. (Plant Physiology, Cytology and Bacteriology.) (1926.)
Breed, Frederick S., Ph. D., School of Education, Univ. of Chicago, Chicago, Ill. (Education.) (1921.)
Bregowsky, Ivan M., 4600 W. Harrison St., Chicago, Ill. (Chemistry and Metallurgy.) (1926.)
Bretz, J. Harlan, Ph. D., University of Chicago, Chicago, Ill. (Geology.) (1921).
Brown, Agnes, 1205 W. State St., Rockford, Ill. (1921.)
Brown, George A., 304 E. Walnut St., Bloomington, Ill. (Education.) (1920.)
Brown, H. Clark, B. S., 409 Hamilton St., St. Charles, Ill. (Botany.) (1924.)
Browne, G. Aritins, B. S., Community High School, Lincoln, Ill. (Physics.) (1928.)
Browne, George M., 902 S. Normal St., Carbondale, Ill. (Chemistry.) (1921.)
Brundage, John T., A. B., A. M., St. Louis University School of Medicine, 1403 Grand Ave., St. Louis, Mo. (Physiological Chem.) (1927.)
Bussart, J. Everett, B. S., Arthur, Ill. (Biology.) (1928.)
Buswell, A. M., Ph. D., Chief, State Water Survey, University of Illinois, Urbana, Ill. (1921.)
Buzzard, Robt. G., M. S., Ill. 608 Normal Ave., Normal, Ill. (Geography and Geology.) (1922.)
Cahn, Alvin R., Ph. D., University of Illinois, Urbana, Ill. (Zoology.) (1925.)
Caldwell, Delia, M. D., 590 W. Main St., Carbondale, Ill. (Medicine.) (1921.)
Cammack, R. R., B. S., 409 S. Buchannan St., Marion, Ill. (Chemistry.) (1926.)
Campbell, Ian, M. A., Geological Museum, Cambridge, Mass. (Geology.) (1925.)
Card, H. H., Botany Department, University of Illinois, Urbana, Ill. (Botany.) (1925.)
Carleton, Ralph Kimball, M. A., Shurtleff College, Alton, Ill. (Chemistry.) (1926.)
Carlson, A. J., Ph. D., University of Chicago, Chicago, Ill. (Physiology.) (1911.)
Carlson, Fred, E. B., State Teachers' College, DeKalb, Ill. (Geography.) (1923.)
Carrick, O. W., 1636 E. William St., Decatur, Ill. (Chemistry.) (1928.)
Caven, Jordon, M. A., Rockford College, Rockford, Ill. (Psychology.) (1926.)
Causey, David, Ph. D., Zoology Department, Princeton University, Princeton, N. J. (Biology.) (1922.)
Challis, Frank E., 121 N. Wabash Ave., Chicago, Ill. (Chemistry.) (1921.)
Chandler, S. C., B. S., Carbondale, Ill. (Entomology.) (1921.)
Chapman, Hazel, 301 W. Washington St., Urbana, Ill. (Zoology.) (1925.)
Cheddix, J. C., B. E., 312 Water St., Normal, Ill. (Chemistry.) (1928.)
Chester, S. Arthur, S. B., 802 Normal Ave., Normal, Ill. (Physics.) (1928.)
Christie, J. R., B. S., East Falls Church, Va. (Biology.) (1929.)
Clark, Albert Henry, B. S., 701 W. Wood St., Chicago, Ill. (Chemistry.) (1920.)
Clark, H. Walton, M. A., California Academy of Sciences. Golden Gate Park, San Francisco, Calif. (Biology.) (1917.)
Cletcher, J. O., M. D., 10 N. Main St., Tuscola, Ill. (Medicine). (1921.)
Clute, W. N., Editor, "The American Botanist," Joliet, Ill. (Botany.) (1918.)
Coale, Henry K., Highland Park, Illinois. (Ornithology.) (1926.)
Coffin, Fletcher B., Ph. D., Lake Forest, Ill. (Physical Chemistry.) (1911.)
Coggeshall, Ruth, B. S., 3927 N. Hamlin Ave., Chicago, Ill. (Biology.) (1924.)
Colby, Arthur Samuel, Ph. D., University of Illinois, Urbana, Ill. (Horticulture.) (1920.)
Colby, Chas. C., Ph. D., University of Chicago, Chicago, Ill. (Geography.) (1920.)
Cole, Fay-Cooper, B. S., Ph. D., 5710 Blackstone, Chicago, Ill. (Anthropology.) (1927.)
Colyer, F. H., M. S., State Normal University, Carbondale, Ill. (Geography.) (1915.)
Compton, James S., Eureka, Ill. (1914.)
Cooper, Rachel M., M. D., State Normal University, Normal, Ill. (Medicine.) (1928.)
Cox, F. W., M. A., Clark University, Worchester, Mass. (Geography.) (1926.)
*Crandall, Chas. S., University of Illinois, Urbana, Ill. (Horticulture.) (1908.)
Crandle, Ellis R., Ed. B., 509 S. Poplar, Carbondale, Ill. (Biology.) (1927.)
Crathorne, A. R., Ph. D., University of Illinois, Urbana, Ill. (Mathematics.) (1920.)
Cribb, Aubrey, "The Associated Press," Springfield, Ill. (1921.)
Crompton, Mabel, M. S., 310 Normal Ave., Normal, Ill. (Geography.) (1927.)
Crosier, W. M., M. D., Alexis, Ill. (Medicine.) (1921.)

Cross, C. L., B. S., M. S., 604 Normal Ave., Normal, Ill. (Physics.) (1928.)
Crowe, A. B., M. A., Eastern State Teacher's College, Charleston, Ill. (Physics.) (1910.)
Croxton, Orson, B. S., Ed., 128 W. Hickory St., Watseka, Ill. (Chemistry.) (1927.)
Crummer, Mrs. Emma C., 134 S. Kenilworth Ave., Oak Park, Ill. (Botany.) (1925.)
Culler, Elmer A., Ph. D., University of Illinois, Urbana, Ill. (Psychology.) (1927.)
Currens, Frederick Hawley, Ph. D., 130 N. Normal St., Macomb, Ill. (Chemistry.) (1914.)
Curtis, George M., B. A., M. A., Ph. D., M. D., Billings Hospital, University of Chicago, Chicago. Ill. (Anatomy.) (1927.)
Danheim, Bertha, M. S., High School, LaSalle, Ill. (Zoology.) (1928.)
Darling, Elton R., Ph. D., P. O. Box 825, Danville Ill. (1920.)
Dart, Carlton R., 706 Greenleaf Ave., Wilmette, Ill. (Civil Engineering.) (1921.)
Davenport, Eugene, LL. D., Woodland, Mich. (Agriculture.) (1910.)
Day, William B., Ph. G., 715 S. Wood St., Chicago, Ill. (Botany.) (1927.)
Deam, Hon. Chas. C., M. A., Bluffton, Ind. (Forestry and Flora.) (1921.)
Dean, Ella R., B. Ed., 221 S. Mill St., Olney, Ill. (Chemistry.) (1921.)
DeLee, Jos. B., M. A., 5028 Ellis Ave., Chicago, Ill. (1921.)
DeLoach, R. J. H., M. A. 5541 Dorchester, Chicago, Ill. (Botany, Soils, Economics.) (1926.)
Dempster, A. J., Ph. D., University of Chicago, Chicago. Ill. (Physics.) (1921.)
De Ryke, Willis, Ph. D., 1051 Grove, Jacksonville, Ill. (Biology.) (1927.)
De St. Cyr. William H., D. O., 30 N. Michigan Ave., Chicago, Ill. (Medical Sci. & Physics.) (1927.)
DeTurk, Ernest E., Ph. D., 306 Agric. Bldg., University of Illinois, Urbana, Ill. (Agriculture.) (1920.)
Dilts, Charles D., A. B., 3121 Fairfield Ave., Ft. Wayne, Ind. (Chemistry.) (1921.)
Dodge, Lawrence E., B. S., 500 Broadway, Gillespie, Ill. (Chemistry.) (1926.)
Donoghue, Julia O., 5538 Magnolia, Chicago, Ill. (Nature Study.) (1927.)
Doolittle, Rilus, B. S., 313 W. Walnut St., Harrisburg, Ill. (Biology.) (1926.)
Downie, Thos. R., 1216 N. Kellogg St., Galesburg, Ill. (Geology.) (1923.)
Downing, Eliot R., Ph. D., University of Chicago, Ill. (Zoology.) (1913.)
Dufford, R. T., University of Missouri, Columbia, Mo. (Physics.) (1918.)
Dungan, Geo. H., B. S., M. S., Ph. D., University of Ill., Urbana, Ill. (Plant Physiology.) (1927.)
Earle, C. A., M. D., DesPlaines, Ill. (Botany.) (1920.)
East, Clarence W., M. D., F. A. S. C., 326 W. Jackson St., Springfield, Ill. (Preventive Medicine.) (1921.)
Eaton, Scott V., Ph. D., University of Chicago, Chicago, Ill. (Botany.) (1925.)
Eddy, Samuel, M. A., Vivarium Bldg., University of Illinois, Urbana, Ill. (Biology.) (1925.)
Edwards, Linden F., B. A., M. S., Ph. D., 401 Nat. Hist. Bldg., University of Illinois. Urbana, Ill. (Zoology.) (1926.)
Ehrman, E. H., M. E., Homan Ave. and Fillmore St., Chicago, Ill. (1920.)
Eifrig, C. W. G., 504 Monroe Ave., River Forest, Ill. (Ornithology, Botany, Zoology.) (1920.)
Eklund, Edwin G., M. A., 1451 S. Lincoln St., Springfield, Ill. (Psychology.) (1925.)
Eldredge, Arthur G., University of Illinois, Urbana, Ill. (Photography.) (1916.)
Eller, W. H., S. B., 230 N. Ward St., Macomb, Ill. (Physics.) (1924.)
Ellison, Lewis M., 214 W. Kinzie St., Chicago, Ill. (Engineering.) (1927.)
Englis, Duane T., Ph. D., University of Illinois, Urbana, Ill. (Chemistry.) (1917.)
Erffmeyer, Clarence E., Ph. D., North Central College, Naperville, Ill. (Education.) (1928.)
Ernest, Mary R., 463 W. Decatur St., Decatur, Ill. (Physiology.) (1928.)
Esmaker, John Benjamin, M. A., 1076 W. Roosevelt Road, Chicago, Ill. (Physics.) (1926.)
Essex, Hiram E., Ph. D., 1127 W. Center St., Rochester, Minn. (Zoology.) (1928.)
Evans, Frank N., M. D., 407 S .Seventh St., Springfield, Ill. (Medicine.) (1925.)
Falk, I. S., Ph. D., University of Chicago, Chicago. Ill. (Bacteriology and Hygiene.) (1925.)
Farnam, Bertha L., Carbondale, Ill. (Biology.) (1927.)
Fasoldt, Karl N., B. Ph., Johnston City, Ill. (Botany.) (1927.)
Faught, Eva E., Dept. of Health, Carbondale, Ill. (Bacteriology.) (1925.)
Faust, Mildred E., M. S., 848 Lancaster Ave., Syracuse, N. Y. (Botany.) (1925.)
Ferguson, Harry F., S. B., Dept. Public Health, Springfield, Ill. (Sanitary Engineer.) (1925.)
Fetter, Dorothy, M. S., Rockford College, Rockford, Ill. (Physiology.) (1926.)
Finley, C. W., M. A. State College of Education, Upper Montclair, N. J. (Zoology.) (1910.)
Fisher, D. Jerome, Ph. D., Rosenwald Hall, University of Chicago, Chicago, Ill. (Geology.) (1926.)

Fiske, David, M. S., Amer. Soc. Refrigerating Engineers, 29 W. 29th St., New York, N. Y. (Physics.) (1926.)
Flint, W. P., Ass't State Entomologist, 1006 S. Orchard St., Urbana, Ill. (Entomology.) (1914.)
Foreman, Blye E., B. E., Pearl, Ill. (Zoology.) (1927.)
Franing, E. C., M. D., 404 Bank of Galesburg Bldg., Galesburg, Ill. (Medicine.) (1921.)
Franing, Russell, A. B., Dundee Community High School, Dundee, Ill. (Chemistry.) (1924.)
Frank, O. D., 6207 Kimbark Ave., Chicago, Ill. (Biology.) (1918.)
Frazier, John C., M. A., 1010 Prairie St., Bloomington, Ill. (Botany.) (1928.)
Freeman, Harriette, M. S., 111 S. Eastern, Joliet, Ill. (Botany.) (1927.)
French, G. H., M. A. Herrin Hospital, Herrin, Ill. (Botany and Entomology.) (1921.)
Friedli, F. J., S. M., 149 So. Penn. St., Belleville, Ill. (Zoology.) (1928.)
Frison, Theodore H., Ph. D., 316-A-Natural History Bldg., University of Illinois, Urbana, Ill. (Entomology, General Biology.) (1917.)
Fryxell, Fritiof M., M. A., 715 3rd St., Moline, Ill. (Geology.) (1925.)
Funk, Donald S., B. A., Sangamo Electric Co., Springfield, Ill. (1925.)
Gamble, Faith, 206 Clintin Ave., Oak Park, (1926.)
Garnett, H. W., B. S., 205½ North St. Normal, Ill. (Chemistry.) (1927.)
Gault, B. T., 564 N. Main St., Glen Elyn, Ill. (Ornithology.) (1910.)
Gault, Robert H., Ph. D., Northwestern University, Evanston, Ill. (Psychology.) (1926.)
Gay, Berry E., Ph. G., 720 W. Olive St., Decatur, Ill. (Bacteriology.) (1927.)
Geauque, H. A., Lombard St., Galesburg, Ill. (Chemistry.) (1923.)
Gersbacher, Willard M., Ed. B., 1102 W. Oregon St., Urbana, Ill. (Zoology.) (1926.)
Givens, Harry V., B. S., Midland Ave., Joliet, Ill. (Biology.) (1927.)
Glattfeld, J. W. E., Ph. D., Kent Chemical Laboratory, University of Chicago, Chicago, Ill. (Chemistry.) (1921.)
Goldstine, Mark T., M. D., L. M., 25 E. Washington St., Chicago, Ill. (Medicine.) (1926.)
Goode, J. Paul, Ph. D., 6227 Kimbark Ave., Chicago, Ill. (Geography.) (1912.)
Gore, G. W., M. D., 231 N. McCleamsboro St., Benton, Ill. (Internal Med.) (1921.)
Gorrell, T. J. H., M. D., Chicago Heights, Ill. (Medicine.) (1921.)
Gould, Prof. Wm. C., M. A., 625 DeKalb Ave., DeKalb, Ill. (Geography.) (1925.)
Gradle, Harry S., M. D., 22 E. Washington St., Chicago, Ill. (Opthalmology.) (1920.)
Graham, Robert, B. S., D. V. M., 105 Animal Pathology, University of Illinois, Urbana, Ill. (Pathology.) (1910.)
Graham, V. O., M. S., 4028 Grace St., Chicago, Ill. (Botany.) (1926.)
Greathouse, G. A., B. E., 400 Nat. Hist. Bldg., Urbana, Ill. (Biology.) (1927.)
Green, Bessie, M. A., Oregon State Agr. Coll., Corvallis, Ore. (Zoology.) (1911.)
Green, Helen R., A. B., R. F. D. 8, Jacksonville, Ill. (1927.)
Greenhill, J. P., M. D, 426 E. 51st St., Chicago, Ill. (Embryol.) (1928.)
Greenman, J. M., Ph. D., Missouri Botanical Garden, St. Louis, Mo. (Botany.) (1911.)
Greer, Frank E., A. B., M. S., 5458 Kimbark Ave., Chicago, Ill. (Bacteriology.) (1927.)
Griffin, J. P., A. B., 909½ S. Fifth St., Champaign, Ill. (Geology.) (1927.)
Gronemann, Carl F., 310 N. Liberty St., Elgin, Ill. (Artist, Naturalist.) (1921.)
Grove, P. F., M. A., 603 E. Ridge St., Mt. Carroll, Ill. (Botany.) (1926.)
Gueffroy, Edna M., M. A., Teachers' College, Carbondale, Ill. (Geography.) (1928.)
Haas, Flora Anderson, Ph. D., 736 E. 3rd St., Bloomington, Ind. (Botany.) (1925.)
Haas, William H., M. A., Northwestern University, Evanston, Ill. (Geography.) (1914.)
Haefuer, R., M. A., 1538 4th St., Charleston, Ill. (Psychology.) (1926.)
Hagler, Mrs. E. S., 1900 W. Lawrence Ave., Springfield, Ill. (1910.)
Hall, Henry, 404 W. High St., Urbana, Ill. (Zoology.) (1928.)
Haldeman, W. S., A. M., 305 N. Second St., Monmouth, Ill. (Chem.) (1928.)
Hamilton, Angelina G., M. D., State Hospital, Anna, Ill. (Psychiatry.) (1926.)
Hamp, Mattie S., Rosiclare High School, Rosiclare, Ill. (Biology.) (1926.)
Hanke, Martin E., S. B., Ph. D., 8424 Rhodes Ave., Chicago, Ill. Physiology & Chem.) (1927.)
Hanks, Mary E., M. D., 307 N. Michigan Ave., Chicago, Ill. (Roentgentheraphy.) (1927.)
Hansen, Paul, 9741 Avenue H, Chicago, Ill., (Geology.) (1927.)
Hansen, Paul, 6, No. Michigan Ave., Chicago, Ill. (Sanitation.) (1913.)
Hardin, Sarah M., Ph. B., 402 W. Walnut St., Carbondale, Ill. (Biology.) (1924.)
Harding, H. A., Ph. D., 685 Mullett St., Detroit, Mich. (Bacteriology.) (1916.)
Hargitt, T. F., Ph. D., 207 W. Kelsey Ave., Bloomington, Ill. (Physics.) (1928.).

Harland. Marion B., B. S., 655 Old Agriculture Bldg., University of Illinois. Urbana, Ill. (Soils.) (1925.)
Hartman, Ernest, B. S., M. S., Sc. D., Lingnan University, Canton, China. (Parasitology.) (1927.)
Harvey, Alice L., B. A., 2036 Spruce St., Murphysboro, Ill. (Chemistry.) (1926.)
Hatfield, E. Frances, A. M., Normal University, Normal, Ill. (Biol.) (1928.)
Haupt, Arthur W., University of California, Los Angeles, Calif. (Botany.) (1912.)
Hawkes, Joseph Bulkley, A. B., Dept. of Botany, University of Chicago, Chicago, Ill. (Botany.) (1925.)
Hay, Logan, B. A., 1220 S. Grand Ave., W., Springfield, Ill. (Mathematics.) (1925.)
Hayes, Wm. P., Ph. D., 200 Natural History Bldg., Urbana, Ill. (Entomology.) (1926.)
Heath, Geo. D., M. D., 1308 N. Main, Bloomington, Ill. (Epedemiology.) (1928.)
Hedrick, Leslie, A. B., 410 Conover Ave., Eureka, Ill. (Zoology.) (1927.)
Heflin, H. N., M. D., Kewanee, Ill. (Medicine.) (1921.)
Hemenway, Henry B., M. D., 620 Amos Ave., Springfield, Ill. (Public Health.) (1918.)
Henbest, Lloyd G., A. B., A. M., 305 Ceramics Bldg., University of Illinois. Urbana, Ill. (Geology and Biology.) (1927.)
Henderson, Lena B., M. S., Rockford College, Rockford, Ill. (Botany.) (1926.)
Henderson. Luther B., M. A., B. D., 176 Woodlawn Ave., Decatur, Ill. (Psychology.) (1925.)
Hendrickson, Eliz., B. S., 3501 Montrose Ave., Chicago, Ill. (Botany.) (1926.)
Henkel, H. B., M. D., 401 E. Capitol Ave., Springfield, Ill. (Medicine.) (1925.)
Herrick, C. Judson. Ph. D., University of Chicago, Chicago, Ill. (Anatomy.) (1920.)
Herrick, Julia F., M. A., Mayo Foundation, Rochester, Minn. (Physics.) (1926.)
Herron, James C., 1417 W. Jackson Blvd., Chicago, Ill. (Illuminating Engineer.) (1926.)
Hieronymus, R. E., LL.D., 109 New Agricultural Bldg., University of Illinois, Urbana, Ill. (1926.)
Higgins, George M., Ph. D., Inst. Experimental Medicine, Rochester, Minn. (Zoology.) (1921.)
Higginson, Glenn D., Ph. D., 1117 W. Illinois St., Urbana, Ill. (Psychology.) (1927.)
Higley, L. A., Ph. D., Box 776, Wheaton, Ill. (Chemistry.) (1926.)
Hildebrand, L. E., M. A., 1620 Ridge Ave., Evanston, Ill. (Zoology.) (1911.)
Hines, Murray A., Ph. D., 1416 Hinman Ave., Evanston, Ill. (Chemistry.) (1914.)
Hinrichs, Marie A., Ph. D., University of Chicago, Chicago, Ill. (General Physiology.) (1926.)
Hockenyos, Geo. L., 1003 Oregon St., Urbana, Ill. (Botany.) (1927.)
Hoffman, Frank F., M. D., 3117 Logan Blvd., Chicago, Ill. (Phys. Surg.) (1921.)
Holmes, Harriet F. (Miss), A. B., South Batavia Rd., Batavia, Ill. (Plant Pathology.) (1927.)
Holmes, Leslie A., 249 Nat. Hist. Bldg., University of Illinois, Urbana, Ill. (Geology.) (1926.)
Holmes, Manfred J., B. L., 703 Broadway, Normal, Ill. (Social and Education.) (1920.)
Holmes, Ralph R., M. D., 458 W. 61 St., Chicago, Ill. (Astronomy.) (1926.)
Holtz, F. C., B. S., 1358 Dial Court, Springfield, Ill. (Mathematics.) (Physics.) (1925.)
Honey, Edwin E., B. S., 314 Burr Oak St., Albion, Mich. (Plant Pathology, Botany, Entomology.) (1921.)
Hopkins, B. Smith, Ph. D., 706 W. California St., Urbana, Ill. (Inorganic Chemistry.) (1920.)
Hopkins, Frank, Makanda, Illinois, (Optometry.) (1926.)
Horrell, C. R., B. S., Sangamon Electric Co., Springfield, Ill. (Electrical Engineering.) (1925.)
Howard, W. V., Ph. D., University of Illinois, Urbana. (Geology.) (1928.)
Houdek, Paul, 710 N. Gross St., Robinson, Ill. (Biology.) (1928.)
Howe, Samuel W., Ed. B., 311 N. 14th St., Herrin, Ill. (1925.)
Huey, Walter B., M. D., Elgin, Joliet & Eastern Ry., Joliet, Ill. (Medicine.) (1921.)
Hufford, G. N., A. B., 216 Seeser, Joliet, Ill. (Botany.) (1927.)
Hull, Thos. G., Ph. D., State Board of Health, Springfield, Ill. (Health.) (1921.)
Hungerford, Warren H., 1920 City Hall Square Bldg., Chicago, Ill. (Physics.) (1927.)
Hunt, L. W., B. S., Galesburg, Ill. (Chem.) (1928.)
Hunter, George W., Ph. D., 210 Mesa Ave., Claremont, Calif. (Biology.) (1921.)
Hunter, Geo. W., III, Ph. D., Rensselaer Poly Institute, Troy, N. Y. (Zoology.) (1928.)
Illinois State Library, State House, Springfield, Ill. (1921.)
Isenbarger, Jerome, B. S., 2200 Greenleaf Ave., Chicago, Ill. (Zoology.) (1921.)
Jackson, George H., Jr., M. D., 310 S. Michigan Ave., Chicago, Ill. (Medicine.) (1926.)

Jacobi, Wm. H., M. E., Springfield Boiler Co., Springfield, Ill. (Physical Chemistry.) (1925.)
Jacobs. Margaret C., 413 Leland St., Baraboo, Wis. (Botany.) (1925.)
Janaurius, Sister M., M. A., 106 W. Chestnut, Bloomington, Ill. (Physics.) (1928.)
Jane, Wm. T., 5 N. Wabash Ave., Chicago, Ill. (Bausch & Lomb Opt. Co.) (1921.)
Janson, Ardylle A., 636 Church St., Evanston, Ill. (Bacteriology.) (1927.)
Jeliff, Fred R., B. A., Editor. Daily Republican-Register, Galesburg, Ill. (Geology.) (1917.)
Jenks, Ira J., M. S., State Teachers' College, DeKalb, Ill. (Chemistry.) (1922.)
Jensen, Jens, Ravinia, Ill. (Geology-Botany.) (1921.)
Johnson. George F., 625 Black Ave., Springfield, Ill. (Astronomy.) (1914.)
Johnson, John H., B. Ed., Supt. of Schools, Tremont, Ill. (Biology.) (1923.)
Johnson, T. Arthur, M. D., 503 7th St., Rockford, Ill. (Medicine, Science and Surgery.) (1920.)
Jones, Elmer E., Ph. D., Northwestern University, Evanston, Ill. (Mental Development-Heredity.) (1920.)
Jurica, Hilary S., Ph. D., 1818 S. Paulina St., Chicago, Ill. (Botany.) (1922.)
Kaplan, Bertha, M. S., B. S., 1350 S. Avers Ave., Chicago, Ill. (Bacteriology & Parasitology.) (1927.)
Karr, Gertrude. B. A., Fredericksburg, Va. (Botany.) (1925.)
Karraker, Edward L., Jonesboro, Ill. (Forestry.) (1921.)
Kelsey, Alice B., A. M., So. Ill. State Normal, Carbondale, Ill. (Mathematics.) (1926.)
Kempton, F. E., M. S., Centerville, Ind., (Plant Pathology.) (1917.)
Kennedy, E. V., Ed. B. Ava, Ill. (Biology.) (1925.)
Kennicott, Ransom. 547 Cook Co. Bldg., Chicago, Ill. (Forestry.) (1921.)
Kent, R. A., Ph. D., 625 Emerson St., Evanston, Ill. (Education.) (1926.)
Keyes, D. B., B. A., M. A., Ph. D., 107 Chem. Bldg. Urbana, Ill. (Chemistry.) (1927.)
Kibbe. Alice L., Denhart Hall, Carthage, Ill. (Botany.) (1925.)
Kienholz, Aaron Raymond, Ph. D., 606 Washington St., Urbana, Ill. (Botany.) (1925.)
Kirby, E. R., B. S., 1101 S. University Ave., Normal, Ill. (Chem.) (1928.)
Kirkpatrick, Amy R., Anna, Ill. (Artist.) (1926.)
Kirn, George H., Ph. D., D. D., Northwestern College, Naperville, Ill. (Phychology and Philosophy.) (1923.)
Kline, R. G., M. D., Hoopeston, Ill. (Medicine.) (1921.)
Koch, Fred Conrad, Ph. D., University of Chicago, Chicago. Ill. (Physiological Chemistry.) (1920.)
Koontz, D. Lionel, 902 Reba Place, Evanston, Ill. (Mechanical Engineer.) (1926.)
Kordiemon, Anna M., 825 Washington, Quincy, Ill. (1926.)
Krause, Heinrich, D. D. L., 9238 Normal Ave., Chicago, Ill. (Anthropology.) (1926.)
Krenz, Mathilde H., B. A., A. M., 1002 W. Oregon St., Urbana, Ill. (Botany.) (1925.)
Kuh, Sidney, M. D., 30 N. Michigan Ave., Chicago, Ill. (Medicine.) (1911.)
Kyle, Alfred J., Momence, Ill. (Herpetology.) (1928.)
Lackie, G. D., M. D., Springfield, Ill. (Medicine.) (1927.)
Lacy, Robert, M. E., 1354 Dial Court, Springfield, Ill. (Engineer.) (1925.)
Lake, Bae M., B. E., 203 Grand Ave., Lincoln, Ill. (Biology.) (1927.)
Lamar. J. Everts, B. S., State Geological Survey Div., Urbana, Ill. (Geology.) (1924.)
Lambert Earl L., B. S., 217 N. 1st St., Carthage, Ill. (Botany and Zoology.) (1917.)
Lambky, Ernest, Ph. D., Fall Ave., Normal, Ill. (Botany.) (1928.)
Landon, R. E., 4122 N. Keystone Ave., Chicago, Ill. (1926.)
Lanphier, Robert C., Ph. B., Sangamo Electric Co., Springfield, Ill. (Electricity.) (1914.)
Lansing, W. D., B. S., 1605 N. Neil St., Champaign, Ill. (Physics.) (1928.)
Large, J. M., A. B., 105 Mound, Joliet, Ill. (Geography.) (1927.)
Larned, S. J., M. E., 212 W. Washington St., Chicago, Ill. (Physics.) (1926.)
Larson, E. A., B. A. M. S., 115 Cagwir, Joliet, Ill. (Chemistry.) (1927.)
Larson, Karl C., B. A., Augustana College, Rock Island. Ill. (Chemistry.) (1917.)
Lathrop, W. G., Principal Township High School, Johnston City, Ill. (Geology and Geography.) (1922.)
Laufer, D. Berthold, Ph. D., Field Museum, Chicago, Ill., (Archaeology.) (1925.)
Laves, Kurt, Ph. D., University of Chicago, Chicago, Ill. (Astronomy and Mathematics.) (1920.)
Leech, Bert S., Ph. B., A. M., Highland Park, Ill. (Biology.) (1927.)
Leighton, Morris Morgan, Ph. D., Chief, Illinois Geological Survey Division, Urbana, Ill. (Geology.) (1920.)
Leonard, Thos. H., M. D., 509 S. 6th St., Springfield, Ill. (Medicine.) (1925.)
Lessman, Lem. L., 412 N. Monroe, Peoria, Ill. (1926.)
Lewis, Howard B., Ph. D., University of Michigan, Medical School, Ann Arbor, Michigan. (Physiology, Chemistry.) (1920.)
Lewis, Julian H., D. D., Ricketts Laboratory, University of Chicago, Chicago, Ill. (Pathology.) (1921.)

Lichty, Daniel, M. D., 1920 Harlem Blvd., Rockford, Ill. (Collateral Anthropology.) (1926.)
Linder, O. A., 208 N. Wells St., Chicago, Ill. (1910.)
Link, T. A., Geology Department, Imperial Oil, Ltd., Calgary, Alberta, Canada. (Geology.) (1926.)
Linkins, R. H., M. A., 706 Broadway, Normal, Ill. (Zoology.) (1917.)
Loach, R. J. H., A. M., 5541 Dorchester Ave., Chicago, Ill. (Biology.) (1927.)
Lockie, G. D., M. D., Springfield, Ill. (Archeology.) (1927.)
Lodge, Fred S., B. S., 423 S. Stone Ave., LaGrange, Ill. (Zoology, Agriculture, Chemistry.) (1926.)
Logan, Hay, A. B., 1220 S. Grand Ave., Springfield, Ill. (Mathematics.) (1927.)
Logan, C. C., B. S., So. Ill. Normal University, Carbondale, Ill. (Agriculture.) (1926.)
Logsdon, Mrs. M. I., Ph. D., University of Chicago, Chicago, Ill. (Mathematics.) (1923.)
Longbons, Elizabeth, B. S., 2 E. Walnut, Harrisburg, Ill. (Chemistry.) (1925.)
Longden, A. C., Ph. D., Knox College, Galesburg, Ill. (Physics.) (1917.)
Lukens, Herman T., Ph. D., 330 Webster Ave., Chicago, Ill. (Geography.) (1920.)
Lutes, Neil, 1595 Atlantic St., Dubuque, Iowa. (Chemistry.) (1912.)
Lyon, William I., 124 Washington, Waukegan, Ill. (Ornithology.) (1926.)
MacDowell, Charles H., D. Sc., 111 W. Jackson Blvd., Chicago, Ill. (Chemistry.) (1926.)
Mackie, Arthur D., 400 E. Monroe St., Springfield, Ill. (Electricity.) (1915.)
MacMillan, W. D., Ph. D., University of Chicago, Chicago, Ill. (Astronomy.) (1922.)
Madison, Wm. D., M. D., Eureka, Ill. (Medicine.) (1921.)
Magill, Henry P., 175 W. Jackson Blvd., Chicago, Ill. (Geology, Sociology, Finance.) (1920.)
Mahoney, Sister Myra, A. B., 856 W. Garfield Blvd., Chicago, Ill. (Chemistry.) (1928.)
Main, Helen, B. S., Gladstone Hotel, Chicago, Ill. (Botany.) (1927.)
Malinovsky, A., Washington Iron Works, Los Angeles, Calif. (Chemistry.) (1920.)
Mann, A. L., M. D., 392 E. Chicago St., Elgin, Ill. (Medicine.) (1921.)
Mann, Jessie R., B. S., State Teachers' College, DeKalb, Ill. (Biology.) (1923.)
Manning, W. E., Ph. D., 308 Nat. Hist. Bldg., Urbana, Ill. (Botany.) (1928.)
Marks, Sarah, Pecatonica, Ill. (Biology.) (1917.)
Markus, H. C., Vienna, Ill. (Geology.) (1926.)
Martin, George W., Ph. D., Washington and Jefferson College, Washington, Penn. (Biology.) (1923.)
Marvel, Carl S., Ph. D., University of Illinois, Urbana, Ill. (Chemistry.) (1927.)
Mason, Arthur J., Homewood, Ill. (1921.)
Mason, Carol, Milwaukee Downer College, Milwaukee, Wis. (Geography, Botany.) (1926.)
Maynard, M. M., A. B., A. M., 734 E. Boston, Monmouth, Ill. (Psychology & Education.) (1927.)
McAvoy, Blanche, M. A., 206 S. Main St., Normal Ill. (Botany.) (1928.)
McClure, S. M., Box 57, Lebanon, Ill. (1921.)
McCoy, Herbert N., Ph. D., 161 E. Grand Blvd., Chicago, Ill. (Chemistry.) (1914.)
McCulloch, E. C., D. V. M., Box 55, Auburn, Alabama. (Parasitology.) (1927.)
McDavitt, Neva, 303 North St., Normal, Ill. ((Geography.) (1925.)
McEvoy, S. Aleta, B. S., Rockford High School, Rockford, Ill. (Chemistry.) (1923.)
McGinnis, Helen A., 6400 S. Maplewood Ave., Chicago, Ill. (General Science.) (1923.)
McKee, W. A., D. D. S., East Side Square, Benton, Ill. (1922.)
McMaster, Archie J., 102 W. Iowa St., Urbana, Ill. (Physics and Chemistry.) (1922.)
Mecham, John B., Ph. D., 118 S. Center St., Joliet, Ill. (1917.)
Metcalf, C. L., Ph. D., Old Law Bldg., University of Illinois, Urbana, Ill. (Entomology.) (1925.)
Metzner, Albertine E., M. S., 24 Marshner St., Plymouth, Wis. (Geology, Physics.) (1918.)
Miller, Isiah Leslie, M. A., College Station, Box 53, Brookings, So. Dakota. (Mathematics and Chemistry.) (1920.)
Miller, P. H., High School, Henning, Ill. (Biology.) (1920.)
Miller, R. B., M. F., 121 Capitol Bldg., Department of Conservation, Springfield, Ill. (Forestry and Ecology.) (1920.)
Milum, Vern. G., Ph. D., Vivarium Bldg. Univ. of Ill., Urbana, Ill. (Agriculture.) (1928.)
Mitchell, Catharine, A. B., 144 Fairbank Road, Riverside, Ill. (Botany and Ornithology.) (1925.)
Mohme, Fred S., A. B., 1141 W. 28th St., Los Angeles, Calif. (Geography.) (1927.)
Mongerson ,Oscar V., B. S., Supt. of Schools, Chenoa, Ill. (Physics.) (1925.)
Montgomery, C. E., M. S., State Teachers' College, DeKalb, Ill. (Biology.) (1917.)
Moore, Clarence E., B. A., 901 W. Main St., Urbana, Ill. (Botany.) (1924.)
Morgan, John J. B., Ph. D., 2133 Ridge Ave., Evanston, Ill. (Psychology.) (1926.)

Morgan, Wm. E., M. D., 1016 Hyde Park Blvd., Chicago, Ill. (Medicine.) (1921.)
Mortimer, F. S., Ph. D., Illinois Weslyan Univ., Bloomington, Ill. (Chem.) (1928.)
Moulton, C. Robert, Ph. D., 509 S. Wabash Ave., Chicago, Ill. (Chemistry.) (1926.)
Moulton, F. R., Ph. D., 327 South LaSalle St., Chicago, Ill. (Astronomy.) (1912.)
Mumford, H. W., B. S., University of Illinois, Urbana, Ill. (Agriculture.) (1910.)
Murray, Frank C., M. D., 105½ N. Park Ave., Herrin, Ill. (Medicine.) (1921.)
Murray, A. N., M. S., 311 W. High, Urbana, Ill. (Geology.) (1926.)
Murray, Sister Mary Samuela, B. A., 856 W. Garfield Blvd., Chicago, Ill. (Physics.) (1928.)
Mylius, L. A., S. B., M. E., 704 Shell Bldg., St. Louis, Mo. (Geology.) (1921.)
Nadler, Walter H., M. D., 30 N. Michigan Ave., Chicago, Ill. (Medicine.) (1921.)
Nash, Edna L., A. B., 316 Linden Place, DeKalb, Ill. (Geography.) (1927.)
Neave, Sidney Lionel, M. A., 1208 W. Clark, Urbana, Ill. (Chemistry.) (1926.)
Neifert, Ira E., M. S., Knox College, Galesburg, Ill. (Chemistry.) (1917.)
Nelson, C. Z. 534 Hawkingson Ave., Galesburg, Ill. (Botany.) (1917.)
Nelson, Emil A., M. E., 1123 W. Edwards St., Springfield, Ill. (Engineering.) (1924.)
Neureiter, Paul Richard, Ph. D., Western Ill. State Teachers' College, Macomb, Ill. (Chem.) (1928.)
Newcomb, Rexford, M. A., University of Illinois, Urbana, Ill. (Engineering Applications.) (1920.)
Newell, M. J., M. A., 2226 Hartzell St., Evanston, Ill. (1920.)
Newman, H. H., Ph. D., University of Chicago, Chicago, Ill. (Zoology.) (1912.)
Nicholson, F. M., 611 S. Ashland Blvd., Chicago, Ill. (Anatomy.) (1920.)
Noe, Adolf Carl, Ph. D., University of Chicago, Chicago, Ill. (Botany.) (1923.)
Noyes, Wm. Albert, Jr., D. Sc., University of Chicago, Chicago, Ill. (Chemistry.) (1925.)
Nuttall, Mrs. Olive, B. S., Springfield H. S., Springfield, Ill. (Botany.) (1928.)
O'Donoghue, Julia, Magnolia Ave., Chicago, Ill. (1928.)
Obenchain, Jeanette Brown, M. D., Hotel Del Prado, Chicago, Ill. (Anatomy.) (1921.)
Oesterling, H. C., A. B., 611 Ohio St., Urbana, Ill. (Ecology.) (1928.)
Ogilvy, Robert S., 411 Taylor Ave., Glen Ellyn, I., (1921.)
O'Hanlon, Sister Mary Ellen, Rosary College, River Forest, Ill. (Biology.) (1928.)
Olson, George A., M. S., 4423 N. LaVergne Ave., Chicago, Ill. (Chemistry.) (1926.)
Ozment, Arel, 806 Washington Ave., Johnston City, Ill. (General.) (1921.)
Packard, W. H., Ph. D., Bradley Poly, Institute, Peoria, Ill. (Biology.) (1909.)
Paddock, Walter R., M. D., 904 State St., Lockport, Ill. (Medicine.) (1921.)
Paine, Leland S., A. B., A. M., 918 S. Fell Ave., Normal, Ill. (Geography.) (1927.)
Paintin, Mrs. Ruth D., 827 Ridge Ave., Evanston, Ill. (Botany.) (1928.)
Palmer, Charles Shattuck, Ph. D., 1704 Hinman Ave., Evanston, Ill. (Chemistry.) (1925.)
Parr, Rosalie M., Ph. D., 1107 W. Oregon St., Urbana, Ill. (Chemistry.) (1926.)
Parson, S. F., State Teachers' College, DeKalb, Ill. (Mathematics.) (1922.)
Paton, Robt. F., Ph. D., 1005 S. Busey, Urbana, Ill. (Phsyics.) (1928.)
Patterson, Alice J., Illinois State Normal University, Normal, Ill. (Entomology, Nature Study.) (1910.)
Patterson, Cecil F., B. S., University of Saskatchewan Saskatoon, Canada. (Botany.) (1920.)
Patton Charles L., M. D., 612 Myers Bldg., Springfield, Ill. (Medicine.) (1925.)
Patton, Fred P., M. D., Glencoe, Ill. (Medicine.) (1921.)
Paul, Edna, 714 W. California St., Urbana, Ill. (Botany.) (1925.)
Peacock, C. Sheller, LL. B., 323 North 3rd, Monmouth, Ill. (Mycology.) (1925.)
Pearsons, H. P., 1816 Chicago Ave., Evanston, Ill. (1921.)
Penney, Mark Embury, Ph. D., S. T. B., 1441 W. Macon St., Decatur, Ill. (Psychology.) (1926.)
Petefish, Charles, A. B., N. Main, Winchester, Ill. (Biology.) (1928.)
Petersen, C. Beecher, 706 Second Ave., Joliet, Ill. (Geography.) (1927.)
Peterson, Oliver H., A. M., School of Education, James Millikin Univ., Decatur, Ill. (Psychol.) (1928.)
Phelps, Lillian B., Golconda, Ill. (Physics.) (1926.)
Phelps, Walter S., D. D. S., 57 Public Sq., Monmouth, Ill. (Mycology.) (1925.)
Phipps, Charles Frank, M. S., 342 Grand Ave., Long Beach, Calif. (Physics and Chemistry.) (1917.)
Pieper, Chas. J., University of Chicago, Chicago, Ill. (General Science.) (1921.)
Planstiehl, Carl, Wood Path Ave., Highland Park, Ill. (Physics and Chemistry.) (1926.)
Plapp, F. W., 4140 N. Keeler Ave., Chicago, Ill. (Botany, Geology.) (1922.)
Platt, Robert S., Ph. D., University of Chicago, Chicago, Ill. (Geography.) (1921.)

Plummer, Beulah A., B. S., College of Industrial Arts, Denton, Texas, (Physiology and Zoology.) (1925.)
Plummer, F. B., 608 W. 7th, Austin, Texas. (Geology.) (1926.)
Plummer, Mrs. Helen J., 608 W. 7th, Austin, Texas. (Geology.) (1926.)
Poling, J. A., M. D., Henny Bldg., Freeport, Ill. (Medicine.) (1921.)
Pollock, M. D., M. D., Powers Bldg., Decatur, Ill. (Medicine & Surgery.) (1920.)
Quill, Lawrence L., Ph. D., 805 W. Illinois, Urbana, Ill. (Chemistry.) (1928.)
Quirke, T. T., Ph. D., 234 Nat. Hist. Bldg., University of Illinois, Urbana, Ill. (Geology.) (1921.)
Radcliffe, H. H., Principal of Night School, 1346 W. Macon St., Decatur, Ill. (Physics, Chemistry.) (1909.)
Railsback, O. L., A. M., State Teachers' College, Charleston, Ill. (Physics.) (1928.)
Rambo, Jessie E., A. M., 208 W. Irving Ave., Normal, Ill. (Chem.) (1928.)
Ransom, James H., Ph. D., James Millikin University, Decatur, Ill. (Chemistry.) (1923.)
Ranne, Geo. C., A. M., 405 S. Eastern Ave., Joliet, Ill. (Physics & Chem.) (1927.)
Rauth, Andy Fred, McCormick Theological Seminary, 2330 N. Halsted St., Chicago, Ill. (Biology.) (1924.)
Rea, Helen E., 5904 Midway Park, Chicago, Ill. (Chemistry.) (1927.)
Renich, Mary E., Ph. D., Biol. Dept., Alma College, Alma, Mich. (Botany.) (1921.)
Rew, Irwin, A. B., 217 Demster St., Evanston, Ill. (1920.)
Rice, William F., A. M., Wheaton College, Wheaton, Ill. (Physics.) (1909.)
Richardson, Baxter K., A. B., Dept. of Public Health, Springfield, Ill. (Public Health.) (1921.)
Richardson, R. E., A. M., Box 715, Station A., Champaign, Ill. (Zoology.) (1910.)
Ridgeway, Robert, M. S., 1030 S. Morgan St., Olney, Ill. (Ornithology.) (1917.)
Rinker, Jacob Arron, B. S., Eureka, Ill. (Physics.) (1923.)
Rinker, M. M., B. S., 328 Richland St., Olney, Ill. (Physics.) (1926.)
Roberts, Elmer, B. S., Ph. D., 508 W. Iowa St., Urbana, Ill. (Genetics.) (1927.)
Robinson, Ray R., M. H., 510 Grant Ave., Joliet, Ill. (Geology.) (1927.)
Romer, A. S., Ph. D., University of Chicago, Chicago, Ill. (Paleontology.) (1925.)
Root, Clarence J., U. S. Weather Bureau, Springfield, Ill. (Climatology.) (1913.)
Rose, Dorothy E., B. S., 305 Ceramics Bldg., University of Illinois, Urbana, Ill. (Geology.) (1928.)
Rose, William C., Ph. D., University of Illinois, Urbana, Ill. (Chemistry.) (1924.)
Ross, Herbert H., B. S. A., Nat. Hist. Survey, Urbana, Ill. (Entomology.) (1928.)
Royce, Bertha M., B. A., M. A., 204 N. School, Normal, Ill. (Zoology) (1927.)
Sakemiller, Vera M., B. E., 1007 S. Low, Bloomington, Ill. (Biology.) (1927.)
Salter, Allen, M. D., Lena, Ill. (Medicine.) (1920.)
Salzberg, Paul, 375 E. Losy St., Galesburg, Ill. (Chemistry.) (1925.)
Sampson, H. C., Ph. D., Ohio State University, Columbus, Ohio. (1912.)
Saunders, Mrs. Amy, M. P., M. D., 1819 W. Polk St., Oak Park, Ill. (Neurology.) (1928.)
Saunders, Dr. Felix, Ph. D., University of Chicago, Chicago, Ill. (Chemistry.) (1928.)
Savage, Margaret, 613 W. Nevada St., Urbana, Ill. (Botany.) (1925.)
Schantz, Orpheus M., Room 521, 137 S. LaSalle St., Chicago, Ill. (Birds, Plants.) (1920.)
Schaub, Edward L., Ph. D., Harris Hall, Evanston, Ill. (Psychology.) (1920.)
Schertz, Ray J., A. B., Township High School, Metamora, Ill. (Chem.) (1928.)
Schmidt, Otto L., M. D., 5 So. Wabash Ave., Chicago, Ill. (History.) (1921.)
Schmoll, Hazel Marguerite, B. E., M. S., Ward, Colo. (Botany.) (1921.)
Schrepfer, Frank A., A. B., University of Pennsylvania, Philadelphia, Pa. (Botany.) (1925.)
Schulz, W. F., Ph. D., University of Illinois, Urbana, Ill. (Physics.) (1910.)
Schwartzberg, Benj., 1317 So. Homan Ave., Chicago, Ill. (Bacteriology.) (1926.)
Sears, O. H., 606 E. Chalmers St., Champaign, Ill. (Chemistry.) (1922.)
Sellin, Hilding, A. B., Snell Hall, No. 43, University of Chicago, Chicago. (Geology.) (1927.)
Shank, Marjorie M., A. M., 718 S. Normal, Carbondale, Ill. (Geography.) (1924).
Shantz, H. L., Ph. D., D. Sc., University of Arizona, Tucson, Ariz. (Botany.)
Sheretz, D. Ransom, Ed B., 108 S. Center St., Collinsville, Ill. (Zoology.) (1925.)
Shull, Chas. A., Ph. D., University of Chicago, Chicago, Ill. (Botany, Plant Physiology.) (1924.)
Simer, Dorr M., B. E., 1660 N. College, Decatur, Ill. (Chem.) (1928.)
Simmons, Marguerite L., B. S., M. A., 325 Melrose Ave., Centralia, Ill. (Biology.) (1921.)
Simonds, O. C., 1101 Buena Ave., Chicago, Ill. (Botany.) (1920.)
Simons, Etoile B., Ph. D., 7539 Colfax Ave., Chicago, Ill. (Botany.) (1920.)

Singer, H. Douglas, M. D., 25 E. Washington St., Chicago, Ill. (Psychiatry.) (1920.)
Slye, Maud, A. B., 5836 Drexel Ave., Chicago, Ill. (1921.)
Smisloff, Walter, 5008 Eddy St., Chicago Ill. (Chem.) (1928.)
Smith, Arthur Bessey, B. S., 2324 Hartzell St., Evanston, Ill. (Telephony.) (1920.)
Smith, Arthur L., A. B., Eureka, Ill. (Biology.) (1927.)
Smith, Clarence R., B. S., M. S., Aurora College, Aurora, Ill. (Physics.) (1921.)
Smith, Erman S., B. S., Barrington, Ill. (Nat. Study.) (1928.)
Smith, George Hume, Ph. D., 206 Zoology Bldg., Univ. of Penn., Philadelphia, Pa. (Biological Abstracts.) (1921.)
Smith, Grant, M. S., Ph. D., 6107 Woodlawn Ave., Chicago, Ill. (1921.)
Smith, Guy N., B. S., Rockford High School, Rockford, Ill. (Botany.) (1925.)
Smith, K. K., Ph. D., 2200 Sherman Ave., Evanston, Ill. (Physics.) (1916.)
Smith, R. S., Ph. D., University of Illinois, Urbana, Ill. (Chemistry and Physics of Soils.) (1920.)
Snider, Alvin B., M. D., Blue Island, Ill. (Medicine.) (1921.)
Snider, H. J., B. S., University of Illinois, Urbana, Ill. (Soils, Agriculture.) (1921.)
Solheim, Wilhelm G., B. A., M. A., Botany Dept., N. Dakota Agri. College, Fargo, North Dakota. (Botany.) (1927.)
Sonnenschein, Robert, M. D., 4518 Woodlawn Ave., Chicago, Ill. (Medicine.) (1920.)
Spooner, Charles S., A. B., A. M., 1436 7th St., Charleston, Ill. (Zoology.) (1920.)
Spoor, H. C., Jr., B. S., 407 W. Washington, Urbana, Ill. (Geology.) (1926.)
Stabin, George W., M. D., First National Bank Bldg., Springfield, Ill. (Medicine.) (1925.)
Stansfield, John, M. A., M. S., 902 West Illinois, Urbana, Ill. (Geology.) (1925.)
Stark, John Thomas, M. A., 749 Sherman Ave., Evanston, Ill. (Geology.) (1925.)
Stauffer, Andrew Z., M. Sc., 633 Kenilworth Ave., Glen Ellyn, Ill. (Botany.) (1928.)
Steagall, Mary M., Ph. D., 808 S. Illinois Ave., Carbondale, Ill. (Botany.) (1921.)
Stein, Hilda Anna, B. Ed., 409 W. Jackson, Carbondale, Ill. (Zoology.). (1926.)
Stevens, F. L., Ph. D., University of Illinois, Urbana, Ill. (Plant Pathology.) (1914.)
Stillians, A. W., M. D., 911 East 50th St., Chicago, Ill. (Medicine.) (1921.)
Stout, Gilbert L., A. B., State Natural History Survey, Natural History Hall, Urbana, Ill. (Botany.) (1927.)
Stover, E. L., State Teachers' College, Charleston, Ill. (Botany.) (1924.)
Stover, Mrs. E. L., M. S., 930 Second St., Charleston, Ill. (Botany.) (1923.)
Strong, Harriett, B. S., 702 Maple Ave., Downers Grove, Ill. (Biology.) (1917.)
Struble, R. H., A. B., 4481 Sheridan Ave., Detroit, Mich. (Physics.) (1921.)
Sturm, Kathryn, Ed. B., 608 S. Main St., Anna, Ill. (Zoology.) (1927.)
Swan, W. S., M. D., Cor. Main and Walnut Sts., Harrisburg, Ill. (Medicine.) (1921.)
Talmage, Sterling B., M. S., Ph. D., 2249 Ridge Ave., Evanston, Ill. (Geology.) (1927.)
Tarvin, Donald, B. E., Roberts, Ill., (Chem.). (1928.)
Tatum, Arthur L., Ph. D., M. D., University of Wisconsin, Madison, Wis. (Physiology, Pharmacology.) (1920.)
Taylor, Harry, Harrisburg, Ill. (1925.)
Terwilliger, George L., B. E., 330 College Ave., DeKalb, Ill. (Biology.) (1926.)
Teuscher, H., Boyce Thompson Inst., Yonkers, N. Y. (Botany.) (1928.)
Thomas, E. T., M. A., Willow Grove, Tennessee. (Geology.) (1923.)
Thomas, Gertrude M., 1003 N. Court St., Rockford, Ill. (Biology.) (1924.)
Thomas, Lyell J., Ph. D., 313 Natural History Bldg., University of Illinois, Urbana, Ill. (Zoology, Parasitology.) (1923.)
Thurlimann, Leota, 15065 Myrtle Ave., Harley, Ill. (1921.)
Thurston, Fredus A., 1361 E. 57th St., Chicago, Ill. (1921.)
Tiffany, L. Hanford, Ohio State Univ., Columbus, Ohio. (Botany.) (1914.)
Toler, H. N., B. S., Care of The Texas Company, 17 Battery Place, New York, N. Y. (Geology.) (1926.)
Townsley, Fred D., B. A., James Millikin University, Decatur, Ill. (1916.)
Trapp, A .R., M. D., Illinois National Bank Bldg., Springfield, Ill. (Medical Diagnosis.) (1914.)
Tunnicliff, Ruth, M. D., McCormick, Memorial Institute, 637 S. Wood St., Chicago, Ill. (Medicine.) (1928.)
Turner, Lewis M., B. S., Blackburn College, Carlinville, Ill. (Botany.) (1925.)
Tuttle, H. H., M. D., Illinois Bank Bldg., Springfield, Ill. (Medicine.) (1925.)
Tyler, Rayen W., A. M., 204 W. University Ave., Urbana, Ill. (Physics.) (1928.)
Ulrich, Katherine, Ph. B., 1006 No. Boul. Oak Park, Ill. (Geology, Geography, Botany.) (1921.)
Underhill, Editha, M. S., Rockford College, Rockford, Ill. (Chemistry.) (1926.)
Vance, Charles, Rantoul, Ill. (Physics.) (1926.)
Van Hooser, B., A. B., M. D., 25 E. Washington St., Chicago, Ill. (Medicine.) (1927.)
Van Tuyle, Francis M., Ph. D., Colorado School of Mines, Golden, Colo. (Geology.) (1916.)

Vestal, A. G., Ph. D., Biology Laboratory, Stanford University, Calif. (Ecology.) (1910.)
Vogel, Alfred C., B. S., M. S. (1927.)
Voss, John, 200 Dixon Ave., Peoria, Ill. (Biology.) (1928.)
Waechter, I. Edmund, B. S., 609 Woodland Ave., Springfield, Ill. (Metallurgy.) (1927.)
Waldo, Jennie E., 1204 Third Ave., Rockford, Ill. (Biology.) (1922.)
Walker, Ellis David, M. D., B. Sc., 5519 University Ave., Chicago, Ill. (Pedagogical Med., Biol., Agri.) (1921.)
Walsh, John, Box 212, Galesburg, Ill. (Water Supply.) (1921.)
Wanless, Harold R., Ph. D., 1114 W. Nevada, Urbana, Ill. (Geology.) (1924.)
Warbrick, John C., M. D., M. C., 306 E. 43rd St., Chicago, Ill. (Birds, Nature Study.) (1920.)
Ward, Harold B., B. S., Northwestern Univ., Evanston, Ill. (Geology, Geography.) (1910.)
Warner, Glen W., A. B., A. M., 7633 Calumet Ave., Chicago, Ill. (Physics.) (1927.)
Waterman, Warren G., Ph. D., Northwestern University, Evanston, Ill. (Botany.) (1914.)
Watson, F. R., Ph. D., Dept. of Physics, University of Illinois, Urbana, Ill. (1909.)
Watson, Josiah S., B. S., M. S., Ind. & Adella, Joliet, Ill. (Zoology, Botany.) (1927.)
Waugh, Anna, A. B., 6620 Yale Ave., Chicago, Ill. (Botany.) (1927.)
Weatherwax, Paul, Ph. D., 416 So. Dunn St., Bloomington, Ind. (Botany.) (1928.)
Weaver, George H., M. D., 629 S. Wood St., Chicago, Ill. (Medicine, Bacteriology.) (1920.)
Weber, H. C. P., Ph. D., Westinghouse Electric Co., Pittsburgh, Pa. (Chemistry.) (1914.)
Weckel, Ada L., M. S., Twp. High School, Oak Park, Ill. (Zoology.) (1917.)
Weese, Asa Orrin, Ph. D., University of Oklahoma, Norman, Oklahoma. (1924.)
Weir, Mary E., Ph. B., Carbondale, Ill. (Geography.) (1927.)
Weichelt, A., M. D., Barrington, Ill. (Medicine.) (1921.)
Weinard, F. F., Ph. D., 713 Iowa St., Urbana, Ill. (Botany.) (1928.)
Welker, William H., Ph. D., Univ. of Illinois College of Medicine, 1817 W. Polk St., Chicago, Ill. (Biological Chemistry.) (1920.)
Weller, J. Marvin, University of Illinois, Urbana, Ill. (Geological Survey.) (1926.)
Wellman, Murrell, Joliet, Ill. (Physiography.) (1927.)
Wells, M. M., Ph. D., General Biological Supply House, 761-763 East 69th Place, Chicago, Ill. (Zoology.) (1913.)
Wentworth, Edward N., B. S., M. S., Armour's Bureau of Agricultural Research and Economics, Chicago, Ill. (Genetics and Economics.) (1922.)
Wentzlemann, Gus, S. Cedar St., Galesburg, Ill. (Therapy.) (1928.)
White, Mrs. Florence, B. A., 119 Dement, Dixon, Ill. (Biology.) (1927.)
White, J. Kay, Milledgeville, Ill. (Geology.) (1926.)
Whitmore, Frank C., Ph. D., Northwestern University, Evanston, Ill. (Organic Chemistry.) (1921.)
Whitney, Worallo, A. M., 5743 Dorchester Ave., Chicago, Ill. (Botany.) (1910.)
Whitten, J. H., Ph. D., 7111 Normal Blvd., Chicago, Ill. (Botany.) (1917.)
Wicks, Nina H., B. S., M. S. 218 Iowa, Joliet, Ill. (Zoology). (1927.)
Wickwire, Geo. C., B. S., M. S., Univ. of Ill., Urbana, Ill. (Physiology.) (1927.)
Williams, E. H., Ph. D., 804 Michigan Ave., Urbana, Ill. (Physics.) (1925.)
Williams, Pauline, B. S., 226 S. 19th St., Murphysboro, Ill. (Biology.) (1926.)
Willier, Benj. H., Ph. D., University of Chicago, Chicago, Ill. (Zoology.) (1921.)
Willman, H. B., 505 Gregory Place, Urbana, Ill. (Geology.) (1925.)
Wilson, A. H., James Millikin University, Decatur, Ill. (Botany.) (1928.)
Windsor, Mrs. P. L., 701 Michigan Ave., Urbana, Ill. (Entomology.) (1913.)
Winfield, Gerald, 301 Nat. Hist. Hall, Urbana, Ill. (Zoology.) (1928.)
Wise, Anna Evelyn, 211 So. Center St., Joliet, Ill. (1928.)
Witt, J. C., Ph. D., 5834 Stony Island Ave., Chicago, Ill. (Chemistry.) (1923.)
Witzemann, Edgar J., Ph. D., Science Hall, University of Wisconsin, Madison, Wis. (Chemistry.) (1920.)
Wolkoff, M. I., Ph. D., 226 E. 56th St., Chicago, Ill. (Soil Fertility.) (1922.)
Woods, F. C., 100 N. Cherry St., Galesburg, Ill. (Physics.) (1917.)
Woods, Ruth, B. S., Springfield, Illinois, 713 Iowa St. (Botany.) (1928.)
Workman, L. E., M. S., Asst. Geologist, State Geological Survey, Urbana, Ill. (Geology.) (1926.)
Worsham, Walter B., A. B., 403 W. Monroe St., Springfield, Ill. (Physics.) (1924.)
Wright, Mrs. Maurie Bailey, A. B., A. M., Beloit College, Beloit, Wis. (Botany.) (1927.)
Wright, Frank, M. D., 5 S. Wabash Ave., Chicago, Ill. (Biological Chemistry.) (1920.)
Wright, Paul R., B. A., Michigan Ave. and Oak St., Highland Park, Ill. (Geology.) (1924.)
Wynne, Ross B., A. B., 7335 Kenwood Ave., Chicago, Ill. (Botany.) (1920.)
Yoggy, I. D., B. S., 116 Bartleson St., Joliet, Ill. (Physics.) (1927.)

Young, Mrs. J. D., M. S., Windermere Hotel, 56th St. and Cornell Ave., Chicago, Ill. (Zoology.) (1911.)
Zimmerschied, Charlotte, M. A., 1048 Winona St., Chicago, Ill. (Physics.) (1926.)
Zoller, C. H., M. D., 416 Monroe Bldg., Litchfield, Ill. (Medicine.) (1921.)

SCIENTIFIC SOCIETIES AFFILIATED WITH THE ACADEMY.

Botany Club of Joliet, Joliet, Ill. (1925.)
Burrill Botany Club, 204 Natural History Bldg., University of Illinois, Urbana, Ill. (1925.)
Englewood Biology Club, Englewood, Illinois. (1925.)
Illinois Association of Biol. Teachers, Mary R. Earnest, Secy., Decatur High School, Decatur, Ill.
Illinois Society of Chem. Teachers, Rosalie M. Parr, Secy.-Treas., 321 Chem. Bldg., Urbana, Ill. (1928.)
Illinois Nature Study Society of Elgin, 310 N. Liberty St., Elgin, Ill. (1924.)
Joliet Botanical Club, Joliet. Ill. (1925.)
Knox County Academy of Science, Galesburg, Ill. Fred R. Jelliff, President. (1923.)
Normal Science Club, Illinois State Normal University, Normal, Ill. (1923.)
Rockford Nature Study Society, Miss F. A. Davey, Corey Bluff, Rockford, Ill. (1923.)
Science Club, State Normal University, Carbondale, Ill. (1925.)
Sigma Xi, University of Chicago Chapter, Chicago, Ill. (1925.)
Sigma Xi, University of Illinois Chapter, Urbana, Ill. (1925.)
The Chicago Academy of Science, Chicago, Ill. (1925.)
The Southern Illinois Science Club, State Normal University, Carbondale, Ill. (1926.)

HIGH SCHOOL SCIENCE CLUBS.

Assisi Junior College, 303 Taylor St., Joliet, Ill. (1927.)
Boys' Science Club, High School, Galesburg, Ill. (1923.)
Danville Science Club, High School, Danville, Ill. (1923.)
Edisonian Science Club, Henry, Ill. (1926.)
Edisonian Science Club, West Chicago Community High School, Louis A. Astell, Secretary, West Chicago, Ill. (1928.)
Englewood High School General Science Club, 62nd St. and Stewart Ave., Chicago, Ill (1924.)
Eureka Science Club, Eureka Township High School, Eureka, Ill. (1923.)